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Editorial **Open Access**

Hidden Hearing Loss - Revisiting the Limits of Audiometric Diagnosis

Iqbal Hussain Udaipurwala

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Hearing loss has traditionally been identified and managed on the basis of audiometric thresholds, with clinicians relying on pure-tone audiograms as the gold standard.[1] However, a growing research has revealed a perplexing phenomenon where individual reports significant hearing difficulty, particularly in noisy environments, despite having normal audiogram.[2,3,4] This condition, termed 'hidden hearing loss' (HHL), is increasingly recognized as a significant but underdiagnosed auditory disorder.[5] Its concept was first elucidated in animal models, demonstrated that noise exposure can cause permanent damage to the synapses between inner hair cells and auditory nerve fibers without altering hearing thresholds.[6] Since then, this cochlear synaptopathy based model has transformed our understanding of auditory dysfunction, pushing the boundaries of clinical audiology and neuroscience.[7,8] Hidden hearing loss challenges traditional assumptions and calls for a rethinking of hearing diagnostics, especially in populations such as veterans, industrial workers, and recreational noise users. About 10% of the patients visiting ENT clinics with complaint of difficulty in understanding speech in noisy environment remain untreated due to this problem.[9]

The World Health Organization in its 2021 report on hearing, estimates that about half population of the globe is at risk of developing noise induced hearing loss due to unsafe exposure to sound in workplace or social activities.[7] Noise induced hearing loss typically damages outer hair cell in the cochlea and subsequent neuronal degeneration which elevates hearing thresholds and is easily detected via standard audiometry.[10] On the other hand in cochlear synaptopathy, pathology lies in the synapses between the hair cells and spiral ganglion which preserves the hearing threshold sensitivity. As a result, individuals with significant synaptic damage may pass audiometric tests yet struggle to interpret complex auditory scenes, particularly speech-in-noise. Electrophysiological studies have provided strong support for this mechanism as reduced amplitude in auditory brainstem response wave I correlates with synaptic loss, even when audiograms appear normal. Furthermore, advanced tests such as envelope following responses (EFRs) and auditory steady-state responses (ASSRs) suggest impaired temporal dependability in the auditory pathway that is another hallmark of synaptopathy. Although most evidence originates from animal models, postmortem analyses and indirect testing in humans support the idea that noise exposure, aging, and possibly ototoxicity contribute to synapse degeneration. Importantly, these changes may not be linear, suggesting an early vulnerability of low-spontaneous-rate fibers that are essential for hearing in challenging listening conditions.

Noise is perhaps the most well established cause of hidden hearing loss, even moderate but repeated exposure to high-intensity sounds such as those encountered in concerts, nightclubs, or workplaces can result in significant synaptic loss. A recent study has found evidence of hidden hearing loss among young adults with frequent recreational noise exposure, despite their normal hearing thresholds.[8] Another significant contributor in hidden hearing loss is age-related cochlear synaptopathy. While presbycusis is traditionally associated with both threshold shifts and outer hair cell loss with neural degeneration, research now suggests that synapse loss may precede these changes. This makes hidden hearing loss a potential early biomarker for age-related hearing decline. Ototoxic drugs, such as aminoglycosides or certain chemotherapeutic agents, have also been implicated in the etiology of synaptopathy. Additionally, individuals with tinnitus or hyperacusis often exhibit signs consistent with hidden hearing loss, even when standard hearing tests fail to capture their auditory dysfunction.[11] Occupational data further highlight the relevance of HHL as military veterans and workers in industrial environments frequently report auditory problems not explained by audiograms. A study by Tepe et al. (2017) documented such deficits in soldiers, suggesting that current hearing conservation programs may underestimate the true burden of auditory damage.[12]

Clinically, hidden hearing loss presents with a diagnostic enigma. Patients often describe difficulty understanding speech in noisy environments, poor sound clarity, listening fatigue, and tinnitus, yet standard audiograms and tympanometry often yield normal results. This dissonance can lead to underdiagnosis, misdiagnosis, or even dismissal of patients' complaints. Standard audiological evaluations lack the sensitivity to detect HHL. As a result, new diagnostic

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paradigms are being explored like speech-in-noise (SiN) test, electrophysiological markers, such as ABR wave I amplitude and EFR metrics, TEN (threshold equalizing noise) testing and self-report auditory questionnaires, which can contextualize physiological findings. Recent reviews emphasize the need for multi-modal diagnostic batteries that incorporate both objective and subjective assessments. Without such integrative approaches, many cases of HHL will continue to go unrecognized, with adverse effects on patients' communication abilities, mental health, and quality of life.

The implications of HHL extend far beyond hearing difficulties. Social withdrawal, cognitive fatigue, and depression are commonly reported in individuals with undiagnosed auditory impairments. From a society standpoint, untreated HHL contributes to productivity loss, educational challenges, and increased healthcare utilization. The issue is especially critical in high-demand auditory environments, such as classrooms, military operations, emergency services, and busy workplaces. Children with undiagnosed HHL may be mislabeled as inattentive or underperforming, while adults may suffer in job performance or safety-sensitive tasks. Moreover, the potential for progression from HHL to overt hearing loss remains a matter of concern. While the natural course of cochlear synaptopathy is still under investigation, early synaptic damage may predispose individuals to accelerated hearing decline if left unaddressed.

Given the limitations of current treatment options, prevention remains the cornerstone of HHL management. Public health strategies should include:

- Educational campaigns about safe listening practices, particularly among youth.
- Stricter enforcement of occupational noise regulations and enhanced protective equipment.
- Routine auditory screenings that go beyond audiograms, particularly for at-risk populations.

On the research front, the development of non-invasive, cost-effective diagnostic tools is urgently needed. Technologies such as portable ABR and machine learning-assisted SiN analysis may help bridge the gap between research and clinical practice. Furthermore, therapeutic innovation is on the horizon. Experimental models suggest that neurotrophic factors can promote synapse regeneration. Gene therapy and nanoparticle-mediated drug delivery are also being explored, though translation to human application remains pending. Longitudinal studies are essential to understand the trajectory of HHL, identify early predictors of progression, and evaluate the impact of targeted interventions. Multidisciplinary collaboration encompassing audiology, neurology, otolaryngology, and behavioral science will be key to advancing the field. By recognizing HHL as a genuine and pressing auditory disorder, we can offer better support, develop novel therapies, and, most importantly, validate the lived experiences of those who hear but cannot truly listen.

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Iqbal Hussain Udaipurwala: Conception, writing, literature search, proof reading

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Editorial **Open Access**

Making Oral Pathology Clinically Relevant: A Call to Action for Pakistan's Healthcare System

Muhammad Shahrukh Khan Sadiq, Daud Mirza, Shahid Ali Khan

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Oral pathology is a fundamental component of the dental and medical disciplines, as it is extensively involved in the identification, diagnosis, and comprehension of diseases that affect the oral and maxillofacial region. It is essential for the early detection of malignancy, the diagnosis of lesions, and the guidance of therapeutic decisions.[1] Oral pathology remains an underdeveloped and under-integrated discipline within the healthcare system, despite its clinical importance, particularly in a country like Pakistan with one of the highest burdens of oral cancer in the world.[2]

Oral pathology education commences in the third year of the Bachelor of Dental Surgery (BDS) program in Pakistan. Regrettably, the undergraduate curriculum continues to be predominantly didactic, with minimal practical diagnostic exposure and virtually no integration with clinical departments.[3] In comparison to other fundamental disciplines in medical and dental education, oral pathology is characterized by a dearth of applied learning experiences and insufficient curriculum hours. The outcome is a cohort of dental graduates who are inadequately prepared to diagnose or treat intricate oral pathologies.[3, 4]

Limited to academic tracks, namely the MPhil and PhD, only a handful of institutions offer postgraduate education in Oral Pathology. The MPhil program is typically structured over a three-year period, with one year of coursework and two years of research. In contrast, PhD programs prioritize research output and publication. Although these programs do develop scholarly and research skills, they do not adequately equip graduates with the necessary skills to assume real-world clinical responsibilities. Structured, standardized clinical training components are conspicuously absent. The majority of graduates have minimal to no experience in multidisciplinary team collaboration, patient interaction, or hospital-based diagnosis.

The absence of a Fellowship in Oral Pathology (FCPS) from the College of Physicians and Surgeons Pakistan (CPSP), the nation's highest body for clinical specialization, is an even more pronounced lacuna. Conversely, countries such as India and Sri Lanka have established oral pathology as a robust clinical specialty, providing FCPS-equivalent pathways that are characterized by clinical exposure, oncology rotations, and interdepartmental collaboration.[5, 6]

Oral pathologists receive training in a variety of interrelated disciplines, such as: in countries such as the United Kingdom and the United States.[7] They actively engage in molecular and immunohistochemical diagnostics, administer biopsies, and participate in multidisciplinary tumor boards. In Pakistan, however, oral pathologists, particularly those with MPhil or PhD credentials, are frequently confined to academic or lab-based positions with minimal or no patient interaction, despite their significant potential.

This discrepancy has far-reaching consequences; Despite its relevance, Oral pathology becomes less appealing to top dental graduates, who tend to prefer clinically recognized specialties such as orthodontics or oral surgery.[5] The discipline experiences difficulty in establishing its relevance or visibility in clinical environments. Additionally, opportunities for international collaboration, research funding, and public health policymaking are substantially diminished.[8]

In order to alter this trajectory, it is imperative that we establish a clinically structured postgraduate curriculum for Oral Pathology, which will be led by CPSP and will include a formal FCPS training program. Rotations through oncology clinics, surgical pathology departments, diagnostic histopathology units, and exposure to molecular techniques should comprise this program. Furthermore, it should include patient-centered diagnostic roles, clinical-pathological correlation meetings, biopsy reporting, and tumor board participation.

It is imperative that the current MDS, MPhil, and PhD faculty in Oral Pathology are actively involved in the design and delivery of this clinical training. These professionals, who are already thoroughly ingrained in academic and diagnostic systems, are in the best position to establish a

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connection between theoretical knowledge and clinical application. By collaborating with general pathologists, they can co-create a hybrid educational model that is both clinically relevant and academically rigorous.

Simultaneously, institutions that provide MPhil and PhD programs must be required to incorporate hospital-based rotations, diagnostic lab exposure, and clinical case discussions into their core curriculum. This training can be further enhanced by collaborating with tertiary care centers and medical colleges, which will enable pathology residents to conduct histological evaluations, manage real-time cases, and acquire knowledge of contemporary diagnostic modalities.

Additionally, policy-level action is required. The Pakistan Medical and Dental Council (PMDC) and the Higher Education Commission (HEC) are required to promote international linkages, assure faculty development, and enforce uniformity in oral pathology curricula. Continuing medical education (CME) programs and investments in diagnostic laboratory infrastructure are both indispensable.

In a nutshell, the field of oral pathology in Pakistan is currently at a critical juncture. It is clinically inert, despite its academic activity. Without the integration of oral pathologists into real-world patient care teams and the establishment of an FCPS clinical training pathway, the specialty is at risk of becoming irrelevant in both the public health and clinical sectors.[9] To revitalize oral pathology in Pakistan, focused reforms are essential. Integrating clinical training, diagnostic exposure, and multidisciplinary collaboration into postgraduate programs will enhance its practical relevance. Public awareness campaigns, digital diagnostics, and partnerships with tertiary hospitals can extend its reach and visibility. Faculty development, international collaborations, and funding for translational research must also be prioritized.[10] By aligning academic training with real-world clinical demands, oral pathology can regain its rightful place in healthcare.[11] The specialty holds immense potential to impact early cancer detection and public health.[12] With coordinated efforts, we can transform it into a vital, respected, and patient-centered discipline. A significant revival necessitates the utilization of the expertise of our current academic oral pathologists and the collaboration with general pathologists to establish a future that is representative of both clinical impact and academic excellence. The time for reform is now, as it is essential for the public health outcomes, our profession, and our patients.

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Muhammad Shahrukh Khan Sadiq: conception, writing, literature search, proof reading
Daud Mirza: Writing proof reading
Shahid Ali Khan: Literature search, proof reading

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Original Article **Open Access**

Comparison of Outcome and Quality of life between Breast Conserving Surgery and Modified Radical Mastectomy for Breast Cancer

Muhammad Zafar Mengal, Uzma Shaheen, Muhammad Muneeb Saqlain Bajwa, Rehan Hameed, Zain Mukhtar Chaudhary, Zafar Ali Chaudhary

ABSTRACT

Objectives: To compare the clinical outcomes, recurrence rates, post-operative complications, and quality of life between patients undergoing BCS and MRM for early-stage breast cancer.

Study Design and Setting: This was a prospective cohort study (comparative) conducted at DHQ Teaching hospital Narowal

Methodology: This one-year study (January 2023–January 2024) included 93 early-stage breast cancer patients, with 46 undergoing MRM and 47 BCS. Demographics, tumor traits, recurrence rates, complications, and quality-of-life outcomes were analyzed. Statistical tests, including chi-square were performed using SPSS version 20.

Results: Complications occurred in 18.1% (17 out of 93) patients in which 7 (14.9%) were from the BCS group, and 10 (21.7%) were from the MRM group. Recurrence rate was 10.9% in MRM group and 4.3% for the BCS group (P<.05). Wound infection was more common in the MRM group (6.5%) compared to the BCS group (4.3%), though this difference was not statistically significant (p = 0.41). Tests of quality of life at the end of a year revealed that BCS patients have far better body image and mental health findings than MRM patients.

Conclusion: Although BCS offers higher quality-of- life results, both BCS and MRM are appropriate surgical choices for early-stage breast cancer. These findings make BCS appear like a reasonable choice compared to MRM, More research is advised using larger samples.

Keywords: Breast-conserving surgery, modified radical mastectomy, post-operative complications, Recurrence rate

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INTRODUCTION

Breast cancer, the most often occurring cancer in women worldwide, it results in a lot of morbidity and mortality. Improvements in early detection techniques, public health expertise, and treatment strategies over the past few years have fundamentally altered the management of this illness.[1]One of the most crucial methods to treat breast cancer remains surgery even with these developments.[2, 3] Dramatic operations like the Halsted radical mastectomy were the most often used approach of treating breast cancer in the past. These procedures concentrated on eliminating all the surrounding breast tissue and structures to lower the recurrence risk but the physical and psychological issues accompanying it spurred the hunt for less intrusive techniques such as breast-conserving surgery (BCS).[4]

Multiple randomized controlled trials as well as cohort studies performed at scale have validated that combining BCS with radiotherapy provides an effective treatment method compared to MRM for early-stage breast cancer. The NSABP B-06 trial together with various meta-analyses prove BCS achieves the same survival prognosis as MRM and maintains both physical appearance and mental health.[5] The choice of breast cancer surgery is shaped by both patient health conditions and tumor characteristics and healthcare

delivery systems. Some resource-deprived regions choose MRM over other options because they lack radiotherapy resources even though MRM is not necessary for oncological care. Knowledge of these elements enables better optimization of individualized treatment approaches for patients.[6]

The choice of surgical procedure depends equally on surgical safety and treatment-related quality of life as well as patient preference. Research indicates breast cancer surgery patients demonstrate superior satisfaction together with better adjustment to their social environment and enhanced sexual outcomes when receiving BCS instead of MRM.[7] Healthcare providers face challenges because radiotherapy for BCS breast cancer patients creates longer treatment times and raises financial stress. People with breast cancer anxieties about potential recurrence generally want thorough surgical interventions beyond Breast Conserving Surgery even though appropriate selection demonstrates these surgeries can be safe.[8]

Certain early-stage breast cancer patients might not require a modified radical mastectomy (MRM). Rather, patients can undergo lumpectomy along with further radiation treatment as part of breast-conserving surgery. Studies on general life and survival free from disease have revealed that BCS produces cancer outcomes akin to those of MRM. Apart from maintaining the looks of the breasts, BCS has psychological and social consequences that improve the quality of life of patients.[9] Still the best choice for those whose cancer has progressed locally or to other places is MRM, which entails removing the whole breast and lymph nodes in the armpit.[10] It is also advised in areas where radiation is difficult to access since BCS requires further treatment for the optimum effects.

Among the several factors influencing the choice between BCS and MRM are tumor size and stage, patient wishes, and the availability of healthcare resources. There are advantages and disadvantages in both approaches of accomplishing things. BCS demands rigorous follow-up and commitment to extra therapy to reduce the possibility of recurrence, even if it may make surgery less physically and psychologically taxing.[11, 12]

Though much research has been done to evaluate BCS and MRM, there is still gap, particularly in areas where good diagnostics and radiation facilities are rare. Furthermore lacking is a lot of localized data examining these surgical technique in a spectrum of healthcare environments and socioeconomic levels. Examining the outcomes of modified radical mastectomy and breast-conserving surgery in terms of patient satisfaction, quality of life, and safety in the battle against cancer helps this study to close in the evidence gaps.

METHODOLOGY

This study was conducted after obtaining ethical approval from the Institutional Review Board (IRB) of the Narowal medical college college/DHQ teaching hospital Narowal under ERC number 237/NMCN dated 25.01.2023. Written informed consent was obtained from all participants, and the study adhered to the ethical guidelines outlined in the Declaration of Helsinki. The research was a prospective cohort study carried out in the Department of Surgery at teaching hospital Narowal. The aim was to compare the clinical outcomes of breast-conserving surgery (BCS) and modified radical mastectomy (MRM) in patients diagnosed with early-stage breast cancer. The study spanned one year, from 13-Jan-2023 to 13-January-2024, allowing for a comprehensive assessment of post-surgical outcomes and follow-up data for one year till December 2024.

A consecutive sampling method was employed to recruit eligible participants. The sample size was calculated using the formula for comparative studies :

$n = 2(Z\alpha/2 + Z\beta)2 \cdot p(1-p)/(p1-p2)$. Here $z \propto /2 = 1.96$ for a 95% confidence level and z β=0.84 for 80% power. Proportions (p1 and p2) of recurrence rates for BCS and MRM were extracted from previously published studies[13]. Assuming an expected difference of 10% and adjusting for potential attrition, the sample size was finalized at 93 patients. Eligible participants were women aged 30–70 years with histologically confirmed early-stage breast cancer (Stage I or II) who were suitable for either BCS or MRM based on clinical and radiological evaluations. Patients with metastatic or recurrent breast cancer, bilateral breast cancer, a history of breast surgery or radiotherapy, or contraindications to surgery or radiotherapy were excluded. Patients were divided into two groups randomly after explaining all the details of procedure and outcome of treatment and then informed consent was taken on the preformed Performa.

No experimental drugs or specialized apparatus were required. Standard surgical instruments and diagnostic tools available at DHQ teaching hospital were utilized. Surgery was performed by qualified surgeons with post fellowship experience of more than five years to minimize complications and best possible outcomes. Radiotherapy for patients undergoing BCS was administered using a cobalt-60 unit, commonly available in most oncology centers in Pakistan and this was done in diagnostic center Narowal (DCN) established in hospital by atomic energy commission. Patients received a total dose of 50 Gy in 25 fractions over five weeks. Patients of both groups were followed postoperatively on weekly basis for first month and then on monthly basis for next eleven months to see the complications by history and clinical examination of patients. Beside history of any mass in axilla, clinical examination of BCS patients, their ultrasound of axilla was also done on follow up to assess the lymph nodes and if positive then by axillary lymph node biopsy for twelve months to see any involvement by tumor.

SPSS software version 20 was used to conduct the statistical analysis. While categorical data like lymph node involvement and post-operative problems were displayed as frequencies

and percentages, continuous variables like age and tumor size were summarized as means and standard deviations. Continuous variables were compared between the BCS and MRM groups using independent sample t-tests. For categorical data, chi-square tests were utilized, and when the number of cells was less than five, Fisher's exact test was applied. Standard methods were used to manually perform Kaplan-Meier survival analysis, and survival curves were compared using the log-rank test. P-values below 0.05 were regarded as statistically significant.

RESULTS:

46 patients underwent a modified radical mastectomy (MRM) and 47 underwent breast-conserving surgery (BCS). The study involved 93 participants in all. The two groups' ages, tumor sizes, lymph node involvement, and molecular characteristics at first were somewhat similar. Whereas those in the MRM group had a mean age of 52.7 ± 7.9 years, the patients in the BCS group had 51.2 ± 8.3 years (p = 0.37). With 2.6 ± 0.5 cm, the tumors in the BCS group were roughly 2.4 ± 0.6 cm smaller than those in the MRM group; nonetheless, this difference was not statistically significant (p = 0.09). P = 0.35; it was found in 32.6% of patients in the MRM group and 23.4% of patients in the BCS group. Based on the histology, both groups developed comparable kinds of breast cancer. The most of the patients turned out to be invasive ductal carcinoma (IDC). Table 1 presents the demographic and clinical details about the start participants of the trial. A total of 18.1% of patients (17/93) experienced post-operative complications. Figure 1 shows the post-operative complications for both surgical groups. The complications included wound infections, seroma, hematomas, and delayed wound healing. There was no flap necrosis or nerve injury in any patient so that were not assessed. Among the 17 patients who experienced complications, 7 (14.9%) were from the BCS group, and 10 (21.7%) were from the MRM group. Wound infection was more common in the MRM group (6.5%) compared to the BCS group (4.3%), though this difference was not statistically significant (p = 0.41).

Table 1: Baseline Demographic and Clinical Characteristics

Characteristic	BCS (n=47)	MRM (n = 46)	p-value
Age (years)			
Mean ± SD	51.2 ± 8.3	52.7 ± 7.9	0.37
Age Range	32–67	33–68	
Tumor Size (cm)			
Mean ± SD	2.4 ± 0.6	2.6 ± 0.5	0.09
Tumor Size Range	1.2–3.8	1.1–3.9	
Lymph Node Involvement (%)			
Positive Nodes	11 (23.4%)	15 (32.6%)	0.35
Histological Type			
Invasive Ductal Carcinoma	43 (91.5%)	42 (91.3%)	0.58
Invasive Lobular Carcinoma	4 (8.5%)	4 (8.7%)	

In both groups, 26 patients (28.0%) had lymph node involvement. Table 1 displays the distribution of lymph node involvement. The BCS and MRM groups' lymph node positivity did not differ significantly. Although the MRM group had a slightly greater rate of lymph node involvement (32.6%) than the BCS group (23.4%), the difference was not statistically significant ($x^2 = 0.86$, p = 0.35).

The quality of life (QoL) scores were recorded at baseline and at 12 months post-surgery. Table 3 presents the QoL scores for both groups at baseline and at 12 months. The baseline QoL scores were similar between the two groups (BCS: 70.3 ± 8.5, MRM: 69.7 ± 9.1, p = 0.71). However, at 12 months, the QoL improved significantly in both groups. The BCS group showed a greater improvement (mean score of 82.4 ± 7.9) compared to the MRM group (mean score of 78.9 ± 8.4), with the difference being statistically significant (p = 0.03). During the follow-up period, 7 patients (7.5%) experienced a breast cancer recurrence. The recurrence rates by surgery group are summarized in Figure 2. The emergence of fresh tumor growth in the same breast or nearby lymph nodes was referred to as recurrence. Overall, recurrences occurred in 5 patients (10.9%) in the MRM group and 2 individuals (4.3%) in the BCS group. Despite having a decreased recurrence rate, the BCS group did not experience a statistically significant difference (p = 0.26, Fisher's exact test). Kaplan-Meier survival analysis was conducted to compare recurrence-free survival between the two groups. The median follow-up time was 11.3 months (range: 10–12 months). The recurrence-free survival rates at 12 months were 95.7% for the BCS group and 89.1% for the MRM group. The log-rank test indicated no significant difference in recurrence-free survival between the two groups ($x^2 = 1.20$, p = 0.27).

The statistical analysis showed no significant differences in age (t = 0.90, p = 0.37) and tumor size (t = 1.70, p = 0.09) between the two groups. However, quality of life (QoL) at 12 months was significantly better in the BCS group (t = 2.20, p = 0.03). Post-operative complications were similar in both groups (p = 0.41), and lymph node involvement also showed no significant difference ($x^2 = 0.86$, p = 0.35). Recurrence rates (p = 0.26) and recurrence-free survival ($x^2 = 1.20$, p = 0.27) were comparable between BCS and MRM, indicating similar long-term outcomes for both surgical approaches.

Figure 1: Post-Operative Complications by Surgical Group

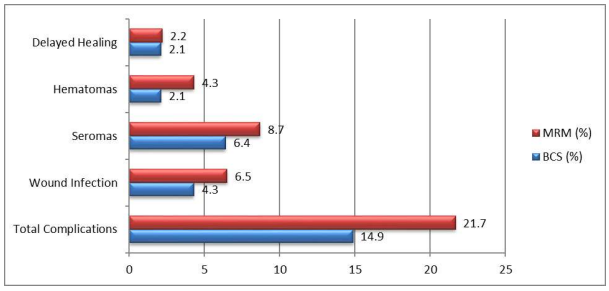
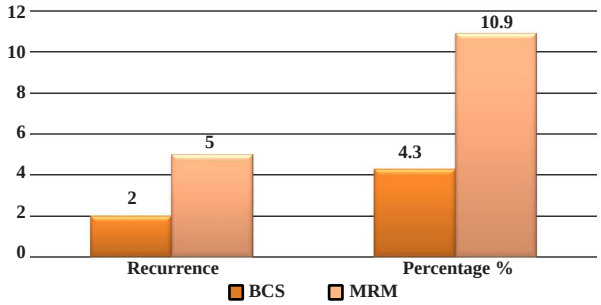


Table 2: Quality of Life (QoL) Scores

Surgical Group	Baseline QoL Score	12-Month QoL Score	p-value
BCS	70.3 ± 8.5	82.4 ± 7.9	0.03
MRM	69.7 ± 9.1	78.9 ± 8.4	

Figure 2: Recurrence Rates by Surgical Group



DISCUSSION

The study sought to evaluate, clinically and in terms of quality-of- life, the outcomes of MRM and BCS. According to the findings, BCS and MRM are connected to rather similar rates of recurrence and difficulties following surgery. At twelve months following surgery, BCS patients did, however, have greater quality of life. Although both surgeries are effective in treating breast cancer, BCS is a suitable option for many since it may enable patients recuperate and feel better psychologically following surgery.

With regard to age, tumor size, and histological characteristics, our investigation revealed no appreciable variations between the BCS and MRM groups. This is consistent with findings of other investigations.[13] usually depending on the sort of tumor they have and their desired outcome, both medications are prescribed to patients not in consideration of their age or other demographic background. The BCS group had a somewhat smaller average tumor size; however this difference was not statistically significant according to our findings. This result aligns with past studies indicating, depending on factors including tumor location and patient general health, both BCS and MRM can be employed for tumors of various diameters.[14] As long as the margins are clear, BCS has been demonstrated to be safe and helpful for tumors up to 5 cm in size.

The incidence of lymph node involvement in both groups in our study was similar to other studies, which have shown that lymph node positivity does not significantly influence the choice between BCS and MRM.[15] Although lymph node involvement is an important factor for staging and treatment decisions, both procedures have been found to offer comparable outcomes in patients with positive lymph nodes when adjuvant therapies such as chemotherapy are used. The incidence of post-operative complications in our study was 18.1%, with a slightly higher rate in the MRM group. This is consistent with existing studies that report a higher rate of complications in MRM patients, primarily due to the more extensive nature of the surgery, which may involve longer recovery times, greater risk of wound infection, and a higher likelihood of post-operative pain.[16] On the other hand, BCS, being a less invasive surgery, typically results in fewer complications and faster recovery. Although both procedures involve some risk of complications, the lower complication rates in the BCS group are consistent with literature that advocates for BCS in suitable candidates due to its lower risk of morbidity.[17]

Quality-of-life assessments revealed that BCS patients experienced a significantly greater improvement in their QoL scores at 12 months, compared to those who underwent MRM. This finding is in agreement with studies that have emphasized the psychological and emotional benefits of breast conservation, particularly in terms of body image, self-esteem, and overall satisfaction with the surgical outcome.[18] Patients undergoing MRM often experience a more significant emotional and psychological impact due to the loss of the entire breast, which can lead to increased anxiety and depression. In contrast, BCS allows for the preservation of the breast, leading to improved body image and a less traumatic recovery period.

The recurrence rates in our study were 4.3% in the BCS group and 10.9% in the MRM group. While these findings did not reach statistical significance, they align with the broader body of research that suggests recurrence rates in breast cancer are similar for both BCS and MRM, provided that proper adjuvant therapy is used.[19] It has been shown that recurrence rates between the two procedures are not significantly different, as long as the surgical margins are clear and follow-up care is adequately provided. It is important to note that both treatments are effective in preventing recurrence in patients with early-stage breast cancer.

Regarding the number of years of recurrence-free survival, our study similarly revealed no appreciable variation between the two groups. This is consistent with recent research revealing comparable survival rates between BCS and MRM.[20] Combined with other therapies, these surgeries have roughly the same survival rate. Usually, more crucial than the patient's chance of life are the location of the tumor, their preferences, and the surgeon's capacity to obtain clean surgical margins.

Ultimately, our research supports the theory that, given no significant variations in the rates of recurrence or problems following surgery, BCS and MRM are reasonable surgical options for treating breast cancer. Regarding quality of life, BCS does, however, have a clear advantage. After getting it, patients claim their mental health and physical condition improve. These findings highlight the need of considering both physical and psychological factors in selecting the most

appropriate surgical approach for breast cancer sufferers. To validate these findings and provide additional knowledge regarding the long-term performance of both treatments, future studies including larger groups of people and longer follow-up timeframes is required.[21]

Limitations and Future Suggestions: This study has several limitations should be considered. With only 93 instances, the sample size is somewhat small, thus the findings might not be relevant to a larger population. If the sample size was larger, the variations between BCS and MRM would be more easily apparent. Furthermore, the 12-month follow-up period might not be sufficient to completely investigate rates of long-term survival and recurrence. Future research should employ longer follow-up times to observe long-term effectiveness of both approaches. Furthermore, even if our study concentrated on clinical outcomes, other elements such as genetic profiles, patient preferences, and socioeconomic background could also be quite crucial in determining the optimal operation. Future research should examine these aspects so that we may better understand the decisions taken in breast cancer treatment.

CONCLUSION

With nearly the same rates of recurrence and complications following surgery, this study reveals that both modified radical mastectomy and breast-conserving surgery are good approaches to treat breast cancer surgically. Regarding quality of life, however, BCS clearly benefits mainly in terms of body image and mental health. These findings highlight the need of considering clinical outcomes as well as patient perspectives in deciding on the optimum surgical technique. More study with larger sample counts and longer follow-up times will help us to ascertain the long-term impacts and advantages of both operations.

Authors Contribution:
Muhammad Zafar Mengal: Article Writing
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Muhammad Muneeb Saqlain Bajwa: Reference Writing
Rehan Hameed: Data Analysis
Zain Mukhtar Chaudhary: Study Review
Zafar Ali Chaudhary: Proof Reading

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Original Article **Open Access**

Fetomaternal Outcome and its Associated Factors in Patients with Decreased Fetal Movements

Maimoona Qadir

ABSTRACT

Objective: To determine the fetomaternal outcome of antenatal patients with reduced fetal movements and its association with different maternal parameters.

Study Design And Setting: Prospective case control study Gynae Department of Khyber Teaching Hospital, Peshawar.

Methodology: This study was conducted from 1st February 2022 to 31st July 2022.80 antenatal women at >34 weeks, reporting less fetal movements were included. Exclusion criteria was multiple pregnancies, refused consent, IUFD, congenital malformations, and <34 weeks gestation. Sampling technique was consecutive non probability sampling. After detailed history and examination, 20-minute non-stress test, Color Doppler and Ultrasonography (AFI)was assessed and recorded. NICU admission, perinatal morbidity, meconium stained liquor and APGAR score < 7 were recorded. Control group of 80 pregnant women, not reporting any reduction in fetal movements, at similar gestation, delivering within 48 hours of admission, was constituted. Descriptive statistics and Chi-square test were applied.

Results: 58 (73%) patients were 21-30 years old.63 (79%) were primiparous.57 (72%) were at term pregnancy. AFI was < 5 cm in 19(23.7%),15 had spontaneous labor, whereas 56 (67%) were induced. 54 (67%) had NVD, 9 (11.5%)instrumental delivery, and 17 (20%) Caesaraen section.16 (20%) with an AFI < 5 cm had NVD. Mean birth weight was 2.67+0.46 kg.68 had > 7 and 12 had < 7 APGAR, no perinatal mortality among the 14(20%) newborns admitted to NICU.

Conclusion: Reduced fetal movenets are reliable method of assessing fetal well being. Primigravidae and term pregnancy are risk factors for RFM. Modalities like non-stress testing, ultrasound, and color Doppler studies are useful in diagnosis.

Key Words: Colour Doppler, Gestational age, Meconium Stained Liquor, Neontatal Intensive Care, Nonstress test, Perinatal Morbidity.

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INTRODUCTION:

Visits to the prenatal clinic or delivery room are frequently prompted by mother's concerns about their sense of diminished fetal movements. Reduced or ceased fetal movements have been linked to higher risks of major perinatal morbidity and death as well as a poor pregnancy outcome, according to several studies.[1] Pregnant women have traditionally been advised to count fetal movements as a screening method for compromised placental function.[2]

The theory is that a fetus will lessen its gross movements in response to decreased uteroplacental blood supply and fetal hypoxia. Reduced fetal movement has been linked to a variety of unfavorable pregnancy outcomes, such as fetal growth limitation and mortality, as well as placental diseases.[3]. Adverse consequences may be avoided if reduced fetal movements is identified early and treated effectively. Fetal movement counting by mothers is a simple, affordable, and effective screening method for fetal health that strengthens the link between mother and fetus. One potentially significant symptom that may precede stillbirth is a rapid shift in the fetal movements or a reduction in them (RCOG, 2011). Although there are several ways to measure reduced fetal movements, daily fetal movement counts are a dependable and efficient way to measure fetal health.[4] Any woman presenting with reduced fetal movements who has an abnormal cardiotocography, a prolonged maternal impression of reduced fetal movements, or if there is suspected intrauterine growth restriction should have an ultrasound examination and color Doppler study conducted.[5]

One straightforward indicator of foetal health is movement. Acute or chronic placental malfunction linked to foetal hypoxia causes the peripheral chemoreflex to be activated, cardiac output to be centralised to important organs, and foetal movements to decrease, which limits oxygen and energy consumption.[6] The usefulness of DFM in predicting poor obstetric and perinatal outcomes is debatable, as the majority of women who report DFM in the third trimester have favourable outcomes, despite the fact that DFM is linked to infants born SGA, stillbirth, higher rates of induction of labour , emergency caesarean delivery, and adverse neonatal outcomes.[7]

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Up to 15% of pregnancies result in a presentation at antenatal clinics due to concerns about reduced foetal movements; this presentation is linked to later negative pregnancy outcomes, such as stillbirth and foetal growth restriction. [8]Several investigations have shown connections between DFM and placental disease, and case control studies have shown a correlation between DFM and stillbirth after 28 weeks of gestation. These associations support a causal relationship between DFM and adverse outcome. [9]

There is no widely accepted definition of foetal movements, and the way mothers perceive them is also very subjective. Nowadays, a lot of international guidelines highlight DFM as a significant warning sign linked to the fetus's risk of stillbirth, and they advise women to keep an eye on their baby's movements and notify their doctors if they do.[10]However, the evidence supporting the incorporation of DFM into national guidelines and as part of a broader stillbirth reduction strategy remains limited. In order to reduce perinatal mortality by alerting health providers, counting fetal movements is a straightforward method that can be used to determine foetal well-being through the quantification and qualification of the number and type of movements that a woman perceives. [11]However, this method can also increase maternal anxiety or lead to unnecessary interventions, such as induction of labour or caesarean section, which also increases antenatal hospitalizations and prematurity. In addition to the quantitative method, the qualitative one includes an increased strength and number of movements in the semi-sitting position of women, or during the evening, after walking or in response to noise and palpation of the abdomen.[12]

The rationale of this study was to ascertain the relationship between reducing daily counts of fetal movements, nonstress test, ultrasound, Color Doppler, and the outcomes for the mother and the fetus. Different modalities like AFI on ultrasound. Color Doppler, nonstress test gives a clear indication of fetal condition in case of reduced fetal movements and has effect of timing and mode of delivery. This study will give a deep insight to the young doctors how to evaluate antenatal women who present with decreased fetal movements.

METHODOLOGY:

This prospective case control study was conducted in Gynae Department of Khyber Teaching Hospital, Peshawar from 1st February 2022 to 31st July 2022 and a total of 80 antenatal women who met the requirements for admission were selected. We included pregnant women who gave consent and who were over 34 weeks gestation and who reported having less fetal movements during a singleton pregnancy. Exclusion criteria included multiple pregnancies, patients who refused to provide permission, those with diagnosed intrauterine fetal death or congenital malformations, and pregnancies lasting less than 34 weeks gestation Sampling technique was consecutive non probability sampling. Expected prevalence of antenatal women with reduced fetal movements is 13.5%, estimated from results in previous studies in our population. Detectable changes were estimated to be a 10% increase of identification of these high risk pregnancies, which gave an estimated sample of 80 in each arm of the trial with 80% power and a significance level of 0.05. Informed consent was taken from all women who were included in the study. A control group consisted of 80 pregnant women who did not report any reduction in fetal movements, and who were matched in terms of age, parity, and delivery within 48 hours of admission, was included in our study. The institutional ethical committee approved the study (38/ERC/KTH)

A comprehensive record was made, documenting several prenatal risk factors such as gestational diabetes mellitus, hypertension, obstetric cholestasis, anemia, and history of smoking, alcohol use, and sedative intake. Additionally, information on the duration of decreased fetal movements, as well as the specific pattern of reduced movement in terms of frequency and intensity, was noted. Comprehensive physical and obstetrical evaluations were conducted. Women who reported a reduction in fetal movements were instructed to record the fetal movement for the following two hours while resting in a left lateral decubitus position. Cardiotocography was conducted for a minimum of 20 minutes within a 2-hour timeframe, and the findings were analyzed based on the criteria provided by the National Institute for Health and Care Excellence. Women who exhibited nonreassuring cardiotocography results were promptly delivered. Additional individuals had investigations for a comprehensive blood count, oral glucose tolerance test, liver function test, thyroid stimulating hormone analysis, and regular urine assessment. An extensive ultrasonography with Doppler examination is performed to document the amniotic fluid index, position and quality of the placenta, assess the precise gestational age and estimated fetal weight, evaluate the biophysical profile, and measure the umbilical artery systolic to diastolic ratio. If all indicators were within acceptable ranges and the maternal record of fetal movements for a duration of 2 hours was 10 fetal movements, the women were discharged and follow-up was conducted during delivery. The study investigated the method of delivery and its impact on newborn outcomes, including birth weight, Apgar scores, and the need for admission to the neonatal intensive care unit.

The following parameters were used to evaluate the pregnancy's outcome: Neonatal intensive care unit hospitalization, perinatal morbidity, and liquor stained with meconium with an APGAR score less than 7. The data were analyzed using SPSS 22.0. Demographic and clinical characteristics were summarized by the mean+ SD for continuous variables and as frequency counts (percentages) for categorical variables. Effect size was analyzed using chi square.

RESULTS:

The research involved the recruitment of 80 antenatal women between February 2022 and July 2022. 11 (12%) belonged to the less than 20 years age group.58 (73%) of the total patients were 21-30 years old.17(21%)were multiparous, and 63 (79%) were primiparous. 23(28%) were between 34 and 37 weeks of gestation, while 57 (72%) had more than 37 weeks period of gestation.

Out of the total patients, 23(27.81%) complained of reduced fetal activity within 12 hours, and 59 (71.5%) had a reactive non-stress test. Amniotic Fluid Index was less than 5 cm in 19(23.7%) of the patients. A normal color Doppler examination was obtained for each subject. 15 were permitted to proceed into spontaneous labor, whereas 56 (67%) were induced owing to oligohydramnios. Weekly non-stress tests were performed on ten individuals who had premature labor and sufficient amniotic fluid. 54 (67%) were vaginally delivered, 9 (11.5%) had instrumental delivery, and 17 (20%) had Cesarean section.16 (20%) patients with an Amniotic Fluid Index of less than 5 cm had vaginal births. 10 (12.5%) of the remaining 63 patients with normal Amniotic Fluid Index had Caesarean section, and 54 (67.5%) had vaginal births.

Mean birth weight was 2.67+0.46kg whereas.10 newborns are between 1.5 and 2.5 kg in weight, whereas 70 babies weigh more than 2.5 kg. In terms of APGAR scores, at the time of delivery, 68 had more than 7 and 12 had less than 7. There were no perinatal or intrapartum deaths among the 14(20%) newborns admitted to the NICU. Every infant was discharged.

DISCUSSION:

One of the crucial markers of fetal health is reduced fetal movements. When a patient exhibits diminished fetal activity, prompt intervention can identify a fetus in danger and preserve its life. The majority of the patients in our research were in the 21–30 years age range. The results of this investigation were supported by those of Damhuis SE et al. (57.26%),and Housseine N et al. (62.86%).[12,13] The majority of patients in this research (87.95%) were primiparous, with gestations between 38 and 40 weeks. In studies by Radestad I et al., 46.67% of patients reported reduced fetal movements at full term gestation,and in Akselsson A et al., 46.07%.[14,15]

In the current investigation, the nonstress test was non-reactive in 23 (27.71%) patients and reactive in 60 (72.29%) cases. Reactive nonstress test was found in 78.2% of cases in studies by Nama N et al. and 84.29% of cases by Monari

Table 1: Features Of Cases and Controls (N=160**)**

Characteristic	Study Group (n=80)		Control Group (n=80)		P-Value
	Frequency	Percentage	Frequency	Percentage	
AGE					**0.902**
Less than 20 years	11	12%	6	8%	
21-30 years	58	73%	66	82%	
>30 years	11	15%	8	10%	
Gravidity					**0.005**
Primigravida	63	79%	51	64%	
Multigravida	17	21%	29	36%	
Residence					**0.161**
Urban	28	33%	13	14%	
Rural	52	67%	67	86%	
Period Of Gestation					**0.003**
34-37 weeks	23	28%	26	67%	
>37 weeks	57	72%	54	33%	

Table 2: Distribution of Cases and Controls According to Perinatal Outcome (N=80)

Characteristic	Study Group		Control Group	
	Frequency	Percentage	Frequency	Percentage
Normal BPP	66	82.5%	75	93.75%
Low Birth Weight	14	17.5%	7	8.75%
NICU Admission	7	8.75%	3	3.75%
APGAR score >7	68	85%	72	90%
<7	12	15%	8	10%
Mortality	0		0	

F et al. These numbers are similar to the 72.56% of patients in our research that had reactive nonstress test.[16,17] Twenty instances (24.10%) had an amniotic fluid index of less than 5 cm, whereas 63 patients (74.9%) had an index of greater than 5 cm. AFI<5 cm was found in 13.9% of cases in other studies by Bradford BF et al., [18] To rule out prenatal growth limitation, all patients who had lower fetal movements were also assessed for liquor volume. color Doppler studies were performed. Color Doppler study points to normal circulation in the uterus and placenta.

80.73% of the births in our research were vaginal, Thompson JMD et al. had the greatest percentage of vaginal deliveries i.e., 84%[17] Bashir S, on the other hand, had 67.4% vaginal births. [18] which is comparable to the results of studies by Habib F et al.[19] Studies by Turner JM et al. and Winje et al. reported caesrean section rates of 32.6% and 24.1%, respectively.[20,21]The LSCS rate in this research was 19.27%, in line with the findings of Bekiou A et al. [22] Of all the infants in the current research, 73.49% were healthy, maintained at room temperature, and encouraged to breastfeed at an early age. Meconium aspiration syndrome, birth asphyxia, respiratory distress syndrome, and other conditions account for 26.5% of newborns admitted to the NICU. 8.9% of births were premature. At delivery, 18.08% of babies had an APGAR score of less than 7. 50% of infants born to Camacho EM et al. had an APGAR score of greater than 7, compared to 73.49% in the current research.[23] Similar to the findings of Bashir S et al., where 18% of infants had an APGAR score of less than seven at birth and 18% were admitted to the NICU, the current study found that 18.08% of babies had an APGAR score of less than seven at delivery and 26.5% of babies were hospitalized.[18] Our study's 8.9% preterm birth rate was similar to those of studies by Damhuis SE et al. and Housseine N et al., which found preterm birth rates of 9% and 4.4%, respectively.[11,12] There were no stillbirths in our research or the study by Bekiou A et al,[23] but stillbirth rates were 0.2% by Turner et al, 1% by Camacho et al, and 1.4% by Monari F et al.[21,22,24]

Research is underway to develop wearable devices that can monitor fetal movements. These devices may use piezoelectric diaphragms or optical fibers to detect movement. The use of piezoelectric diaphragms to detect fetal movements is still in the early stages of research and development. Optical fibers have shown promise in detecting fetal movements with high sensitivity to motion artifacts, but further research is needed to validate their accuracy.

There were few limitations in this study. More multicentric research with bigger samples are needed to develop a definite approach. We were unable to find a patient's incidence of reduced fetal movements in our setup. The neonates born to those mothers by any mode of delivery who complained of reduced fetal movements, were only followed till their stay in hospital. Given that most of the patients were beyond 38 weeks gestational age and that just a single daily fetal movement count, nonstress test, and ultrasound were conducted in these few cases, it was challenging to determine whether fetal kick count monitoring would be successful in continuing the pregnancy or ending it.

CONCLUSION:

One common prenatal manifestation that is linked to worse perinatal outcomes is decreased fetal movements. Fetal movement counts on a daily basis are a very reliable, affordable, and practical way to identify fetal impairment. Techniques like non-stress testing, ultrasound, and color Doppler studies are useful in diagnosing at-risk fetuses and ensuring prompt delivery. They also aid in determining the causes of decreasing fetal movements in patients and in managing them..Our study also concluded that primigravidas and term pregnancies are also risk factors for reduced fetal movements. The daily count of fetal movements appeared to enhance the capability of mothers to identify significant alterations in fetal activity. Improved perinatal outcomes and early detection of at-risk fetuses have been achieved without increasing the need for obstetric procedures. Significant women with aberrant biophysical profiles have favorable perinatal outcomes as a result of their early hospital admission and prompt management.

Authors Contribution:
Maimoona Qadir: Data collection, analysis, compiling

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Original Article **Open Access**

Cardiopulmonary Bypass and its Impact on Post-Operative Renal Function in Patients Undergoing Adult Cardiac Surgery

Abdul Nasir, Adnan Shah, Attiya Hameed Khan, Syed Shahkar Ahmed Shah

ABSTRACT

Objective: This study aims to investigate the impact of cardiopulmonary bypass (CPB) on post-operative renal function in patients undergoing adult cardiac surgery. Specifically, it seeks to assess the incidence of acute kidney injury (AKI) and renal dysfunction in relation to the duration of CPB and other perioperative factors.

Study design and setting: It was a retrospective observational cross-sectional study and conducted at department of adult cardiac surgery in Peshawar Institute of Cardiology.

Methodology: A retrospective observational study was conducted, including adult patients who underwent cardiac surgery with CPB from 1-June-2024 to 1-December-2024. Patient data were collected from electronic medical records, including demographic information, comorbidities, intraoperative variables (e.g., CPB time, temperature management), and post-operative renal function markers (serum creatinine, urine output).

Results: A total of 150 patients were included in the study. The incidence of AKI was found to be significantly higher in patients with hypertension, elevated pre-op urea and creatine and prolonged Cross clamp times ($p < 0.05$), particularly those with CPB durations exceeding 120 minutes. Other factors such as pre-existing renal comorbidities, intraoperative blood loss, and use of nephrotoxic drugs also contributed to an increased risk of post-operative renal dysfunction.

Conclusion: In conclusion, the results of this study support the notion that CPB and cardiac surgery can lead to renal dysfunction, as evidenced by the significant rise in creatinine and urea levels. However, the lack of significant change in urine volume and the improvement in cardiac function as reflected by LVEF suggest that patient management strategies, including appropriate fluid balance and renal monitoring, may mitigate some of the renal complications.

Key words: Bypass Time, Cardiopulmonary Bypass, Cross Clamp Time, Creatinine, Ejection fraction, Renal Function.

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INTRODUCTION:

Cardiopulmonary bypass (CPB) is a critical component of many adult cardiac surgeries, including coronary artery bypass grafting (CABG), valve repair or replacement, and heart transplantation.[1] During CPB, a machine takes over the function of the heart and lungs, maintaining circulation and oxygenation while the surgeon performs the necessary cardiac procedures.[2] However, despite its life-saving benefits, the use of CPB is associated with a range of potential complications, one of the most concerning being its impact on post-operative renal function.

Renal dysfunction after cardiac surgery is a significant and well-documented problem, affecting a substantial proportion of patients undergoing CPB .[3] The pathophysiology of CPB-associated kidney injury remains complex, involving mechanisms such as hemodynamic instability, systemic inflammatory response, microcirculatory disturbances, and direct effects of the bypass itself. [4] It has been observed that the incidence of acute kidney injury (AKI) increases following CPB, and AKI in the post-operative period is linked to worse outcomes, including prolonged hospital stays, increased risk of long-term renal impairment, and higher mortality rates.[5] Moreover, even mild forms of renal dysfunction after cardiac surgery can have a significant impact on long-term quality of life and recovery.[6]

Chronic kidney disease (CKD) has emerged as a significant global public health challenge. In Pakistan, there are currently

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only about 80 trained nephrologists serving a population of approximately 160 million,[7] while the United States has over 5,000 nephrologists for a population of around 300 million.[8] Due to limitations in public health services, general practitioners (GPs) continue to serve as the primary caregivers for CKD patients in Pakistan. This issue is further exacerbated in South Asian countries such as India, Pakistan, Bangladesh, and Sri Lanka, [9] where social factors and common risk factors for CKD—such as hypertension and diabetes are widespread and often poorly managed. [9]

Several factors influence kidney function during cardiopulmonary bypass (CPB), including patient age, gender, CPB duration, perfusion pressures, and the presence of conditions like diabetes and hypertension. [10] Urine output during CPB and creatinine levels are also key indicators. CPB may adversely affect renal function due to non-pulsatile flow, insufficient renal perfusion, and the presence of free plasma hemoglobin. [10] Non-pulsatile flow can cause vasoconstriction of the afferent glomerular arterioles, leading to reduced perfusion. [10]

Preoperative kidney dysfunction, as indicated by a low estimated glomerular filtration rate (eGFR), is a major predisposing factor for kidney complications during CPB.[11] It is crucial to monitor urine output periodically during bypass to assess renal perfusion, with an adequate output considered to be 0.5 to 1.0 ml/kg/hr (or about 1 ml per minute for an average adult).[11] Monitoring should begin after 15 minutes of bypass to ensure proper renal function.[10]

Several factors can impact renal function during CPB, including reduced cardiac output or hypotension, which can impair renal perfusion and decrease the glomerular filtration rate (GFR). [12] CPB triggers the release of substances like renin, angiotensin, catecholamines, and antidiuretic hormone, which contribute to renal vasoconstriction and diminished renal blood flow. [12] The duration of CPB also influences renal function, and preoperative kidney disease remains a significant risk factor for postoperative renal dysfunction. [13] According to the World Health Organization (WHO), in 2017, cardiovascular diseases were responsible for more than 31% of global deaths, claiming 17.9 million lives. [13]

While several factors contribute to post-operative renal dysfunction, including pre-existing renal conditions, perioperative fluid management, and the duration of CPB, the direct effects of CPB on kidney perfusion and function are particularly significant.[14] Various strategies to mitigate the renal risks associated with CPB, such as optimizing perfusion pressure, using renal protective pharmacological agents, and minimizing the duration of CPB, have been explored in clinical studies with mixed results. [15] Understanding the mechanisms by which CPB influences renal function is crucial in order to develop more effective preventative and therapeutic interventions for improving patient outcomes.[14]

This study explores the relationship between CPB and post-operative renal dysfunction, reviews current evidence on its mechanisms, and discusses potential strategies for mitigating renal injury in patients undergoing adult cardiac surgery.

METHODOLOGY:

This study was approved by the local institutional review board committee of Peshawar Institute of cardiology, approval number (IRC/25/152). This study employed a retrospective cross-sectional design to examine the impact of cardiopulmonary bypass (CPB) on post-operative renal function in adult patients undergoing cardiac surgery at the Peshawar Institute of Cardiology. The study was conducted over a period from 1-June-2024 to 1-December-2024., and the study population included adult patients who underwent cardiac surgeries requiring CPB. The inclusion criteria for the study were patients aged 18 years or older, with a pre-operative left ventricular ejection fraction (LVEF) of 40% or greater. Patients with pre-operative dialysis and those with an LVEF less than 40% were excluded from the analysis. Non-probability convenient sampling was used to select the sample for the study.

Data were collected from adult cardiac operating theatres (OT) at the Peshawar Institute of Cardiology, and post-operative data were gathered from the Intensive Treatment Care (ITC) unit using a pre-structured questionnaire. The data were securely stored in both soft and hard formats to ensure confidentiality. Descriptive data analysis was performed using the latest version of SPSS software. Frequency distribution and percentage calculations were used to summarize the patient data, and comparisons between groups were made using the T-test. Ethical approval for the study was sought from the institutional review board (IRB) of Peshawar Institute of Cardiology to ensure that the study adhered to ethical guidelines and protected patient confidentiality throughout the research process.

RESULTS:

Table 1 summarizes the demographic and clinical history of 150 patients, with 60% being male. Hypertension was present in 20% and diabetes in 27% of patients. Regarding coronary disease, 40% had triple vessel disease (TVCAD), 27% had double vessel disease (DVCAD), and 33% had single vessel disease (SVCAD). Table 2 presents descriptive statistics of patient data, showing a mean age of 49.7 years and average weight of 75.25 kg. Key clinical parameters include pre-op creatinine (0.902 mg/dL), post-op creatinine (1.064 mg/dL), and mean CPB time of 125.12 minutes. Ejection fraction averaged 51.55%, with slight increases in post-op renal markers. Table 3 compares pre- and post-operative measures in 150 patients, showing significant increases in creatinine ($p = 0.02$), urea ($p = 0.04$), and ejection fraction (EF) ($p = 0.01$). Urine volume showed a slight, non-significant increase ($p = 0.21$). These results suggest mild renal function changes and improved cardiac

Table 1: Demographic profile and the history of the patients (n=150)

Characteristics	Frequency (n)	Percentage (%)
Male	90	60
Female	60	40
History of HTN		
No	120	80
Yes	30	20
History of DM		
No	110	73
Yes	40	27
No. of diseased vessels		
TVCAD	60	40
DVCAD	40	27
SVCAD	50	33

Table 2: Shows descriptive statistics:

Variable	Mean	Std. Deviation
Age of the patients(years)	49.70	11.862
Height of the patients(cm)	165.79	16.024
Patient weight	75.250	21.5682
Pre-op creatinine	.902	.1938
Pre-op urea	34.22	9.421
EF	51.55	7.174
Mean arterial pressure	65.7293	4.52092
CPB time	125.12	43.450
Urine volume monitoring	911.50	517.368
Perfusion flow rate	4.2116	.38893
Cross clamp time	65.93	29.951
Post-op creatinine	1.064	.2439
Post –op urea	36.2128	11.08838

Table 3: Comparison of pre and post operative measures (n=150)

Characteristics	Pre- operative	Post operative	*p*-value
Creatinine	.902	1.054	0.02
Urea	34.22	36.21	0.04
Urine volume	890.42	911.50	0.21
EF	51.55	52.56	0.01

DISCUSSION:

The findings of this study emphasize the intricate and multifaceted relationship between cardiopulmonary bypass (CPB) and post-operative renal function in adult patients undergoing cardiac surgery. Cardiopulmonary bypass, a critical component of many cardiac surgeries, temporarily takes over the function of the heart and lungs during the procedure, allowing surgeons to operate on a still heart. [13] However, it is well established in clinical research that CPB, while essential, can have significant physiological effects on various organ systems, including the kidneys. The results of this study highlight the renal challenges that can arise after cardiac surgery, as evidenced by the statistically significant increase in both serum creatinine and urea levels post-operatively. Specifically, serum creatinine levels increased from 0.902 mg/dL to 1.054 mg/dL (p=0.02), and urea levels rose from 33.22 mg/dL to 36.21 mg/dL (p=0.04). These findings suggest that CPB-induced stress can impact renal function, which is particularly noteworthy given that creatinine and urea are key markers for assessing kidney health.

The observed increases in creatinine and urea post-surgery are consistent with a growing body of literature that identifies CPB as a factor in the development of transient renal dysfunction. [16] Acute kidney injury (AKI), which is commonly diagnosed when there is a noticeable increase in these biomarkers, is a well-documented complication following cardiac surgery involving CPB. [16] Elevated levels of creatinine and urea in the post-operative period are often indicative of kidney stress or even injury. While the changes in these renal markers in this study may suggest a decline in renal function, it is important to recognize that mild elevations in creatinine and urea are commonly seen in the immediate post-operative period. These mild elevations may resolve with appropriate post-surgical care and management, indicating that transient renal dysfunction might not always lead to long-term kidney damage. Several studies have found that renal biomarkers often return to baseline or close to baseline levels over time, especially with adequate monitoring and intervention. [17]

Table 4: Regression Analysis of Post-operative renal dysfunction with predictors.

	B	Wald	Sig.	Exp(B)	95% CI for EXP (B)	
					Lower	Upper
Age	0.001	0.002	0.951	1.001	0.953	1.04
Gender(male)	0.752	1.131	0.185	1.114	0.422	6.352
Hypertension	0.33	1.644	0.002	2.708	0.484	1.028
DM	0.306	0.362	0.382	1.403	0.358	3.714
Pre-op Urea	0.54	0.34	0.001	1.66	0.31	1.67
Pre-op creatinine	0.16	0.56	0.004	1.82	0.63	1.73
CPB time	0.001	0.62	0.282	1.001	0.874	1.028
Cross Clamp time	-0.027	4.222	0.010	1.851	0.821	0.883
Weight	-0.021	0.431	0.341	0.866	0.817	1.002

Our study also shows that **hypertension,** elevated pre-op **urea, creatinine,** as statistically significant predictors of post-operative renal dysfunction (p-values = 0.002, 0.001, 0.004, respectively). This underscores the importance of pre-existing renal function and hemodynamic stress during surgery in influencing post-operative outcomes. These results are consistent with prior studies that report elevated baseline renal markers and prolonged cross clamp duration as risk factors for AKI after cardiac surgery [19]. For instance, cross clamp time has been previously associated with ischemia-reperfusion injury and oxidative stress, both of which are known contributors to renal impairment post-CPB. This is an important observation, as urine output is a widely used clinical indicator of renal perfusion and function. In the context of CPB, where renal perfusion can be compromised due to non-pulsatile flow and other factors, a decrease in urine output is often seen as a strong predictor of AKI. [18] However, the lack of a significant difference in urine volume post-operatively in this study suggests that, despite the biochemical changes in serum creatinine and urea, renal perfusion may have been preserved to a certain extent. This could indicate that some patients were able to maintain adequate renal function in terms of urine output, even though there was evidence of transient renal stress reflected by elevated biomarkers. The preservation of urine output could also reflect the variability in how patients recover post-surgery, as kidney function can differ widely among individuals, particularly following major procedures such as those involving CPB. [19]

Cardiac surgery activates the sympathetic nervous system (SNS) and the hypothalamic-pituitary-adrenal (HPA) axis, leading to the release of neurohormonal agents like epinephrine and norepinephrine. This can also increase the production of vasopressin and endothelin-1.[19] Research has shown that plasma levels of epinephrine and norepinephrine peak during cardiopulmonary bypass (CPB) cardiac surgery.[20] High levels of these hormones can cause unstable hemodynamic conditions and systemic vasoconstriction, [20] which may reduce renal perfusion and ultimately result in kidney damage. Another common consequence of CPB is the release of free iron. [21] During CPB, red blood cells are exposed to artificial surfaces and air, which inevitably leads to some degree of hemolysis. The cold temperatures during the procedure further promote hemolysis and the release of free iron, which induces vasoconstriction by scavenging nitric oxide through free hemoglobin. [22] Free iron-induced toxicity may also contribute to acute kidney injury (AKI) in patients undergoing CPB surgery. Several novel renal biomarkers have been linked to iron metabolism, such as NGAL, L-FABP, á-1 microglobulin, and hepcidin isoforms.[23] The pathophysiological connection between these biomarkers appears to be free iron and reactive oxygen species (ROS)-mediated renal injury. Iron regulation plays a crucial role in the development of AKI following cardiac surgery and is associated with oxidative stress and ischemia-reperfusion injury (IRI). [22] Various strategies for preventing and treating AKI through iron regulation are currently being explored. [23] Hepcidin, an endogenous acute-phase liver hormone, helps regulate iron by preventing its export from cells by inducing the degradation of ferroportin, the only known iron export protein. [24] Restoration of iron balance through hepcidin significantly reduces ischemia-reperfusion-induced tubular injury, apoptosis, renal oxidative stress, and inflammatory cell infiltration. [24]

Furthermore, an important finding in this study is the improvement in left ventricular ejection fraction (LVEF) from 50.55% pre-operatively to 52.56% post-operatively (p=0.01). This improvement in LVEF suggests that the cardiac function of patients was positively impacted by the surgical procedure, likely contributing to an overall better prognosis and recovery. The increase in LVEF is a favorable outcome that is commonly associated with successful cardiac interventions, such as coronary artery bypass grafting (CABG) or valve replacement surgery. The positive change in LVEF observed in this study aligns with findings from previous research that demonstrates significant improvements in cardiac function following successful cardiac surgeries, which in turn can enhance the patient's long-term recovery and quality of life. [25]

Cardiac surgery is often performed to address underlying heart conditions such as coronary artery disease or valvular dysfunction, and successful correction of these issues leads to improved cardiac output and overall heart function. [22] The improvement in LVEF observed in this cohort of patients is a clear indication that the surgical interventions were effective in restoring the heart's pumping ability, which is critical for the patient's survival and recovery. Studies have consistently shown that improvements in LVEF after surgery are associated with a reduction in the risk of adverse outcomes such as heart failure and cardiovascular mortality. [24] Therefore, the positive change in LVEF observed in this study is an encouraging sign that the patients benefited from the surgery, with the potential for better long-term cardiac health.

In summary, while this study reveals some concerning trends in post-operative renal function, such as increases in creatinine and urea levels, the findings also suggest that urine output may not always correlate with these biochemical markers, indicating that renal perfusion could have been adequately maintained in some cases. Additionally, the improvement in LVEF post-operatively underscores the overall success of the cardiac procedures in enhancing heart function. Taken together, these results highlight the complex interplay between renal and cardiac function in the context of CPB and emphasize the importance of carefully monitoring both parameters in the post-operative period. The study reinforces the need for ongoing research into the mechanisms underlying renal dysfunction following CPB and suggests that individualized patient care strategies may be necessary to

optimize both cardiac and renal outcomes after surgery. As CPB continues to be a cornerstone of many cardiac procedures, understanding its effects on multiple organ systems remains crucial to improving patient care and long-term health outcomes.

CONCLUSION:

In conclusion, the results of this study support the notion that CPB and cardiac surgery can lead to renal dysfunction, as evidenced by the significant rise in creatinine and urea levels. However, the lack of significant change in urine volume and the improvement in cardiac function as reflected by LVEF suggest that patient management strategies, including appropriate fluid balance and renal monitoring, may mitigate some of the renal complications. Future studies with larger sample sizes and longer follow-up periods are necessary to better understand the long-term renal outcomes and to refine strategies for preventing and managing renal dysfunction in this patient population.

Authors Contribution:
Adnan Shah: Write-up and Review
Abdul Nasir: Conceptualize study
Attiya Hameed Khan: Data collection
Syed Shahkar Ahmed Shah: Write-up and Review

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Original Article **Open Access**

Evaluation of the Physicomechanical and Antibacterial Properties of *Glycyrrhiza Glabra a*nd *Piper Nigrum* Modified Glass Ionomer Cement

Raffat Aziz, Shaukat Khalid, Muhammad Khawaja Hammad Uddin, Mah Zul Kaif, Affan Ahmad

ABSTRACT

Objective: To investigate the relationship between concentration of *Glycyrrhiza glabra* (GG) and *Piper nigrum* (PN) on the inhibition zone of *S. mutan, Lactobacili* and *E.coli* and their effect on the physicomechanical properties of conventional Glass Ionomer Cement (GIC).

Study Design and Setting: This experimental study tested the antibacterial activity and microhardness of modified-GIC at Baqai Medical University and NED University Karachi, Pakistan.

Methodology: The herbs were added to GIC in 4-16% concentration separately and in combination. Sample characterization was done by Fourier Transform Infrared Spectroscopy (FTIR) in 4000-700 cm^{-1} range. The antibacterial efficacy was tested in-vitro using disc diffusion method on brain heart infusion (BHI) agar plates. Microhardness was tested by Vickers microhardness tester. The pH was measured using digital pH meter and the data was analyzed using Anova test on SPSS software to compare the inhibition zones and a Post-hoc Tukey's test was conducted.

Results: An increase was observed in the inhibitory zone of group 2 (GIC + GG), group 3 (GIC + PN) and group 4 (GIC+GG+PN) as compared to that of conventional GIC (control group) and the increase was more pronounced for GG as compared to PN. The modified groups showed increase in pH at all intervals. Microhardness of modified groups was equal to control group indicating that the addition of herbs into conventional GIC did not impact its physicomechanical properties.

Conclusions: The tests revealed improved antibacterial activity of herb-modified GIC without significant changes in the physicomechanical properties.

Keywords: Antibacterial, Glass Ionomer cement, *Glycyrrhiza glabra*, Microhardness, Physicomechanical, *Piper nigrum*.

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INTRODUCTION

Dental caries affects around 75% of the world population according to WHO. A large population of school-going children (60-90%) and most adults are affected by it. It is a complex oral disease with multi-factorial etiology which includes bacteria, diet, oral hygiene habits, immunity of host and disruption in oral micro-ecological equilibrium of tooth plaque. Although a number of oral *Streptococci* strains have the ability to produce tooth plaque biofilms and cause degradation, S*treptococcus mutans (S. mutans)* plays a key role in the initiation of caries process.[1]

Various restorative materials and anti-caries agents have been developed for the treatment of this disease. Acid-producing bacteria cause demineralization of tooth structure at the restoration-tooth interface leading to secondary caries and hence failure of restoration which is why materials which stop surface colonization and bacterial development are preferred for use in restorative applications. About 50% of restorations fail within 10 years primarily due to the development of secondary caries. Therefore, good bactericidal characteristics are essential for restorative materials. This leads to the search of materials with improved bactericidal

properties.[2]

Glass ionomer cement (GIC) also known as "glass polyalkenoate cement", is an acid-base cement which have gained popularity due to its ability to bond to tooth structure chemically and fluoride leaching properties.[3, 4] This ability of GIC to release fluoride and its low pH prior to hardening may be the cause of the antibacterial activity of GIC powder. GIC have become the most popular water-based cements in recent years for its use in procedures such as fissure and sealant restorations, cementation of dental crown and bridges, placement of orthodontic brackets, etc. Although GIC leaches 10 ppm of fluoride in the first 48 hours after application, this is still considered minimal for obtaining the necessary bactericidal effects and research shows that bacteria remain viable under GIC restorations for up to two years.[5, 6] By including more antimicrobial agents into GIC, therapeutic advantages maybe achieved. Incorporating antibacterial compounds into restorative materials unfortunately frequently leads to changes in the material's mechanical and physical properties over time.

Various plants and herbs are known to have the ability to combat cariogenic and periodontal disease causing bacteria without leading to development of any bacterial resistance. Studies have been able to demonstrate the effectiveness of several of these plants and to better understand their mechanisms of action with the use of scientific approaches and advanced methods. Despite the fact that some of them, like in mouthwash or toothpaste, have showed efficacy against cariogenic salivary flora, there is not enough information present in the literature for the addition of natural antibacterial agents to GIC.

Two herbs used in this study are *Glycyrrhiza glabra (GG)* and *Piper nigrum (PN).* GG is a sweet herb produced from the root of *liquorice* generally considered as safe herbal medication. Titerpene glycoside glycyrrhizin, primary active component of this herb, has anti-ulcer, anticancer, antidiabetic, anti-inflammatory and antibacterial properties.[7, 8]

PN is commonly known as white pepper. It can be used to treat rheumatism, muscle discomfort, colds, flu, and fever. It is applied locally to treat some skin conditions and soothe throat inflammation externally. Its antibacterial and anti-mutagenic properties have been evaluated. It slows down bacterial growth rate and alkaloid compounds in its extract can damage bacterial DNA and inhibit the production of bacterial cell walls.[9, 10]

Although these two powerful herbs have therapeutic and antibacterial properties, no literature exists on the use of these in conventional GIC restorative material and their effect on *S. mutans, E.coli* and Lactobacili. These microbes were selected due to their role in caries activity. Therefore this study aims to investigate the relationship between concentration of both herbs on the growth inhibition zone of *S. mutan, Lactobacili* and *E.coli* and their effect on the physical and mechanical properties of conventional GIC by incorporating GG and PN separately as well as in combination into the conventional GIC powder in 4%, 8%, 12% and 16% concentrations. The hypothesis of the present study is that there is significant difference in the antibacterial properties of Conventional GIC and modified GIC.

METHODOLOGY

This experimental research study was conducted at Baqai Medical University from July 2022 - December 2023. After approval of project (ERC No. BMU-EC/01-2023) from institutional Ethics Review Committee, the herbs (GG and PN) were bought from the local market of Karachi and identified from PCSIR voucher number FMRC/Herb./0180/23and FMRC/Herb./0181/23. The GIC was purchased from the dental store of Baqai Dental College (BDC), Baqai Medical University. The herbs were powdered manually by grinding in mortar and pestle for 10 minutes. The powdered herbs were added w/w into the powder of conventional GIC in 4%, 8%, 12% and 16 % concentration separately as well as in combination. Weighing balance (KERNALS-220-4 SALFORD SCIENTIFIC.UK) was used for weight by weight (w/w) measurement of powdered herbs and GIC in grams. Conventional GIC was used as control group (CG). The powder liquid ratio for conventional GIC is 1:1 and the same was used for the preparation of all samples. Cylindrical samples of conventional GIC and modified GIC were made using S.S and Teflon molds. The sample size was calculated using Mead's resource equation which is:

E= Total number of variable – Total number of groups

where total no of variables = number of variables (4) x No of groups (4)

Fig. 1: (A). Mixing pad with GIC **(B).** Mixing of material **(C) .** Sample Preparation with S.S and Teflon Mold

(A) **(B)** **(C)**

E = (4 x 4) – 4 = 12 samples for each test and a total of 192 samples required for all tests. The samples were divided into following groups:

G_1: Conventional GIC (GC Gold Label 2) (control), **G_2:** Conventional GIC + *Glycyrrhiza glabra* , **G_3:** Conventional GIC + *Piper nigrum and* **G_4:** Conventional GIC + *Glycyrrhiza glabra + Piper nigrum*

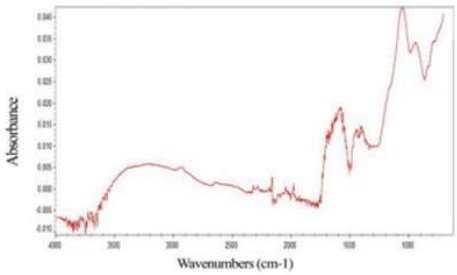
The molecular interactions of GIC and powdered herbs was analyzed using Fourier Transform Infrared Spectroscopy (FTIR, Thermo Scientific Nicolet iD7 ATR, USA) and Ominic (version 9.0) software with the wavelength range of 4000-700 cm^{-1} at Research Laboratory of Baqai Institute of Pharmaceutical Sciences. The sample discs were ground in mortar and pestle individually to make powder. The powder was then placed centrally on the platform to measure the transmittance.

The antibacterial efficacy of GIC and modified GIC was tested in vitro using the conventional disc diffusion method on brain heart infusion (BHI) agar plates at Baqai Institute of Pharmaceutical Sciences. Strains of *S. mutans*, *E.coli*, and *Lactobacillus* were employed for this investigation. There were nine agar plates used. Sterile instruments were used to make the cement discs (6 mm diameter, 4 mm thickness) which were then sterilized by UV radiation (CAMAG UV Cabinet, CAMAG Germany) at 254nm for 60 minutes. To ensure a uniform dispersion of the inoculum, the surface of every agar plate was swabbed three times using a sterile swab. A spectrophotometer was used to verify the check of Mueller–Hinton agar plates (Sigma Aldrich, MO, USA) seeded with 1.8× 108 cfu/mL (0.5 OD600) of the test bacteria. Sterile agar punchers were used to create three wells measuring 6 × 4 mm in diameter in each plate. The specimens were placed into the wells and the plates were then placed into an aerobic incubator at 37°C for 24 hours to check for the presence of inhibition zones after a 24-hour incubation period. A digital caliper was used to measure the inhibition zones surrounding the samples.

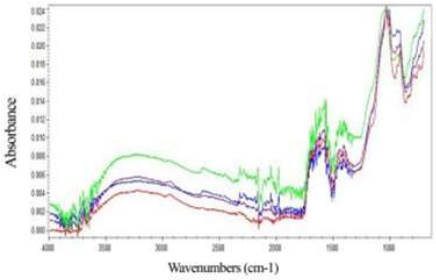
The pH was measured using Accumet Research 10 microprocessor pH meter (Fisher Scientific UK) at Baqai Institute of Pharmaceutical Sciences. The sample discs were powdered and dissolved individually in 5ml distilled water. The electrode was washed and submerged in the solution and the measurement was recorded. The electrode was washed thoroughly after each analysis. The pH was recorded after 1 day, 7 days and 28 days.

Microhardness of the samples was tested by Vickers microhardness tester HMV- G-31 Brand Shimazu Display Type Digital (Japan) at Nadirshaw Eduljee Dinshaw (NED) University Karachi, Pakistan. Twelve samples having 6mm thickness and 4mm in diameter from each group were tested. The finishing of samples was done using sequential grit paper (coarser to finer) mounted on a Rotor-3 finishing machine followed by polishing using diamond polishing paste on automatic lapping and polishing unit. The samples

Fig 2.1: Absorbance peaks of conventional GIC (group 1) and GIC+GG (group 2

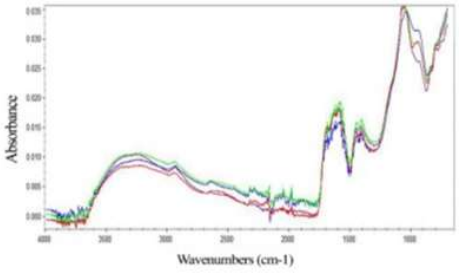


Group1: GIC

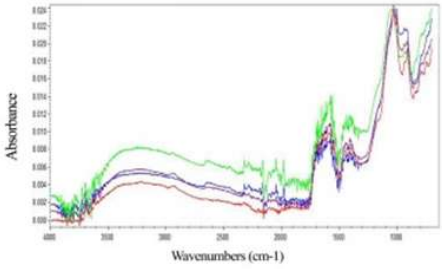


Group2: GIC+*GG* (4-16%)

Fig 2.2: Absorbance peaks of GIC + PN (group 3) and GIC+GG+ PN (group 4)



Group3: GIC+ *PN* (4-16%)



Group4: GIC + *GG* + *PN* (4-16%)

were positioned and a load (P) of 300gm was applied for 15 seconds. The following formula was used:

Vickers Hardness number = KP/L (value of K is 1.854).

Where P is load applied, L is average diagonal length of sample and K is constant.

Data was analyzed using SPSS software (version 20). Mean and standard deviation (SD) was calculated for all groups. Analysis of variance (Anova) was used to compare the inhibition zones. Post-hoc Tukey's test was done for the comparison of variations in zones of inhibition of all experimental groups. A *p*-value < 0.05 was considered significant.

RESULT

Characterization of samples was done using an ATR-FTIR spectrophotometer. Fig 2.1 shows the peaks of control group. From the many peaks, the major ones are ë 1 ?- ë 5, with values of 1068, 1365, 1456, 1637 and 1740 cm^{-1}. The GG-modified GIC had multiple significant peaks including ë 1 with 1060 cm^{-1}, ë2 with 1360 cm^{-1}, ë3 with 1460 cm^{-1}, ë4 with 1650, and ë5 with 1755 cm^{-1}. The FTIR analysis of PN-modified GIC (4-16%) is shown in Fig 2.2 below. The peaks of GIC modified by the combination of both GG and PN are also displayed in Fig 2.2. From the several peaks, ë5 with 1,050 cm1, 1,360 cm1, 1,450 cm1, 1,630 cm^{-1}, and 1,745 cm^{-1} were significant. Peak shift is observed with increase in herb content. This demonstrates that the powder created has significant bio-active characteristics.

There was an increase observed in the inhibitory zone of group 2 (GIC + GG), group 3 (GIC + PN) and group 4 (GIC+GG+PN) as compared to the inhibitory zone of conventional GIC (control group). This indicates that GG and PN enhanced the antibacterial activity of GIC significantly separately and in combination. Incorporation of GG into conventional GIC enhanced the antibacterial activity more as compared to the addition of PN into GIC I.e a statistically significant difference was observed in both group 1 and group 2 when compared with group 3, i.e. ($p < 0.05$). As per the findings of this investigation, the combination of GG and PN with conventional GIC resulted in a greater mean inhibitory zone when compared with group 3 (GIC + PN). The ANOVA results indicate that there was a statistically significant antibacterial effect of herb-modified GIC against *S. mutans*, *L. bacilli*, and *E. coli* as compared to unmodified GIC.

A quick way to test material's physical properties is by evaluating its microhardness. It is the most typical strength parameter used to describe dental cements. The microhardness values of the groups was significantly different from each other but more or less equal to control group with the highest value among the modified groups being 69.123 + 2.9847 of group 3 (GIC+ PN) and the lowest being 61.173 + 22.0267 of group 2 (GIC + GG). The microhardness of conventional GIC (group 1) is 71.600 + .00. This demonstrates that the difference between the microhardness values of conventional and modified groups was insignificant and addition of herbs into conventional GIC did not impact the physicomechanical properties of GIC. The mean hardness value and SD of each group is given below in table 2.

The acidic pH of GIC during setting is due to the acrylic acid component of GIC. The herb-modified groups of GIC showed increase in pH at all intervals (after 1 day, 7 days and 28 days). The pH values of all the groups was close to neutral at 7 and 28 days interval indicating stabilization of ions in cement. After 7 days, a significant increase in pH of all modified groups was observed. The pH values of control group and herb-modified groups after 1 day, 7 days and 28 days of soaking in distilled water are given below in table 3. The pH value of control group was lower as compared to the pH values of modified groups reaching a stable value of 5.8. This maybe due to anti-oxidative properties of GG and PN which also caused increase in anitibacterial and anticariogenic properties of modified GIC.[11]

DISCUSSION

The growing concern of development of bacterial resistance to modern antibiotics has provided the opportunity to study natural herbs for their potential use against infectious diseases.[12] The herbs, GG and PN have a proven history of safety, efficacy, have previously been used in CaOH, ZnO eugenol, AgNPs, ZnPO cement, mouth-rinses and chlorhexidine and the absence of any recorded detrimental side effects in both traditional and modern medical literature. Although, the incorporation of natural herbs in restorative materials has been proven beneficial, it is also known to compromise the physical and mechanical properties of restorative material.[13-15] Although, GIC contains fluoride, it is unable to achieve and maintain the effective level of antibacterial effect after a certain period.[16] Therefore, this study investigates the therapeutic, antibacterial and the

Table 1. Control and Group vise Mean SD Distribution with Significant *p*-value

Variables	N	Mean	SD	Min- Max	Test Statistics	*p* value
Control group 1	12	5.4100	0.346	5.24-5.57	5.048	0.004
Group 2	12	5.8592	0.154	5.69-6.02		
Group 3	12	5.6825	0.316	5.51-5.85		
Group 4	12	5.7105	0.298	5.54-5.87		

Table 2. Statistics of Vickers Microhardness tests

	Group	Mean	SD	N
4-16%	Group 1	71.600	.0000	12
	Group 2	61.173	22.0267	12
	Group 3	69.123	2.9847	12
	Group 4	66.277	2.9610	12
	Total			48

Table 3. Number of samples against tested time intervals

pH measurement GIC GC Gold Label 2 (control)			
Date	After1day	After 7 days	After 28 days
8/2/23	5.02	5.83	5.74
pH measurement Grp I GIC +*Glycyrrhiza glabra*			
GIC+GG	After 1 day	After 7 days	After 28 days
4%	5.63	5.83	6.07
8%	5.68	6.0	6.09
12%	5.73	5.97	6.07
16%	5.64	5.87	6.03
pH measurement Grp 3 GIC +*Piper nigrum*			
GIC+Pn	After 1 day	After 7 days	After 28 days
4%	5.50	5.60	5.61
8%	5.56	5.61	6.09
12%	5.67	5.87	6.05
16%	5.07	5.23	5.89
pH measurement Grp 4 GIC+*Glycyrrhiza glabra*+*Piper nigrum*			
GIC+GG+Pn	After 1 day	After7 days	After 28 days
4%	5.85	6.20	6.21
8%	5.72	6.01	6.09
12%	5.50	6.00	6.00
16%	4.95	5.89	5.90

microhardness of herb-modified GIC.

The FTIR gives information about the chemical changes in the material in the form of any new bands in the absorption spectrum that result after any modification to the material. The analysis of GG and PN has identified different compounds including monoterpenes, linolene, O-cymene, coumarins, phenols, etc. The lipophilic molecule was assumed as the trigger for all these terpenoids' potential membrane disruptions. Phenols and coumarins have strong antibacterial effect against both gram-positive and gram-negative bacteria by causing protein denaturation and modifying the permeability of bacterial cell membrane.[17] The analysis showed carboxylic acid's OH group and the C=O stretching vibrations in the carboxylic group peak at 1635 cm^{-1} and 1706 cm^{-1}, respectively.

GlC is the one of the most commonly used material in dentistry owing to its excellent biocompatibility, known antibacterial activity and its ability to chemically bond to tooth surface. However, Several studies conducted has led to the conclusion that fluoride release takes place mainly in the first 24 - 48 hours but decreases and stabilizes with the passage of time as a result the antibacterial activity of GIC diminishes as the time passes resulting in secondary caries formation. The antiviral and anticarcinogenic properties of liquorice root were studied by Badr et al. (2011). One study reported that GG extract showed great efficacy in the antibacterial test against *S. mutans*. Similarly, Tripathi et al. (2022) studied the antimicrobial activity of PN in concentration against *E. coli* and *S. mutans*. Therefore these herbs were selected for this study and the results of this study indicate a significant difference in the inhibition zone of control group and experimental groups. This suggests that the addition of GG and PN in conventional GIC significantly slowed the bacterial growth. These findings are supported by the study conducted by Khere etal., 2019; Paulraj and Nagar, 2020.[18, 19] The comparison between the different percentages used (4%, 8%, 12% and 16%) showed similar zone of inhibition suggesting that there was no significant difference among groups ($p > 0.05$). These results are contradictory to Hajipour et al. (2012) who reported that the antimicrobial activity was dependent upon the concentration of antibacterial agent incorporated.[20] Although multiple researches suggest that the antimicrobial activity increases with increase in concentration, the findings of our study are consistent with the results of study reported by Tripathi (2022) which suggest no difference in response to multiple dosage forms.[21] The current investigation demonstrates the enhanced antibacterial efficacy of the *Glycyrrhiza glabra* and *Piper nigrum* modified GIC against strains of *E. coli*, *S. mutans*, and *L. bacilli*.

Microhardness is the most typical parameter of strength for dental cements.[22] The mean microhardness values of the modified and unmodified GIC as shown in table 1 are 71 of conventional GIC (control group), 69.05 of GG + GIC, 68.1 of PN + GIC and 65.1 of GG + PN + GIC. These results suggest improvement of antibacterial properties of conventional GIC with the addition of GG and PN without any significant impact on the physicomechanical properties of the material.

GlC has low pH during the initial setting phase which can irritate the pulp.[23] The pH values of all the groups tested was close to neutral ranging from 5.0 - 6.0 after 7-28 days. This highlights the ability of the material to inhibit bacterial growth as well as stabilization of ions over the period of 7-28 days.[24] The pH of control group was lower than the pH of herb-modified groups ranging from 4.99-5.02 at day 1, climbing to 5.83 after 7 days and reaching a stable value of 5.74 after 28 days. Group 4 having 4% concentration of herbs in combination (conventional GIC+ GG+PN) achieved the highest final pH value of 6.11. The antioxidative characteristics of GG and PN, which are a result of the phenolic and flavonoid antioxidants contained in PN and polyphenolic components of GG, are responsible for this rise in pH of GIC. In comparison to traditional GIC alone, the herb-modified GIC groups showed improved antibacterial and anticariogenic activities because of these antioxidants. Researches suggest that this pH could go as high as 7.[25] The pH of the modified groups increased rapidly in the first three days making it more biocompatible since it would diminish the toxicity of the intense acidity during the initial setting reaction.

The current study's findings demonstrate that, even with the

varying percentages (4, 8, 12 and16%), herbs (GG and PN) in combination with GIC exhibit higher antibacterial efficacy against *S. mutans*, *L. bacilli*, and *E. coli* while maintaining the physicomechanical properties of GIC. Based on the findings of the current investigation and other relevant studies, the modification of GIC with herbs may have potential clinical importance in preventive dentistry due to its demonstrated effects on bacterial growth inhibition and mechanical reinforcement as well as its capacity to release possible bioactive compounds and growth factors. However, the study has several limitations as well such as the study was done in-vitro, to fully understand the potential of herbs in dentistry, in vivo studies and clinical trials should be done. This investigation has used only one brand of GIC and results may differ with other brands. This study did not determine the duration of antibacterial effects of modified GIC against *S. mutans*, *Lactobacili* and *E. coli* and the antibacterial activity on other biofilm models involved in dental caries and gum disorders was not examined in the present investigation.

CONCLUSION

Based on the results obtained in this investigation, the addition of GG and PN significantly improved the antibacterial activity of herb-modified GIC without producing any significant changes in the physicomechanical properties.

Authors Contribution:
Raffat Aziz: Conceptualization, lab work and manuscript writing
Shaukat Khalid: Organization of data and provided supervision
Muhammad Khawaja Hammad Uddin: Data analysis and Review of manuscript as Co-supervisor
Mah Zul Kaif: Manuscript writing, editing and proofreading
Affan Ahmad: Provided support for statistical analysis as Co-supervisor

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Original Article **Open Access**

Clinical and Forensic Relevance of Cranial Bone Thickness Using CT Scan in Relation to Age and Gender

Zunaira, Zumirah Atiq, Saman Ali, Ayesha Sanaullah, Amna Javaid, Athar Maqbool

ABSTRACT:

Objectives: The aim of the study is to assess cranial bone thickness in relation to age and gender using computed tomography (CT) scans, and to determine the clinical and forensic relevance of any observed variations.

Study design and setting: This was a retrospective cross sectional observational analysis carried out on 128 patients head CT at Radiology department of M. Islam Teaching Hospital, Gujranwala from 1st February, 2024 to 1st December, 2024.

Methodology: Adults between the ages of 15 to 70 years were included. Data was collected by multi detector CT incisive 128 Philips using bone window. Sagittal view was selected for the measurements of unpaired frontal and occipital bones. Coronal view for the right and left paired parietal bones and axial view for the right and left paired temporal bones. Independent samples t-tests and one-way ANOVA were used to assess sex- and age-related differences, respectively. A p-value < 0.05 was considered statistically significant.

Results: Our study includes 128 participants, comprising 71 males and 57 females. The mean age of patients was 45.1 ± 18.7. The sex-based difference in cranial bone thickness was significant at upper and lower frontal, right anterior and posterior parietal, left middle and posterior parietal ($p < 0.05$). Based on age group the difference was statistically significant at the level of right anterior parietal only.

Conclusions: Cranial bone thickness varies significantly with gender and, to a limited extent, with age. These findings enhance our understanding of cranial anatomy relevant to surgical planning, trauma management, and forensic identification.

Keywords: CT scan, Cranial bone thickness, Gender variation, Skull anatomy, sexual dimorphism, Forensic identification.

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INTRODUCTION:

A key role of the skull is to protect the brain against mechanical trauma.[1] The human skull forms a protective cavity around brain comprising of around 22 bones. The key bones of the cranium consist of the frontal, parietal, occipital, temporal, ethmoid and sphenoid.[2] Most cranial bones are classified as flat bones, characterized by a layered architecture in which a central cancellous layer, known as the diploë, is enclosed between two outer layers of dense cortical bone.[3] Understanding how bones with a sandwich-like structure respond to external mechanical loading is essential for the design and evaluation of head protection equipment and strategies.[1] Intramembranous ossification forms most cranial bones, facial flat bones, and the clavicles, where both cortical and cancellous bone arise directly from mesenchymal connective tissue sheets.[4]

Each year, approximately 1.7 million people suffer from traumatic bone injuries, primarily caused by falls and motor vehicle collisions. Assessing changes in skull thickness with age is crucial for understanding its effect on skull deformation.[5] Around 76.5 billion dollars annual estimated cost has been attributed to TBI also termed as silent epidemic by centres for disease control. The probability of a skull fracture depends on the point of impact, as different regions of the skull vary in thickness and structural orientation.[6]

In forensic anthropology, the skull and pelvis are key structures for identifying individuals.[2] The cranium remains a key focus of research within the human skeletal system,

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valued for its structural traits related to sex, age, and heritage, making it essential for building a biological profile of unidentified individual.[7] The accuracy of sex determination in skeletal remains is influenced by the specific bones present, their preservation status, and the extent of sexual dimorphism characteristic of the population. Studies have focused on various skull features, including the cranium, mandible, glabella, mastoid process, and occipital bone to develop more accurate, reliable, and consistent methods for sex determination in anthropological analysis.[8] The cranium is the third most commonly used anatomical structure for sex estimation. Sexual dimorphism in the skull is typically evident in specific features, with males generally exhibiting larger mastoid processes, more pronounced supraorbital ridges and glabella, and a more prominent external occipital protuberance.[9]

The skull serves not only as a valuable tool for determining sex, but also supports facial reconstruction efforts, contributing significantly to the identification process. Skeletal morphology is shaped by various factors such as genetic background, environmental influences, population migration, and long-term secular trends. Consequently, population-specific standards should be developed and regularly updated.[10] The thickness of skull bone varies from young age to maturity and at various skull bone sites is required to healthcare professionals for accurate pin type selection and its location in halofixation, as well as cranial reconstruction surgeries.[11]

Studies on neurocranial thickness variation help inform mathematical models that simulate how the head responds to mechanical loading, and assess the connection between skull thickness, mechanical properties, and the likelihood of fractures from such forces.[12]

Bone thickness is thought to be influenced more by systemic and local stimuli than by genetic factors. Systemic elements such as hormonal balance, levels of physical activity, and nutritional status affect bone remodeling and growth, ultimately affecting overall skeletal robustness thus also affecting cranial bone thickness.[13]

A significant portion of the research on cranial bone thickness has been conducted on limited, potentially biased study groups. Furthermore, inconsistencies in sampling techniques and anatomical locations sampled hinder comprehensive comparisons and meta-analyses of the data. In our country knowledge gaps exist regarding skull thickness, its normal variation and potential correlations with biological and anthropological factors, due to a lack of robust evidence. With increasing immigration and population mixing, the necessity for an accurate data bank of osteometric measurements specific to different population types is acknowledged. This research primarily seeks to explain the correlation between skull thickness and age and sex.

METHODOLOGY:

A retrospective, cross sectional observational study 11 months study was carried out from 1st February, 2024 to 1st December, 2024 in the Radiology department of M. Islam Teaching Hospital, Gujranwala in Central Punjab. This research was conducted after taking approval from the Institute's Research Committee (Research Proposal No: CM/MIMDC/03/2024). The need for informed consent was waived, as it was a retrospective study. A total of 128 patients comprising of 71 males and 57 females, who came to Radiology department were selected randomly. Simple convenience sampling method was employed. Inclusion criteria: Adults between the ages of 15 to 70 years, with no history of trauma, bone lesions and concomitant skull fractures were involved in this research. Exclusion criteria: Below 15 years and above 70 years of age having localized skull bone diseases i.e. congenital or acquired deformity, infection, tumor, growth disorder or prior cranial surgery were excluded.

Data was collected by using multi detector CT incisive 128 Philips (Version 5.0.1.771, China) by using bone window. Sagittal view was selected for the measurements of unpaired frontal and occipital bones providing a side view of the skull in an anatomical position of skull. The frontal bone was segmented into three parts according to its vertical alignment; near to frontal sinus was lower third (A), middle third was at the point of the frontal tuberosity (B) and above frontal tuberosity was upper third in connection with parietal bone (C) as shown in Figure 1. The occipital bone was likewise separated into three sections; upper third close to lambdoid suture (D), in space separating lambdoid suture and occipital protuberance was middle third (E), lower third at occipital protuberance (F) as shown in Figure 1 on right side. All the views were selected while skull was in an anatomical position. Axial view was used for the paired right and left temporal bones. The thickness of temporal bone was measured on both sides, 3 cm above the zygomatic process at the right side (G) and at the left side (H) as illustrated in Figure 1 on left side. Both right and left parietal bones were measured at three points in the coronal view; anterior third towards coronal suture (I & J), middle third between the coronal and lambdoid suture (K & L) and posterior third towards lambdoid suture (M & N) as shown in Figure 2. Data analysis: Data collected from the study were analyzed using SPSS version 27.0, New York. Independent samples t-test was used to analyse variation by sex in each parameter, and the bilateral difference in the thickness of temporal and parietal bones. The correlation between cranial bone thickness and age was analysed by using one-way ANOVA test. P value of <0.05 was taken as significant. Normality of data was assessed using the Shapiro-Wilk test, confirming approximate normal distribution for each measurement variable.

RESULT:

Our study includes 128 patients, comprising 71 males (55.5%) and 57 females (44.5%) in Pakistan. The average age of patients was 45.1 ± 18.7. This study analyzed cranial bone thickness variations based on gender, age, and anatomical side using multi detector CT scan. The analysis focused on different skull regions, including the frontal, parietal, temporal, and occipital bones. Results were discussed in the following three tables, each addressing a different variable: gender (Table 1), age (Table 2), and anatomical side (Table 3). Statistical analyses were done using independent samples t-tests for gender and anatomical side and one-way ANOVA for age to identify significant differences in different skull parts.

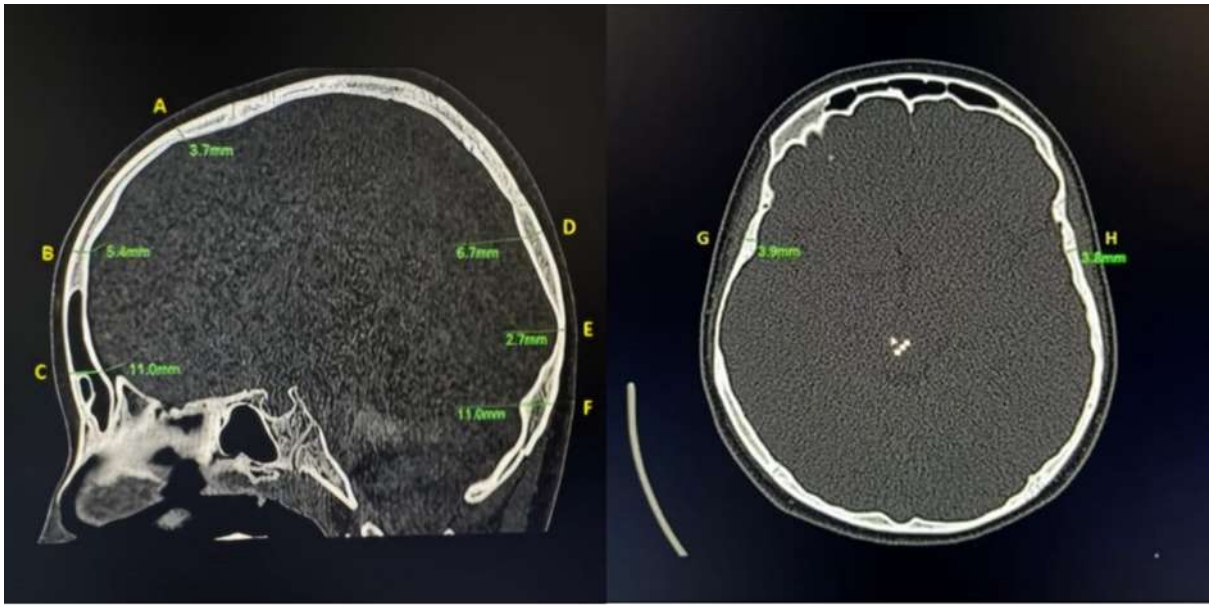
Table 1 shows Gender-Based Differences: This analysis revealed statistically significant differences in skull thickness between males and females in various regions. Particularly, in the frontal bone, both the upper and lower sections were significantly thicker in females compared to males. The upper and lower frontal thickness in females and males showed significant difference ($p < 0.001$). The right parietal bone also showed significant gender-based differences i.e. females had greater thickness in both the anterior and posterior regions. On the left side, the middle and posterior parietal areas were thicker in females when compared to males. These findings highlight significant sexual dimorphism in cranial bone thickness particularly in the frontal, right & left parietal bones.

Table 2 shows Age-Based Differences: Age-related significant variations in skull bone thickness were assessed using one-way ANOVA across the following three age groups: 15–35 years, 36–55 years, and 56–75 years. The results revealed that the most skull regions did not have statistically significant differences in thickness across these three age groups. However, a significant exception was observed in the anterior part of the right parietal bone only. Thickness increased from the youngest group to the older groups, with a significant p-value of 0.014. This suggests that specific portion of the skull i.e. right anterior parietal bone might show thickening with age. Other areas showed non-insignificant patterns. For instance, the lower frontal bone thickness increased with age, but the p-value (0.067) indicated this pattern was not statistically significant. The occipital and temporal bones also exhibited slight, insignificant increases in thickness with age. Overall, the data indicate only minimal age-related variations in skull bone thickness.

Table 3 shows Side-Based Differences: An independent samples t-test was used to compare the right and left sides of the skull. The analysis revealed no statistically significant differences in bone thickness between corresponding areas of the left and right sides of the skull. In the comparison of right and left sides of the anterior, middle and posterior regions of the parietal bone, insignificant difference was seen. Temporal bones also revealed insignificant differences on the right and the left sides. These results reveal a significant degree of symmetry between the right and left sides of the skull, indicating that lateral asymmetry is minimal in the human calvaria, at least in the regions measured.

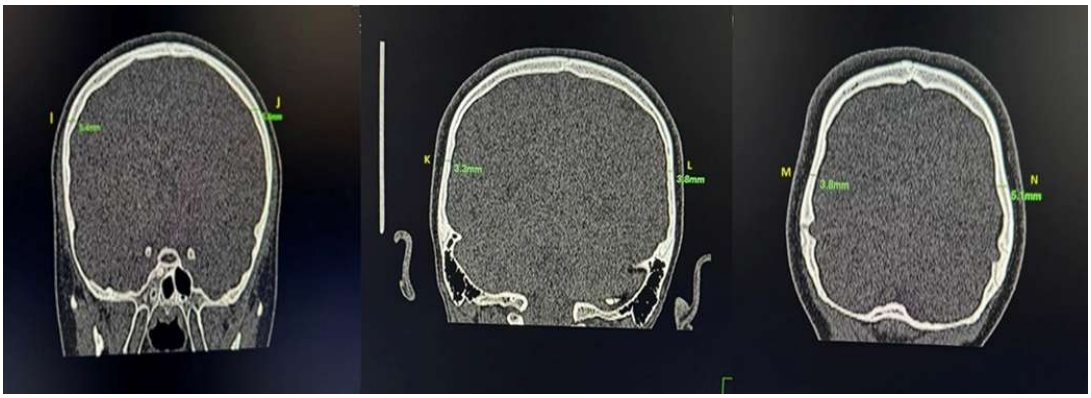
In short, the thickness variation of the frontal bone in its upper and lower sections of males and females shows significant difference with p value less than 0.05. Other regions where the difference in the skull bone thickness was

Figure 1: Measurement of frontal and occipital bone thickness in sagittal section (Right side). Frontal bone;



A: Around frontal sinus, B: At frontal tuberosity, C: Above frontal tuberosity towards parietal junction. Occipital bone; D: Towards lambdoid suture, E: Between lambdoid suture and occipital protuberance, F: At occipital protuberance. Measurement of temporal bone thickness in the axial section, 3 cm vertically above the zygomatic process(Left side). G: Right side, H: Left side.

Figure 2: Measurement of parietal bone thickness in the coronal section, towards coronal suture.



I: Right side, J: Left side. Between coronal and lambdoid suture. K: Right side, L: Left side. Towards lambdoid suture. M: Right side, N: Left side

Table 1: Comparison of CT points based on gender (using independent samples t-test)

CT scan	Region	Males	Females	p-value
Frontal	**Upper**	6.4 ± 1.7	7.5 ± 1.9	<.001*
	Lower	7.2 ± 1.8	8.5 ± 1.9	<.001*
Right parietal	**Anterior**	6.2 ± 1.3	7.5 ± 1.8	<.001*
	Posterior	7.9 ± 1.8	8.6 ± 1.8	.030*
Left parietal	**Middle**	6.4 ± 1.1	7.1 ± 1.5	.007*
	Posterior	7.9 ± 1.6	8.6 ± 1.8	.024*

*Statistically significant

Table 2: Comparison of CT points based on age groups (using one-way ANOVA)

CT scan	Region	15 – 35 yrs	36 – 55 yrs	56 – 75 yrs	p-value
Frontal	Upper	6.4 ± 1.9	6.9 ± 1.8	7.3 ± 2.0	.106
	Middle	7.1 ± 7.6	7.0 ± 1.8	7.1 ± 2.1	.995
	Lower	7.2 ± 1.6	7.9 ± 1.7	8.2 ± 2.3	.067
Right parietal	Anterior	6.2 ± 1.4	7.0 ± 1.4	7.1 ± 1.9	.014*
	Middle	8.1 ± 10.5	6.8 ± 1.3	6.8 ± 1.5	.506
	Posterior	8.3 ± 1.8	8.3 ± 1.9	8.1 ± 1.8	.907
Left parietal	Anterior	6.3 ± 1.5	9.5 ± 15.5	7.2 ± 1.7	.222
	Middle	6.6 ± 1.3	6.9 ± 1.3	6.8 ± 1.4	.572
	Posterior	8.3 ± 1.6	8.3 ± 1.8	8.1 ± 1.8	.887
Temporal	Right	5.5 ± 1.1	5.5 ± 1.2	5.5 ± 0.9	.993
	Left	5.7 ± 1.2	5.7 ± 1.1	5.7 ± 1.0	.937
Occipital	Superior	6.6 ± 1.2	6.9 ± 1.4	6.8 ± 1.3	.507
	Middle	6.3 ± 1.1	6.6 ± 1.2	6.8 ± 1.4	.210
	Inferior	8.9 ± 1.8	9.4 ± 2.5	9.8 ± 2.1	.175

*Statistically significant

Table 3: Comparison of CT points based on side (using independent samples t-test)

CT scan	Region	Right	Left	p-value
Parietal	**Anterior**	6.8 ± 1.6	7.5 ± 8.5	.319
	Middle	7.2 ± 6.2	6.7 ± 1.3	.341
	Posterior	8.2 ± 1.8	8.2 ± 1.7	.972
Temporal	-	5.5 ± 1.1	5.7 ± 1.1	.095

significant between both genders was at right anterior and posterior parietal, left middle and posterior parietal ($p < 0.05$). The comparison of CT points of skull bones based on age group showed p value less than 0.05 at the level of right anterior parietal. No statistically significant variation was seen when skull thickness of right and left sides of parietal and temporal bones were compared.

DISCUSSION:

Adult skull bones are made up of two dense layers of cortical bones separated by a central region of cancellous diploic tissue. Amongst all modern techniques available, Computed tomography (CT) offers a detailed visualization of the calvarial tables and the intervening diploic space. This capability establishes CT as a key tool for detailed cranial analysis rather than conventional radiographic techniques.[14] Our study included a sample of 128 individuals, comprising 71 males and 57 females, with a mean age of 45.1 ± 18.7 years. Previous studies by Kulathunga,[2] De Boer,[7] and Eksi[15] have documented that females have thicker frontal bones than males. This finding is consistent with our results, which revealed significantly greater thickness in females at the upper and lower regions of the frontal bone, with p-values of <0.001 for both regions. This observation could be attributed to hyperostosis frontalis interna, a condition noted to be particularly useful in distinguishing females from males in forensic analysis, as reported by May et al.[16]

The right and left parietal bones exhibited variable measurements, with the right parietal bone showing greater thickness in females than males at the anterior and posterior ends, with p-values of <0.001 and 0.030, respectively. Similarly, the left parietal bone in females demonstrated higher thickness at the middle and posterior aspects, with statistically significant p-values of 0.007 and 0.024. These findings align with Semple's[17] perspective that sex also affects the variability in calvarial thickness. This also aligns with Farzana's[18] study, which reported significant thickness in the posterior parietal region among females but found no notable differences in the anterior aspect. Contrary to

Domenech-Fernandez[11] study where skull bone thickness demonstrated an increase with age for all parameters, in our study significant age-related differences were observed only in the anterior region of the right parietal bone (p=0.014). Anzelmo[19] also stated an interesting point that along the parietal midline, a thin line is likely associated with the development of superior sagittal sinus, with thicker regions on either side but in our study only females represented this pattern while males exhibit an increasing pattern from front to back.

Quite interestingly, the right and the left temporal bones showed no change in thickness with advancing age, while almost all the rest of the studied bones exhibited an increasing pattern, although not statistically significant. This pattern of temporal bones shows contrast to Kulathungas study[2] where temporal bones thickness exhibit a positive correlation with age. Lynnerup's[20] study focussed on thickness of human cranial diploe and failed to find a remarkable correlation between age and diploic thickness of individuals. Ichalakaranji's[21] study also concluded that there cranial thickness has no relation with age. Domenech-Fernandez[11] and Kulathunga[2] also recorded that the lateral aspect of the skull vault is the thinnest amongst all and is further reinforced by our study where the temporal bone remained the one with the least value in both genders.

Anzelmo[19] mentioned that the occipital bone thickness is greatest at the lambdoid suture which is contrary to our study which shows that the occipital bones in both genders exhibit an increasing pattern towards the occipital protuberance as compared to the region closest to the lambdoid. Another CT based study conducted by Ichalakaranji[21] in India showed that in females the superior occipital bone is thicker and in males the inferior occipital bone is thicker, with the p value less than 0.05 making the difference statistically significant. However, our research showed contrast with female skull being thicker at level of inferior occipital bones than males but the difference was not statistically significant. Additionally, no significant variations were observed in the occipital and temporal bone thickness measurements between genders.

Another study by Lynnerup[22] across White and Black racial groups showed that the thickest skulls are of White women and the thinnest are of White men. Additionally, the study found that, in both racial groups, women had significantly thicker skulls than men at almost all levels which was similar to our study.

CONCLUSION:

This study investigates cranial bone thickness among a Pakistani population using computed tomography (CT) imaging, revealing sex-based variation, with females exhibiting significantly greater thickness in the frontal and parietal bones. A subtle but statistically significant age-related increase was observed at the right anterior parietal bone, suggesting localized morphological adaptation. Bilateral symmetry was evident in the parietal and temporal bones, affirming their consistency in clinical evaluation.

These findings support the integration of sex- and age-specific cranial data into neurosurgical planning, craniofacial reconstruction, and forensic anthropology. Statistical analyses confirmed robustness, with significance established at $p < 0.05$.

Future research should prioritize ethnically diverse sampling to enhance generalizability, and examine the differential morphology of inner versus outer calvarial tables. Moreover, coupling such anatomical data with advanced 3D imaging, finite element modeling, and biomechanical simulation presents promising potential for refining implant design, pre-surgical assessment, and forensic reconstruction protocols.

Authors Contribution:
Zunaira: Concept and design of study
Zumirah Atiq: Concept and design of study, drafting
Saman Ali: Drafting and reviewing criteria
Ayesha Sanaullah: Data analysis, reviewing critically
Amna Javaid: Data analysis, reviewing critically
Athar Maqbool: Final approval of version

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Original Article **Open Access**

Diagnostic Accuracy of Modified CT Severity Index in Assessing Severity of Acute Pancreatitis

Maham Zaidi, Jawaid Iqbal, Rizwan Ajmal, Qurat ul ain Haroon, Ramsha Fatima, Sadia Khursheed

ABSTRACT

Objectives: To determine the diagnostic accuracy of the Modified CT Severity Index in assessing the severity of acute pancreatitis, using the APACHE II score as the gold standard.

Study Design and Setting: This was a descriptive cross-sectional study conducted at Liaquat National Hospital, Karachi, over a period of six months from May 1, 2023, to November 30, 2023.

Methodology: A total of 68 patients aged 18–75 years, clinically and ultrasonographically diagnosed with acute pancreatitis, were included through non-probability consecutive sampling. Patients with incomplete APACHE II data or a history of trauma were excluded. MCTSI scores were calculated from contrast-enhanced CT scans and compared with APACHE II scores. Diagnostic accuracy measures, including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy, were calculated. Data were stratified by age and gender.

Results: MCTSI demonstrated a sensitivity and specificity of 75% each when compared with APACHE II scores. In patients aged <45 years, sensitivity and specificity were 88.8% and 70.3%, respectively. In those =45 years, sensitivity was 57% and specificity was 84%. Among females, sensitivity reached 100% with a specificity of 79%, while in males, sensitivity and specificity were 69.2% and 75%, respectively. The overall diagnostic accuracy of MCTSI was 76.4%.

Conclusions: MCTSI offers a reliable and practical alternative to APACHE II for early assessment of severity in acute pancreatitis, especially when rapid imaging is available. Its simplicity and reasonable accuracy make it a valuable tool in routine clinical practice.

Keywords: Acute Kidney Injury, Acute Pancreatitis, APACHE II Score, Diagnostic Imaging, Pancreatitis Severity Score

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INTRODUCTION:

Acute pancreatitis (AP) is a common yet potentially life-threatening gastrointestinal emergency characterized by acute inflammation of the pancreas, often triggered by premature activation of pancreatic enzymes within the gland.[1] The disease presents with a sudden onset of severe epigastric pain, frequently radiating to the back, and is usually accompanied by nausea, vomiting, and elevated serum pancreatic enzymes.[2] The clinical course of AP varies widely, ranging from a mild, self-limiting condition that resolves with supportive care in approximately 70–80% of patients, to a severe form that can lead to extensive local and systemic complications.[3] These complications include pancreatic necrosis, pseudocyst formation, systemic inflammatory response syndrome (SIRS), acute respiratory distress syndrome (ARDS), multiorgan dysfunction syndrome (MODS), and even death.[4] The overall mortality rate for severe acute pancreatitis can reach up to 20–30%, particularly in cases complicated by infected necrosis or persistent organ failure.[5]

In developing countries, the most frequent etiological factors associated with AP are gallstone disease and chronic alcohol abuse.[6] The global incidence of AP ranges from 13 to 45

per 100,000 population annually, and although most patients experience a mild course, approximately 20–30% develop moderate to severe disease.[7] Therefore, a timely and accurate assessment of severity is essential to stratify patients for intensive monitoring and targeted interventions.

Numerous clinical, biochemical, and radiological scoring systems have been proposed for predicting the severity of AP.[8] These include single-parameter markers such as elevated blood urea nitrogen, hematocrit, serum creatinine, and C-reactive protein, as well as multi-parameter scoring systems such as Ranson's criteria, the Bedside Index for Severity in Acute Pancreatitis (BISAP), Systemic Inflammatory Response Syndrome (SIRS), and the Acute Physiology and Chronic Health Evaluation II (APACHE II) score.[9] Among these, the APACHE II score is widely regarded as a robust prognostic tool, as it incorporates a combination of 12 physiological parameters, patient age, and chronic health conditions.[10] It is calculated within the first 24 hours of hospital admission and has been shown to provide reliable prognostic information. However, it is time-consuming and may require data not immediately available in all clinical settings.

Despite the availability of these scoring systems, there remains no universally accepted single tool that accurately predicts severity in all clinical scenarios. Many biochemical and physiological markers are influenced by comorbidities, hydration status, and timing of measurement, limiting their reliability. Serum markers such as C-reactive protein and procalcitonin can be delayed in elevation, and scoring systems like Ranson's require data collected over 48 hours, which may delay risk stratification. Similarly, while APACHE II offers broad applicability in critical illness, its reliance on multiple inputs and complex calculations may reduce feasibility in emergency settings.[11] These limitations underscore the need for simpler, objective, and rapid tools that incorporate both clinical and imaging findings for early and accurate assessment of AP severity.

Radiological imaging, particularly contrast-enhanced computed tomography (CECT), plays a pivotal role in diagnosing AP and evaluating associated complications. The original CT Severity Index (CTSI), introduced by Balthazar et al., provided a standardized radiological grading based on pancreatic inflammation and necrosis.[12] While widely adopted, it had certain limitations, such as inter-observer variability and a lack of correlation with extrapancreatic complications.

Despite its potential, the use of MCTSI is still limited in many healthcare systems, particularly in developing countries, due to a lack of local validation studies. In contrast, APACHE II remains the gold standard for prognostic evaluation in AP, though it does not directly assess morphological changes or complications visible on imaging. Given the ease of use and visual guidance offered by CT-based scores, validating MCTSI as a reliable predictor of severity could enhance early clinical decision-making and reduce the burden of complications. Therefore, this study aimed to determine the diagnostic accuracy of the Modified CT Severity Index in assessing severe acute pancreatitis, using the APACHE II score as the reference standard.

METHODOLOGY:

This descriptive cross-sectional study was conducted at Liaquat National Hospital, Karachi, over 6 months from 1st May 2023 to 30th November 2023. The study was approved by the Ethical Review Committee of Liaquat National Hospital (ERC No: ERC/LNH/67/23; Dated: 19th March 2023). It was carried out following the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments. Written informed consent was obtained from all participants before inclusion in the study.

A total of 68 participants were enrolled following the sample size calculated using a diagnostic accuracy calculator, assuming an expected sensitivity of 80%, specificity of 75%, margin of error of 10%, and a confidence level of 95%, based on previous similar studies[12]. The sampling technique used was non-probability consecutive sampling.[13]

All patients of either gender, aged between 18 and 75 years, who were clinically diagnosed with acute pancreatitis and admitted to Liaquat National Hospital were included in the study. In addition to clinical diagnosis, patients with a confirmed diagnosis of acute pancreatitis on ultrasonography were also eligible for inclusion. Patients were excluded from the study if one or more of the twelve clinical parameters required to calculate the APACHE II score were missing from their medical records. Furthermore, individuals with a history of abdominal trauma were also excluded from participation.

The diagnosis of acute pancreatitis was made based on the revised Atlanta criteria, which requires at least two of the following three features: (i) abdominal pain consistent with acute pancreatitis, (ii) serum amylase or lipase levels at least three times the upper limit of normal, and (iii) characteristic findings of AP on imaging such as ultrasonography or CT scan[3]. Patients were excluded if one or more of the twelve parameters required to calculate the APACHE II score were missing from their medical records or if they had a history of recent abdominal trauma. After enrollment, clinical details, laboratory values, and relevant demographic data were collected from medical records on a structured proforma. The APACHE II score was calculated using standard criteria based on the worst values within the first 24 hours of admission. All patients underwent a contrast-enhanced CT scan, and the Modified CT Severity Index (MCTSI) was computed based on imaging findings, which were also recorded on the proforma.

Data were analyzed using SPSS version 19. Descriptive

statistics, including means and standard deviations, were calculated for continuous variables such as age, and frequencies and percentages were reported for categorical variables like gender and CT findings. Diagnostic accuracy measures, including sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of MCTSI, were calculated using 2x2 contingency tables, keeping APACHE II as the gold standard. Stratification was performed by age and gender, and post-stratification diagnostic values were also computed using standard formulas.

RESULTS:

A total of 68 patients were included in the study. The mean age of the participants was 45.34 ± 18.02 years. The majority were male (n = 41, 60%), while females accounted for 40% (n = 27). The most common presenting symptom was abdominal pain accompanied by nausea and vomiting (56%), whereas others presented with abdominal pain along with constipation and generalized weakness. Most patients (82.4%) were managed conservatively. Endoscopic retrograde cholangiopancreatography (ERCP) with stenting was performed in 8.8% of cases, ERCP followed by laparoscopic cholecystectomy in 4.4%, laparoscopic cholecystectomy alone in 3%, and open laparotomy was performed in one case (1.5%).

Complications were absent in 75% of the patients. However, 17.6% developed pancreatic necrosis with associated abdominal collections. Additionally, three patients developed acute respiratory distress syndrome (ARDS), and two patients experienced acute kidney injury (AKI) with septic shock. In terms of clinical outcomes, 79.4% of the patients recovered, while the mortality rate was 10.3%. Another 10.3% of patients left against medical advice.

A total of 68 patients were included in the study. Based on the APACHE II scoring system, 23.5% of the patients were classified as having severe acute pancreatitis (score >11), while 76.5% were considered non-severe (score <12). According to the Modified CT Severity Index (MCTSI), 35.3% of patients had a score greater than 7, indicating severe disease, while 64.7% had a score of 7 or below. Among those identified as severe by MCTSI, 17.6% also had a high APACHE II score (>11), and 17.6% had a low APACHE II score (<12). Conversely, 5.9% of patients with a low MCTSI score (=7) were found to have severe pancreatitis by APACHE II, whereas 58.8% were consistent with the non-severe classification on both scoring systems. (Table 1). Among male patients (n = 41), 39.0% had an MCTSI score >7, of whom 22.0% were also classified as severe by APACHE II, while 17.1% were classified as non-severe. In contrast, 61.0% of males had an MCTSI score =7; 9.8% of these were severe by APACHE II, and 51.2% were non-severe. Overall, 31.7% of male patients had severe disease by APACHE II, and 68.3% were non-severe. Among female patients (n = 27), 29.6% had an MCTSI score >7, of whom 11.1% were severe by APACHE II and 18.5% were non-severe. The remaining 70.4% had an MCTSI score =7, and all of these were classified as non-severe by APACHE II. Overall, only 11.1% of female patients were categorized as severe based on the APACHE II score, while 88.9% were non-severe. (Table 2). In patients aged less than 45 years (n = 36), 44.4% had an MCTSI score >7. Among these, 22.2% were also classified as severe by APACHE II, while another 22.2% were non-severe. The remaining 55.6% had an MCTSI score =7, of which 2.8% were categorized as severe and 52.8% as non-severe by APACHE II. Overall, 25.0% of patients under 45 years of age had severe pancreatitis according to APACHE II, while 75.0% were non-severe. In patients aged 45 years and above (n = 32), 25.0% had an MCTSI score >7, with 12.5% showing severe disease and 12.5% non-severe by APACHE II. Among the 75.0% who had an MCTSI score =7, 9.4% were classified as severe and 65.6% as non-severe. Overall, 21.9% of patients in the =45 age group were found to have severe pancreatitis by APACHE II, while 78.1% were non-severe. (Table 3). A receiver operating characteristic (ROC) curve was generated to assess the diagnostic performance of the Modified CT Severity Index (MCTSI). A score greater than 8 was identified as the optimal cut-off value for severe pancreatitis, demonstrating a sensitivity and specificity of 75%, as illustrated in Figure 1.

DISCUSSION:

The objective of the present study was to evaluate the diagnostic accuracy of the Modified CT Severity Index (MCTSI) for the assessment of the severity of acute pancreatitis (AP), while using the Acute Physiology and Chronic Health Evaluation (APACHE) II as the standard. The study shows that if we considered MCTSI scores = 7, the sensitivity and specificity were 75% each, thus suggesting that MCTSI can be considered a reasonably accurate tool to predict severe acute pancreatitis in a clinical setting.

Our study revealed that MCTSI possesses a sensitivity of 75% and a specificity of 75%. Meaning that this tool potentially does a decent job at predicting severe acute pancreatitis. The findngs are in agreement with the findings of Hu et al. (2023), where sensitivity 80% specifictiy 61%

Table 1: Overall Comparison between APACHE II and MCTSI (n = 68)

MCTSI	APACHE II Positive (>11)	APACHE II Negative (<12)	Total
Positive (>7)	12 (17.6%)	12 (17.6%)	24 (35.3%)
Negative (=7)	4 (5.9%)	40 (58.8%)	44 (64.7%)
Total	16 (23.5%)	52 (76.5%)	68 (100%)

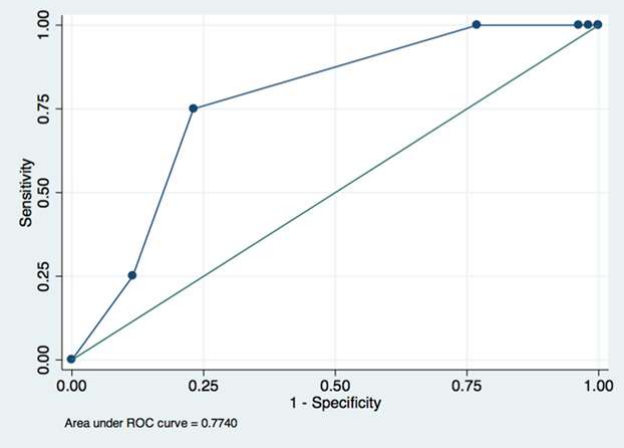
Table 2: Gender-Wise Comparison Between APACHE II and MCTSI

Gender	MCTSI	APACHE II Positive	APACHE II Negative	Total
Male (n=41)	**Positive (>7)**	9 (22.0%)	7 (17.1%)	16 (39.0%)
	Negative (<7)	4 (9.8%)	21 (51.2%)	25 (61.0%)
	Total	13 (31.7%)	28 (68.3%)	41 (100%)
Female (n=27)	**Positive (>7)**	3 (11.1%)	5 (18.5%)	8 (29.6%)
	Negative (<7)	0 (0%)	19 (70.4%)	19 (70.4%)
	Total	3 (11.1%)	24 (88.9%)	27 (100%)

Table 3: Age-Wise Comparison Between APACHE II and MCTSI

Gender	MCTSI	APACHE II Positive	APACHE II Negative	Total
< 45 years (n = 36)	**Positive (>7)**	8 (22.2%)	8 (22.2%)	16 (44.4%)
	Negative (<7)	1 (2.8%)	19 (52.8%)	20 (55.6%)
	Total	9 (25.0%)	27 (75.0%)	36 (100%)
> 45 years (n = 32)	**Positive (>7)**	4 (12.5%)	4 (12.5%)	8 (25.0%)
	Negative (<=7)	3 (9.4%)	21 (65.6%)	24 (75.0%)
	Total	7 (21.9%)	25 (78.1%)	32 (100%)

Figure 1: Receiver operating curve (ROC), showing area under the curve = 0.77



for MCTSI.[8] Yi et al. (2023) also demonstrated lower sensitivity (40%), but high specificity (100%), suggesting that while MCTSI may miss some severe cases, it accurately identifies non-severe cases.[14] However, our study provides value in that it demonstrates there is a is a balanced sensitivity and specificity numbers which suggests MCTSI has a more consistent overall performance when utilized in routine clinical practice.

This study aligns with the findings of Alberti et al. (2021), who showed MCTSI to have greater correlation with clinical outcomes than the original CT severity index.[15] Specifically, Tahir et al.2021 reported that for MCTSI, the sensitivity when comparing MCTSI to clinical severity parameters was 67% while the specificity was 73%.[16] This is consistent with the diagnostic performance we observed. They also reported a sensitivity for MCTSI of 40% and specificity of 100%, and emphasized the strong predictive utility of MCTSI for ruling in severe disease when the number is high, although their sensitivity was low in their setting. In our study, we had similar levels of specificity and sensitivity, suggesting that MCTSI offers an integrated clinical assessment when used in addition to the clinical judgement.

In addition, we share an agreement with the general consensus that MCTSI is easier to apply than APACHE II, which includes 12 physiological parameters and is difficult to apply in all clinical environments. Studies like those by Padmaprakash et al. (2025) and Leghari et al. (2025) have supported APACHE II as a robust predictor of severe pancreatitis.[17,18] While our study did not directly compare MCTSI with other clinical scoring systems such as BISAP or Ranson's criteria, previous research by CF et al. (2021) suggests that imaging-based tools like MCTSI provide valuable supplementary information, especially when laboratory-based scores yield borderline results.[19]

The complication profile in our study, where 17.6% of patients developed pancreatic necrosis and a small subset experienced ARDS or septic shock is consistent with findings from Szatmary et al. (2022) and Heckler et al. (2021), who reported that necrosis and systemic complications are more frequent in severe cases, often confirmed by imaging.[5,20] The overall mortality rate in our study was 10.3%, which also aligns with global data showing mortality in severe acute pancreatitis ranges between 10% and 30%, depending on the presence of organ failure and timely intervention.

Age-wise stratification in our study showed that patients under 45 years of age had a higher sensitivity (88.8%) and diagnostic accuracy (75%) for MCTSI compared to those above 45 years, where sensitivity dropped to 57% and diagnostic accuracy was 78.1%. These findings may be attributed to younger patients presenting with more pronounced imaging findings or possibly fewer comorbidities that may confound the APACHE II score. These age-related discrepancies in diagnostic accuracy are not widely discussed in literature, suggesting a potential area for further research.

Gender-wise analysis revealed notable differences. Among females, MCTSI exhibited impressive sensitivity (100%) and negative predictive value (100%) making it highly successful at identifying people with non-severe cases. Positive predictive value, on the other hand, was low (37.5%), suggesting a potential for over estimating severity in this group. By contrast, males exhibited more balanced sensitivity and specificity (69.2% sensitivity and 75% specificity). These differences may simply represent physiological gender differences in inflammatory response or differences in the distribution of etiological factors; however, literature detailing gender-based accuracy of MCTSI is limited.

The majority of patients in our study had conservative management (82.4%), with only a limited number, undergoing

interventional procedures such as ERCP or laparoscopic cholecystectomy. This is consistent with current global management trends which endorse an approach that supports conservative management of most cases (mild to moderate pancreatitis) unless complications arise.[21,22] In our cohort, the total mortality rate was 10.3%, and the complications included pancreatic necrosis (17.6%), ARDS (4.4%), and AKI with septic shock (2.9%). These comparisons are consistent with worldwide estimates. Severe acute pancreatitis has a mortality rate of between 10% and 30% worldwide, which is especially true with some organ failure.[21]

The use of APACHE II as the standard in our case is supported by the importance of this scale in critical care medicine. Several studies have established APACHE II sensitivity and specificity of 81% and 65% for predicting severe acute pancreatitis, which closely follows our usage of the scale.[8,23] However, APACHE II is time-consuming and influenced by multiple physiological variables, making it less feasible in certain settings. In contrast, MCTSI provides a more direct radiological correlation to disease severity and is easier to apply once imaging is available. Our study supports the idea that MCTSI, due to its ease of calculation and relatively strong diagnostic accuracy, can serve as a reliable adjunct tool for early assessment of severity in acute pancreatitis, particularly in settings where APACHE II scoring is impractical.

CONCLUSION:

The Modified CT Severity Index (MCTSI) has reasonable diagnostic precision for identifying the severity of pancreatitis when assessed against both the APACHE II score. MCTSI provides a useful, practical, and easy to use radiological alternative that demonstrated 75% sensitivity and specificity; useful as clinicians are able to identify non-severe cases, especially within females and younger patients. Since MCTSI may help in early stratification of risk, it may promote timely clinical decision making to promote positive patient outcomes and avoid complications. Further large-scale, multi-center studies are warranted to validate our findings and examine demographics influence on diagnostic performance.

Authors Contribution:
Mahum Zaidi: Substantial contributions to conception and design, acquisition of data, analysis and interpretation of data; Drafting the article & revising it critically for important intellectual content;
Final approval of the version to be published.
Jawaid Iqbal: Acquisition of data, analysis and interpretation of data; Drafting the article, Final approval of the version to be published.
Rizwan Ajmal: Acquisition of data, revising it critically for important intellectual content, Final approval of the version to be published.
Qurat ul Ain Haroon: Drafting the article, Final approval of the version to be published.
Ramsha Fatima: Drafting the article, Final approval of the version to be published.
Sadia Khusrsheed: Analysis and interpretation of data, Final approval of the version to be published

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Original Article **Open Access**

Association of Cardiotocographic (CTG) Abnormalities with Delivery Outcomes in Women with a History of Cesarean Section

Komal Naveed, Asma Zubair, Ikram Ullah, Shadab Shakir, Rehana Bhittani, Neelam Hassan

ABSTRACT

Objectives: This study evaluates the relationship between Cardiotocography (CTG) variations and delivery outcomes in women undergoing a Trial of Labor After Cesarean (TOLAC). CTG variations, such as abnormal fetal heart rate (FHR) patterns, can indicate fetal distress or complications during labor. The study focuses on predicting outcomes such as vaginal birth success, caesarean section, and complications like uterine rupture and scar dehiscence.

Study Design and Setting: A case-control study was conducted at Lady Reading Hospital, Peshawar, from August 2022 to February 2023. The study involved 156 women, divided into two groups: 78 with unsuccessful vaginal deliveries (cases) and 78 with successful vaginal deliveries (controls).

Methodology: CTG was used to assess FHR patterns during labor, focusing on tachycardia, bradycardia, variability, and deceleration patterns. The study analyzed the later stages of labor and the impact of maternal factors such as age, BMI, and gestational age.

Results: Abnormal CTG readings, including fetal tachycardia (odds ratio 3.1) and bradycardia (odds ratio 2.2), were associated with poorer delivery outcomes. Maternal factors like age, BMI, and gestational age also influenced complications during labor.

Conclusions: CTG is an effective tool in managing TOLAC, improving maternal and neonatal outcomes. Its integration into labor protocols can reduce risks, particularly in low- and middle-income countries. Further research is needed to address maternal complications.

Keywords: Body Mass Index, Bradycardia, Cardiotocography, Caesarean Section, Fetal Heart Rate, Tachycardia, Uterine Rupture

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INTRODUCTION

Cesarean delivery rates have been rising globally, with many women who have undergone a previous cesarean section (C-section) considering a Trial of Labor After Cesarean (TOLAC) as a viable option for vaginal birth. TOLAC offers several potential benefits, including reduced maternal morbidity associated with repeat cesarean sections. However, it is not without its risks, the most concerning being uterine rupture and scar dehiscence. These complications are life-threatening for both mother and baby, making it essential to detect them early and intervene promptly. Early identification of potential risks allows healthcare providers to make informed decisions, ensuring better outcomes for both the mother and the fetus. Therefore, the role of effective monitoring during TOLAC cannot be overstated, as it provides critical information that can guide clinical interventions[1]. Cardiotocography (CTG) is a well-established, non-invasive method used to monitor fetal well-being during labor by assessing fetal heart rate (FHR) patterns. CTG allows continuous monitoring, providing valuable insights into fetal heart rate variations that could indicate distress or complications, such as uterine rupture or scar dehiscence.

Abnormal CTG findings, including tachycardia, bradycardia, or altered variability, are red flags that demand immediate attention and intervention. The challenge is determining how these CTG abnormalities correlate with delivery outcomes, particularly in high-risk situations such as TOLAC. The ability to predict and understand these relationships could significantly improve clinical decision-making, especially in settings where access to advanced diagnostic tools is limited[2]. TOLAC can reduce maternal morbidity by avoiding the risks associated with repeat caesarean deliveries, such as infection, haemorrhage, and longer recovery times. However, TOLAC also introduces the possibility of uterine rupture, a serious complication that occurs when the scar from a previous cesarean section tears during labor. Uterine rupture can lead to severe bleeding, fetal distress, and in some cases, fetal death. Another significant risk associated with TOLAC is scar dehiscence, a condition in which the previous C-section scar becomes weakened but does not completely rupture. Both uterine rupture and scar dehiscence present serious risks to maternal and fetal health, and their timely detection is critical to prevent severe outcomes. The need for reliable predictive tools to identify women at higher risk for these complications is essential for optimizing labor management[3]. CTG is one of the most commonly used tools for monitoring fetal heart rate and detecting abnormalities during labor. FHR patterns typically fluctuate based on fetal movement, uterine contractions, and maternal status. However, abnormal patterns in FHR—such as persistent tachycardia (an abnormally high heart rate), bradycardia (an abnormally low heart rate), or altered variability (reduced or absent fluctuations)—can indicate fetal distress. These abnormalities may signal conditions such as hypoxia, which can arise from complications like uterine rupture or placental insufficiency. CTG can also help identify other complications such as fetal acidosis or umbilical cord prolapse, both of which can have severe consequences for the fetus. By detecting these issues early, clinicians can intervene more effectively, potentially avoiding worse outcomes such as emergency cesarean delivery or stillbirth4. The study aimed to investigate the relationship between CTG abnormalities and delivery outcomes in women undergoing TOLAC. Specifically, it focused on predicting complications related to uterine scars, such as uterine rupture and scar dehiscence, which are of particular concern for women attempting a vaginal delivery after a previous C-section. Given the risks associated with these complications, early and accurate detection of CTG abnormalities could significantly improve clinical decision-making and patient management, especially in resource-limited settings. The role of CTG in predicting uterine rupture or scar dehiscence is critical, as it could potentially serve as a reliable, non-invasive method to identify women who may require more intensive monitoring or a shift in labor management protocols5. Previous studies have shown a strong association between abnormal CTG patterns and adverse outcomes in TOLAC, including uterine rupture. For instance, persistent fetal tachycardia has been linked to a higher risk of uterine rupture, while bradycardia and reduced FHR variability can indicate fetal distress related to inadequate oxygenation, which may occur due to uterine rupture or scar dehiscence. Furthermore, research suggests that combining CTG monitoring with maternal factors such as age, body mass index (BMI), and gestational age can improve prediction models for complications during TOLAC. For instance, older maternal age and higher BMI have been identified as risk factors for poor delivery outcomes, including uterine rupture. Integrating these maternal factors with CTG readings may allow for better risk stratification and more personalized labor management6. The findings of this study may have important implications for clinical practice, particularly in settings where access to advanced monitoring techniques is limited. In low- and middle-income countries, where resources may be constrained, the use of CTG as a primary monitoring tool can be especially beneficial. Its non-invasive nature and ability to provide continuous monitoring make it a valuable tool for detecting complications early, potentially reducing the need for more invasive procedures like cesarean sections. Additionally, CTG monitoring can help identify women at higher risk for uterine rupture or scar dehiscence, enabling clinicians to make timely interventions that improve maternal and neonatal outcomes .[7-8] In conclusion, the use of CTG as a monitoring tool during TOLAC is an essential part of managing high-risk pregnancies. Its ability to detect fetal heart rate abnormalities, particularly in relation to uterine rupture and scar dehiscence, provides valuable information for clinicians, helping them to make informed decisions and manage labor more effectively. While further research is needed to refine CTG-based prediction models, its integration into labor protocols has the potential to significantly improve maternal and neonatal outcomes, particularly in settings with limited access to advanced diagnostic technologies. By focusing on the early detection of complications, CTG can help reduce the risks associated with TOLAC and optimize labor management strategies

METHODOLOGY

This study was designed as a case-control investigation, conducted in the Department of Obstetrics and Gynecology at Lady Reading Hospital (LRH), Peshawar. The research took place over six months, from August 29, 2022, to February 29, 2023, involving a total of 156 participants. The participants were divided into two equal groups: 78 cases and 78 controls. The sample size was calculated using the WHO software (Version 2.00), with a 95% confidence level and 80% power, anticipating fetal tachycardia rates of 23% in the control group and 42.75% in the case group, as derived from previously published studies.

The participants were selected using a non-probability sequential sampling technique. Inclusion criteria required participants to be aged between 20 and 40 years, with a

singleton pregnancy verified by ultrasound, and a cephalic fetal position. Additional criteria included a parity of 1 to 4, a gestational age of 37 to 40 weeks (confirmed by the last menstrual period), and a history of at least one cesarean section followed by a trial of labor (TOLAC). The criteria were established according to the ACOG Practice Bulletin No. 205 (2019).

Exclusion criteria included individuals with intrauterine fetal demise, labor arrest during the first or second stage of labor, connective tissue disorders, thyroid dysfunction (hypothyroidism or hyperthyroidism), or those on beta-blockers. Ethical approval for the study was obtained from the Ethics Review Committee (ERC) of Lady Reading Hospital (ERC number 657/LRH/OG). The study was also approved by an independent institutional review board (IRB) after an ethical evaluation of the research. Informed consent was obtained from all participants, who were fully informed about the nature of the study, with assurances of voluntary participation, complete anonymity, and no anticipated risks.

Demographic data such as age, gestational age, parity, weight, and height were collected. Cases and controls were matched based on the number of vaginal deliveries following a previous cesarean section. Cardiotocography (CTG) abnormalities were evaluated in the case group using the most recent CTG strip obtained within the hour prior to repeat cesarean delivery. In the control group, CTG strips from the last hour before expulsive efforts were analyzed. Each CTG strip was divided into two halves of 30 minutes each.

Two consultant gynecologists, each with a minimum of five years of post-fellowship experience and blinded to clinical data, independently assessed the CTG strips for abnormalities, which included fetal tachycardia, bradycardia, variability (increased or decreased), and decelerations (early or late). In cases where discrepancies occurred, a third senior expert resolved the discrepancies, ensuring the accuracy of the definitive findings. Data collection was supported by a meticulously designed proforma to ensure consistency and accuracy in gathering the information.

Statistical analysis was performed using IBM-SPSS version 22. Categorical variables, such as parity, uterine scar issues, CTG abnormalities, and delivery outcomes, were expressed as frequencies and percentages. Continuous variables, such as age, weight, height, body mass index (BMI), and gestational age, were reported as means and standard deviations (SD). Odds ratios for CTG anomalies were calculated using a 2×2 contingency table, with 95% confidence intervals (CI) to assess the strength of associations. Stratified analysis was conducted to evaluate potential effect modifiers based on age groups, BMI categories, gestational age, and parity.

RESULTS

This study, involving 160 women (80 instances of unsuccessful vaginal births and 80 controls with successful vaginal deliveries), revealed significant insights into the determinants of Trial of Labor After Cesarean (TOLAC) delivery outcomes. As outlined in the objectives, the key outcomes of TOLAC in this study are successful vaginal deliveries and unsuccessful vaginal deliveries, which typically require a repeat cesarean section. The mean age of the patients was 30.57 ± 4.665 years, slightly higher than the control group's mean age of 28.72 ± 4.96 years. Advanced maternal age, particularly women aged 31 to 40, was associated with an increased likelihood of unsuccessful vaginal delivery. Additionally, gestational age was a significant factor, with the highest incidence of unsuccessful vaginal deliveries seen in the 39–40-week group. Body Mass Index (BMI) was another significant predictor; women with a higher BMI (>22) showed improved outcomes in the control group. The study also emphasized the role of CTG anomalies such as fetal tachycardia and bradycardia, which were observed more frequently in women with unsuccessful vaginal deliveries. These results underscore the importance of continuous CTG monitoring for high-risk pregnancies, particularly TOLAC candidates, where maternal factors like age, BMI, and gestational age significantly affect the success of vaginal delivery. The findings highlight the need for early identification and timely interventions to avoid complications such as uterine rupture and scar dehiscence, which are risks associated with TOLAC.

Table 1: Demographic and Clinical Characteristics of Participants

Category	Subcategory	Cases (n=80)	Controls (n=80)
Age Group (years)	18-30	42	54
	31-40	38	26
Gestational Age (weeks)	37-38	38	42
	39-40	42	38
BMI (kg/m²)	=22	40	34
	>22	40	46

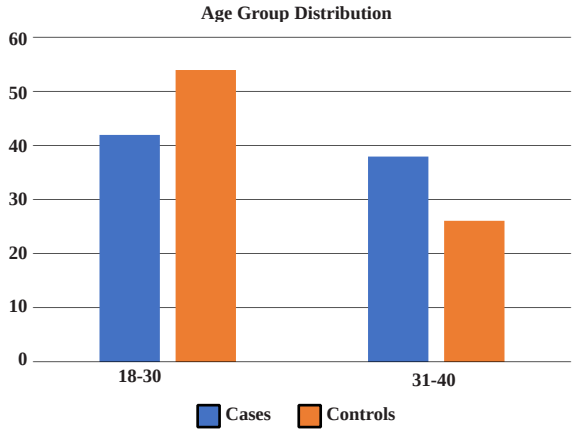


Figure 2: Gastational Age Distribution

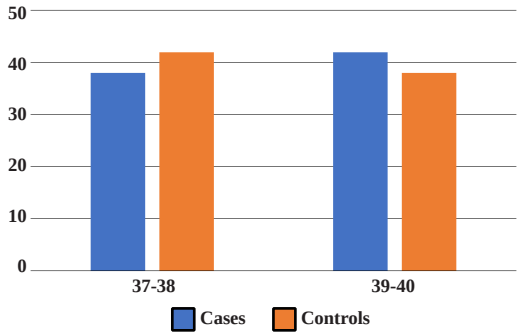


Figure 3: BMI Distribution

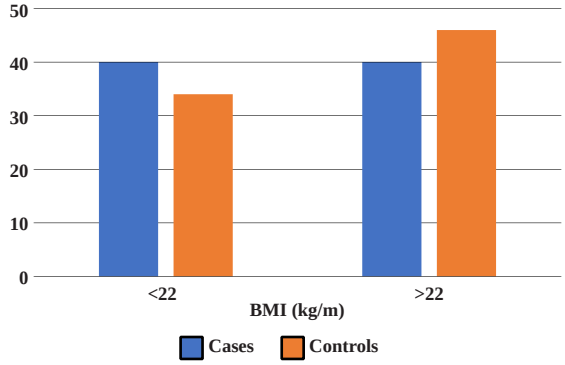
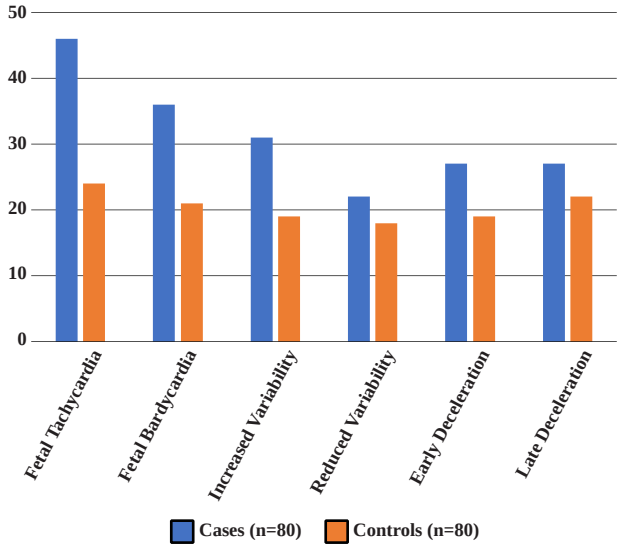


Figure 4: Frequency of CTG Abnormalities in Cases vs Controls



Bar chart showing the frequency of CTG abnormalities in both cases and controls. The odds ratios (with 95% confidence intervals) are also displayed above each bar to provide insights into the strength of the association between the abnormalities and the outcomes.

DISCUSSION

This case-control study, conducted at Lady Reading Hospital in Peshawar, evaluated the association between cardiotocography (CTG) abnormalities and delivery outcomes

Table 2: CTG Abnormalities in Cases and Controls

CTG Abnormality	Cases (n=80)	Controls (n=80)	Odds Ratio (95% CI)
Fetal Tachycardia	46	24	3.1 (1.6-6.0)
Fetal Bradycardia	36	21	2.2 (1.1-4.4)
Increased Variability	31	19	2.0 (1.0-4.0)
Reduced Variability	22	18	1.3 (0.6-2.6)
Early Deceleration	27	19	1.6 (0.8-3.2)
Late Deceleration	27	22	1.3 (0.7-2.6)

in women undergoing a trial of labor after a previous cesarean section (TOLAC). The study provides important insights into maternal risk factors and their influence on delivery outcomes, emphasizing the role of CTG monitoring in detecting potential complications.Demographic comparisons between cases and controls revealed significant differences in age, body mass index (BMI), and gestational age. The cases, which had an unsuccessful vaginal birth, were generally older and exhibited a higher BMI compared to the controls. These findings align with previous studies, which have highlighted advanced maternal age and obesity as significant risk factors for adverse pregnancy outcomes, including labor complications, fetal distress, and increased cesarean delivery rates?,[1°]. Maternal age and obesity have long been associated with complications during pregnancy, and our findings emphasize the need for careful monitoring of these factors in women undergoing TOLAC.In terms of gestational age, the distribution of participants was relatively uniform, with a significant number of complications observed in the 39–40 weeks subgroup. This finding is consistent with existing research indicating that advancing gestational age, especially beyond 39 weeks, increases the risk of complications like uterine rupture and fetal distress in women with a history of cesarean section[11]. The study also found that women with lower parity (1-2 prior births) were more prevalent in the case group, which has been associated with higher risks of labor-related complications in women attempting vaginal birth after cesarean (VBAC)[12]. These demographic variables—maternal age, BMI, and parity—were likely influential in the CTG findings and delivery outcomes, supporting the idea that these factors must be considered when planning TOLAC. One of the most significant findings of this study was the higher incidence of CTG abnormalities in the case group compared to the controls. Specifically, fetal tachycardia (OR: 3.1, 95% CI: 1.6-6.0), bradycardia, and increased variability were more prevalent in the cases, aligning with previous studies that have shown CTG abnormalities as key indicators of fetal distress, particularly in high-risk pregnancies such as TOLAC[13]. Enabudoso (2021) emphasized the importance of CTG monitoring for detecting uterine rupture risks in women undergoing VBAC, with tachycardia and bradycardia serving as significant warning signs of potential complications like uterine rupture or scar dehiscence[14]. Our results also indicate that heightened

variability and fetal bradycardia were linked to adverse delivery outcomes, which suggests that these CTG markers could provide valuable information for clinical decision-making, potentially leading to timely interventions like repeat cesarean delivery to prevent complications. Interestingly, early and late decelerations did not show a statistically significant difference between the cases and controls in this study. This finding raises questions about the reliability of decelerations as indicators of adverse outcomes in this cohort, which is supported by studies that have highlighted the inconsistent relationship between decelerations and severe fetal compromise[15]. As noted by Rajak et al. (2024), while various CTG parameters can help identify labor complications, not all abnormalities, such as early and late decelerations, may always correlate with fetal distress[16-17]. This suggests the need for a more nuanced approach to CTG interpretation and underscores the importance of integrating clinical judgment with CTG findings to improve outcomes for women undergoing TOLAC.The results of this study reinforce the idea that maternal characteristics—such as age, BMI, and parity—play a significant role in determining the likelihood of complications during TOLAC. Additionally, abnormal CTG findings, particularly tachycardia, bradycardia, and increased variability, are associated with poorer delivery outcomes, including uterine rupture and scar dehiscence. These findings highlight the value of continuous CTG monitoring in high-risk pregnancies, particularly for women attempting vaginal birth after a previous cesarean section.Moreover, the study suggests that early and accurate identification of CTG abnormalities, along with a comprehensive evaluation of maternal factors, can improve clinical decision-making and reduce the risks associated with TOLAC[18-19-20]. Although early and late decelerations did not demonstrate a significant correlation with adverse outcomes in this cohort, other CTG abnormalities, such as fetal tachycardia and bradycardia, remain critical indicators of fetal distress. Further research is needed to refine the predictive value of CTG parameters and to explore how maternal factors interact with CTG findings to affect delivery outcomes.

CONCLUSION

CTG remains an essential tool for monitoring fetal well-being in high-risk pregnancies, particularly during TOLAC. The study emphasizes the importance of monitoring CTG findings alongside maternal characteristics to improve labor management and reduce the risk of complications. These findings can inform clinical practices in resource-limited settings, where CTG can serve as a cost-effective and non-invasive tool for detecting complications early. However, more research is needed to better understand the relationship between CTG abnormalities and maternal risk factors to refine labor management protocols further.

Authors Contribution:
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Asma Zubair: Data Collection
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Original Article **Open Access**

Comparison of Extracorporeal Shock Wave Lithotripsy (ESWL) With and Without DJ Stenting in Proximal Ureteric and Renal Pelvis Stones

Anum Ansari, Naresh Kumar Valecha, Arif Ali, Ayesha Khan, Abdul Mujeeb, Hassan Siddiqui

ABSTRACT

Introduction: Urolithiasis requires effective management. ESWL is common for proximal ureteric and renal pelvis stones, but the role of routine DJ stenting is debated. This study evaluates its impact on stone clearance for 1.5–2 cm stones.

Study Design and Setting: A prospective comparative cohort study was conducted over a six-month period from September 2024 to February 2025.

Methodology:A total of 70 patients with renal pelvis or proximal ureteric stones (1.5–2.0 cm, =1000 HU) were enrolled through non-probability consecutive sampling and divided into two equal groups: Group A (ESWL without DJ stent) and Group B (ESWL with DJ stent) by simple randomization through lottery technique. Patients underwent up to five ESWL sessions using the Dornier Sigma Plus 2 lithotripter. Treatment success was defined as complete stone clearance confirmed by X-ray KUB and ultrasound one month after the final session. Data were analyzed using SPSS version 26, Chi square tests were applied, with significance set at p = 0.05

Results: Stone clearance was achieved in 29 (82.9%) patients in the DJ stent group and 27 (77.1%) in the non-stented group. Statistical analysis revealed no significant difference between the groups (p = 0.550). Subgroup analysis by stone size, density, and Body Mass Index (BMI) showed no clear correlation with treatment success.

Conclusion: The findings indicate that routine DJ stenting does not notably improve stone clearance in ESWL for 1.5–2 cm proximal ureteric and renal pelvis stones. A selective, risk-based stenting approach is advised, particularly in resource-constrained settings.

Keywords: Lithotripsy, Shock Wave**,** Stents, Urolithiasis, Kidney Calculi, Treatment Outcome, Risk Factors, Minimally Invasive

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INTRODUCTION

Urolithiasis, or urinary stone disease, is a globally prevalent urological condition characterized by the formation of calculi in the kidney, ureter, or bladder. It often necessitates medical or surgical intervention due to complications such as acute renal colic, urinary tract infections, hematuria, and obstructive uropathy. The incidence and recurrence of stone disease have increased worldwide, driven by dietary, metabolic, and genetic factors. Various treatment modalities are available, including Extracorporeal Shock Wave Lithotripsy (ESWL), ureteroscopy (URS), percutaneous nephrolithotomy (PCNL), and open or laparoscopic surgery. The choice of modality depends on several variables, such as stone size, location, density, patient anatomy, and resource availability.[1] Among these, ESWL has gained popularity as a non-invasive technique since its introduction in the early 1980s. It utilizes focused acoustic shockwaves to fragment stones into smaller pieces, which are then naturally passed through the urinary tract without surgical extraction.[2] ESWL is particularly effective for stones located in the renal pelvis or proximal ureter and measuring less than 2 cm, offering advantages such as reduced morbidity, shorter hospital stays, and minimal postoperative pain.[3]

However, the success of ESWL is not universal and varies based on stone and patient factors. Stone size is one of the most critical determinants of ESWL outcome. Stones smaller than 1.5 cm tend to respond favorably, while larger stones (1.5–2 cm) often exhibit incomplete fragmentation, increasing the risk of complications. High stone burden can lead to the formation of "steinstrasse"—a condition in which fragmented stones obstruct the ureter, causing flank pain, infection, hydronephrosis, or even renal damage.[4] In an attempt to mitigate these risks, the use of ureteral double-J (DJ) stents has become a standard adjunctive measure. These stents maintain the patency of the ureter, facilitate the passage of stone fragments, and help reduce post-ESWL obstruction. Nonetheless, the blanket application of DJ stents in all ESWL patients remains controversial. While theoretically beneficial, stents can also result in adverse effects, including lower urinary tract symptoms (frequency, urgency, dysuria), hematuria, infection, migration, and encrustation. Moreover, their insertion and removal add to healthcare costs and patient discomfort, making the decision to use them more complex, particularly in low- and middle-income countries.[5,6] Numerous studies have explored the necessity and impact of DJ stenting before ESWL, yielding mixed results. A prospective study assessed outcomes in stented and non-stented patients undergoing ESWL for proximal ureteric stones and found no significant difference in stone clearance or complication rates between the two groups. Their findings suggested that routine pre-ESWL stenting may be unnecessary and that a more selective approach based on patient risk factors may be more appropriate.[7,8] While ESWL remains a cornerstone of stone management, its long-term effectiveness has plateaued, partly due to overuse or misuse of adjunctive interventions like stents. and individualized treatment planning should be encouraged rather than a "one-size-fits-all" strategy, encouraging clinicians to reserve stenting for selected cases.[9, 10] The need for high-quality evidence is thereby emphasized to better understand the safety and efficacy of ESWL and its adjuncts. This calls for comprehensive evaluation of outcomes like stone-free rate, retreatment necessity, and adverse events to guide decision-making.[11] The European Association of Urology (EAU) Guidelines on Urolithiasis (2022) echo this sentiment, recommending DJ stenting only in select scenarios such as solitary kidneys, urinary tract infections, significant obstruction, or anatomical abnormalities.[12]

In light of the ongoing debate regarding the necessity and effectiveness of ureteral stenting prior to extracorporeal shock wave lithotripsy (ESWL), the present study was designed to evaluate and compare the clinical outcomes of ESWL performed with and without double-J (DJ) stenting in patients diagnosed with proximal ureteric and renal pelvis stones measuring between 1.5 and 2 cm. This stone size range represents an intermediate category where the decision to place a stent remains particularly controversial. The primary objective of the study is to determine whether routine pre-ESWL DJ stenting confers a significant clinical advantage in terms of stone clearance, prevention of complications such as steinstrasse, and reduction in the need for secondary interventions, or whether its use may be safely omitted in patients who do not present with predisposing high-risk features such as solitary kidney, urinary tract infection, or anatomical abnormalities. This research holds particular relevance in resource-limited healthcare settings like Pakistan, where cost-effectiveness and optimization of medical resources are crucial. By systematically analyzing outcomes including stone-free rates, incidence of post-procedural complications, frequency of hospital readmissions, and patient-reported discomfort or urinary symptoms, the study aims to provide data-driven clarity. Ultimately, the findings may contribute toward a more individualized, patient-centered, and economically viable approach to the management of urolithiasis in diverse clinical contexts.

METHODOLOGY

This Prospective Comparative Cohort study was conducted at the Department of Urological Surgery and Transplantation, Ward 19, Jinnah Postgraduate Medical Centre (JPMC), Karachi, over a period of six months i.e. from September, 2024 to February, 2025. A non-probability consecutive sampling technique was used to enroll patients from the outpatient department. Eligible patients were assessed and randomly allocated to one of the two treatment groups using a simple randomization technique. Based on a power analysis using PASS 2020 software, a total of 70 patients were included in the study—35 in Group A (ESWL without DJ stent) and 35 in Group B (ESWL with DJ stent). The study achieved a statistical power of 81.1% to detect a difference of 33.34% between the two groups, using a two-sided Fisher's Exact Test at a significance level of 0.05.[5]

Inclusion criteria comprised patients of either gender, aged between 15 and 55 years, with renal pelvis or proximal ureteric stones sized between 1.5 and 2.0 cm and a density of <=1000 Hounsfield Units as confirmed by CT KUB with negative urine culture and sensitivity report. Patients with previously positive urine cultures were included only if the infection had been treated. Exclusion criteria included active bacterial infection, bleeding disorders, multiple stones, severe skeletal malformations or obesity, pregnancy, solitary kidney, pyonephrosis or sepsis, distal obstruction, stones outside the defined size range, or stones located in the other locations other than renal pelvis or proximal ureter. Patients who were not able to tolerate pain in ESWL sessions despite adequate analgesia were also excluded from the study.

After obtaining ethical approval from the College of Physicians and Surgeons of Pakistan and the institutional review board, IRB no: NO.F.2-81/2024-GENL/95/JPMC. Eligible patients were assessed and randomly allocated to one of the two treatment groups.

Prior to ESWL, patients underwent imaging (CT KUB, X-ray, or ultrasound) and laboratory evaluations including renal function, coagulation profile, and urine culture. Positive cultures were treated before the procedure. Patients fasted for 4–6 hours and received preoperative analgesics, such as intramuscular diclofenac or intravenous paracetamol, approximately 30–45 minutes before treatment. After checking blood pressure, pulse rate and temperature, demographic and clinical details were recorded on a structured proforma. Patients underwent maximum of five sessions scheduled fortnightly, in the Lithotripsy Suite of the Department of Urological Surgery and Transplantation. All procedures were performed under supervision of a consultant urologist with a minimum of five years of post-fellowship experience.

All extracorporeal shock wave lithotripsy (ESWL) procedures were performed using the Dornier Sigma Plus 2 lithotripter (Dornier MedTech, Germany). This device utilizes electromagnetic shock wave generation technology for non-invasive stone fragmentation. It is equipped with dual imaging modalities, including fluoroscopy and ultrasound. The patient is positioned on an ergonomically designed therapy table that facilitates optimal alignment with the focal point of the shock waves. The patient positioned supine or prone based on stone location. Stone targeting was achieved using fluoroscopic or ultrasonographic guidance. During each 45-minute session, 2500–3000 shockwaves were delivered at a frequency of 60–90 per minute, the shockwaves were administered at an initial low frequency and energy level i.e. 1.0–1.5 kV, which was gradually increased to optimize fragmentation while minimizing tissue injury based on patient tolerance and fragmentation response. Throughout the procedure, real-time imaging was used to monitor stone fragmentation and reposition the patient if needed. Continuous monitoring of the patient's vital signs was performed by the procedural nursing team.

After the procedure, patients were transferred to a recovery room for observation for 1–2 hours. Pain control and hydration were ensured. If no immediate complications such as hematuria, hypotension, or severe pain were observed, the patient was discharged the same day with post-procedural instructions. These included advice on hydration (2–3 liters/day), antibiotics, alpha-blockers, pain management (oral analgesics), activity limitation for 48 hours, and signs of complications (e.g., fever, severe pain, hematuria, or inability to void).

Patients were advised to strain their urine to monitor stone fragment passage and scheduled for follow-up imaging (X-ray KUB and ultrasound) one month after the last session to assess stone clearance. A maximum of five ESWL sessions were allowed per patient, spaced fortnightly, based on fragmentation response and residual stone burden.

Treatment success was defined as complete stone clearance, assessed one month after the final ESWL session using X-ray KUB and ultrasonography. A stone-free status was confirmed by the absence of radio-opaque shadows on X-ray and hyperechoeic areas with acoustic shadows on ultrasound. Treatment failure was defined as the presence of steinstrasse requiring emergency intervention or the need for auxiliary procedures.

Data were analyzed using SPSS version 26 (Build 1.0.0.1275). Variables that were normally distributed were reported as mean ± standard deviation, while skewed variables were presented as medians along with interquartile ranges. Categorical variables, including gender and treatment outcomes, were expressed as frequencies and percentages. To assess the association between DJ stenting and treatment success, the Chi-square test was applied. If the assumptions of the Chi-square test were violated, Yates' corrected Chi-square test was used to account for small expected frequencies. Potential effect modification by age, BMI, and stone size was evaluated through stratification of the data. A p-value of =0.05 was considered statistically significant.

RESULTS:

Among the 70 patients studied, 35 were treated with DJ stents and 35 without. Stone clearance was successful in 29 (82.9%). Of all patients with successful clearance, 51.8% were from the stented group and 48.2% from the non-stented group. Table 1. Although the stented group showed a slightly higher success rate, statistical analysis revealed no significant difference between the groups. The Pearson Chi-square test yielded a p-value of 0.550, and similar findings were supported by the Fisher's Exact Test (2-sided p = 0.766; 1-sided p = 0.383).

Confidence intervals for stone clearance were 69.4%–96.3% in the DJ stent group and 62.7%–91.4% in the non-stented group, with notable overlap, reinforcing the conclusion that the use of DJ stents did not significantly affect stone clearance outcomes in this study population.

Size-Stratified Outcomes: Crosstab analysis comparing stone clearance success by stone size and DJ stenting status revealed that in both groups, smaller stones (15–16 mm) showed higher clearance rates (100% in most cases), while clearance rates declined with increasing stone size. Table 2. Although a trend toward higher stone clearance with smaller stone sizes was observed, the differences were not statistically significant in the stented group (p = 0.340), non-stented group (p = 0.445), or the combined cohort (p = 0.111).

Stone Density-Stratified Outcomes: The analysis showed a clear trend: *stone clearance success decreased as stone density increased*, regardless of DJ stenting. Patients with stone densities =700 HU had a 100% success rate in both groups. However, as density rose, success rates declined. Table 3

Although Chi-square tests showed no significant association

between stone density and clearance success in either group ($p > 0.05$), the Likelihood Ratio test for the combined data indicated a marginally significant result ($p = 0.035$), suggesting a possible trend toward reduced clearance with increasing stone density. BMI-Stratified Outcomes: Among 70 patients undergoing ESWL, the overall stone clearance rate was 80%. Clearance rates varied by BMI: overweight (85%) and underweight (100%) patients had the highest success, while obese patients had the lowest success rate. DJ stenting appeared more beneficial in normal and overweight individuals but not in obese patients. Table 4 Chi-square analysis revealed no statistically significant association between BMI and stone clearance in either group ($p > 0.05$). This may be attributed to the small sample sizes within each BMI subgroup, limiting the power to detect a true difference.

Table 1: Comparison of Success (Stone Clearance) Rate ESWL in patients with DJ stent vs. without DJ stent

Group	**Success (Yes)**	**Failure (No)**	**Success %**	**Failure %**
With DJ Stent	29	6	82.9%	17.1%
Without DJ Stent	27	8	77.1%	22.9%

Table 2: The table compares stone clearance success by stone size for patients undergoing ESWL with and without a DJ stent (stone sizes ranging from 15 to 20 mm). The Success Count/Total shows how many patients cleared their stones out of the total in each category

Stone Size (mm)	With DJ Stent (Success Count / Total)	With DJ Stent (% Success)	Without DJ Stent (Success Count / Total)	Without DJ Stent (% Success)
15	10/10	100.0%	12/13	92.3%
16	4/4	100.0%	2/2	100.0%
17	6/9	66.7%	4/6	66.7%
18	2/3	66.7%	1/1	100.0%
19	2/3	66.7%	5/8	62.5%
20	5/6	83.3%	3/5	60.0%
Total	29/35	82.9%	27/35	77.1%

Table 3: Table shows side-by-side comparison of stone clearance success rates across different stone density ranges (in Hounsfield Units) for patients undergoing ESWL with and without DJ stenting.

Stone Density (HU)	With DJ Stent (Success / Total)	With DJ Stent (% Success)	Without DJ Stent (Success / Total)	Without DJ Stent (% Success)
300–400	–	–	1/1	100.0%
401–500	–	–	1/1	100.0%
501–600	6/6	100.0%	4/4	100.0%
601–700	4/4	100.0%	3/3	100.0%
701–800	8/9	88.9%	8/9	88.9%
801–900	¾	75.0%	3/4	75.0%
901–1000	5/6	83.3%	4/8	50.0%
1001–1200	3/6	50.0%	3/5	60.0%
Total	29/35	82.9%	27/35	77.1%

Table 4: This table compares stone clearance success by BMI category in patients undergoing ESWL with and without DJ stenting.

BMI Category	With DJ Stent (Success / Total)	With DJ Stent (% Success)	Without DJ Stent (Success / Total)	Without DJ Stent (% Success)
Underweight	1/1	100.0%	1/1	100.0%
Normal	17/21	81.0%	16/22	72.7%
Overweight	10/11	90.9%	7/9	77.8%
Obese	½	50.0%	1/3	33.3%
Total	29/35	82.9%	27/35	77.1%

DISCUSSION

This study evaluated how effective Extracorporeal Shock Wave Lithotripsy (ESWL) is for treating proximal ureteric and renal pelvis stones measuring 1.5 to 2 cm, comparing outcomes with and without the use of a Double-J (DJ) stent. The results showed a slightly higher stone clearance rate in the stented group (82.9%) versus the non-stented group (77.1%), but this difference wasn't statistically significant. These findings are consistent with previous research on the role of DJ stents in stone treatment.[8]

Tailly[10] highlighted that ESWL continues to be a key treatment for urolithiasis, especially as technology evolves and improves success rates for medium-sized stones. However, the benefits of adding a DJ stent remain controversial. Research by Pogula et al.[8] suggests that while stents may not significantly increase stone clearance, they can help prevent complications like ureteral blockages or the formation of steinstrasse. Similarly, our study didn't show a major advantage with stenting, although the slight increase in success rates may support its use in select cases.

Cao et al.[11] stressed that selecting the right patients and using proper technique are key to achieving good outcomes. The European Association of Urology also advises using DJ stents selectively, based on factors like stone size, location, and patient risk profile[12]; thus confirming ESWL's effectiveness for stones in the proximal ureter and renal pelvis, with a strong safety profile. Pansota et al.[13] found no significant difference in stone-free rates between patients who received stents and those who didn't. However, they did observe fewer complications in the stented group, suggesting that stenting might be justified in patients with larger stones or anatomical concerns.

When considering stone size, a slightly higher clearance rate was observed in patients with DJ stents, particularly those with larger stones—an observation consistent with findings from previous studies.[8] Stone size is a key factor influencing the effectiveness of ESWL. Park et al. and a meta-analysis published in 2007 reported a significant decrease in ESWL success rates for stones larger than 10 mm, dropping from 86% to 67.5%. Similar trends were observed in our study, where the success rate in the non-stented group declined from 100% for 15 mm stones to 60%

for stones measuring 20 mm.[14, 15]

Stone density also plays a significant role in determining the success of stone clearance following ESWL. In our study, stones with a Hounsfield Unit (HU) value of less than 800 had a success rate of approximately 97.78%, whereas the success rate dropped to 61.66% in stones with HU >800 among patients who underwent ESWL without prior DJ stenting. These findings are consistent with previously reported studies.[16]

BMI also has a negative impact on stone clearance rates following ESWL.[17] In our study, the success rate in the stented group declined from 100% in underweight individuals to 50% in those who were obese. Similarly, in the non-stented group, the success rate dropped from 100% in underweight patients to 33.3% in obese individuals.

There's also growing interest in using other therapies alongside ESWL to improve outcomes. For instance, alpha-blockers like tamsulosin have been shown to help pass stones more easily and reduce the need for multiple ESWL sessions.[18] Though this wasn't covered in our study, it reinforces the value of tailoring treatment to the individual patient.

One critical consideration is how DJ stents affect patients' quality of life. While they may help avoid complications, stents are often uncomfortable and can cause symptoms such as urinary urgency, blood in the urine, and painful urination.[11, 19] This reinforces the need to weigh the benefits against the potential discomfort when deciding whether to use a stent. This was not part of our study protocol but during follow-up visits of patients included in our study with DJ stent in situ similar bothersome symptoms were reported. In addition, the presence of a DJ stent may reduce ESWL efficacy by absorbing some of the shock wave energy and by inducing ureteral edema, which can hinder fragment passage. These factors may limit optimal stone fragmentation and clearance during treatment.[20]

Recent innovations in DJ stent technology aim to improve patient comfort and reduce complications. Biodegradable stents eliminate the need for removal procedures, while magnetic-tip stents allow easy outpatient removal without cystoscopy or anesthesia. Softer silicone stents and custom-length designs help reduce bladder irritation and stent-related symptoms. Although stent insertion is usually done under spinal or general anesthesia, selected patients may tolerate it under local anesthesia using flexible cystoscopy, though complete insertion without any anesthesia is generally not feasible due to discomfort.[21]

This study has a few limitations. Since it was conducted at a single center with a relatively small number of patients, the findings may not fully reflect outcomes in other settings. Also, the follow-up period was short, so long-term results like recurrence or late complications couldn't be assessed. Lastly, it focused only on ESWL with and without stents, without comparing other newer treatments like flexible ureteroscopy or mini-PCNL that might offer better outcomes for similar stones.

CONCLUSION:

This Prospective Comparative Cohort study assessed the effectiveness of ESWL with and without DJ stenting for proximal ureteric and renal pelvis stones measuring 1.5–2 cm. The findings showed no statistically significant difference in stone clearance between stented and non-stented groups, despite a slightly higher success rate in the stented group. Additionally, stone size, density, and BMI did not show a consistent correlation with treatment success.These results support the use of a selective, rather than routine, approach to DJ stenting—tailoring its use based on individual patient risk factors. This strategy is particularly relevant in resource-limited settings, where cost-effectiveness is crucial.Overall, the study contributes to the ongoing discussion about the necessity of routine DJ stenting especially in resource-limited settings where cost-effective treatment strategies are essential in ESWL and highlights the need for larger, more targeted studies to further clarify when stenting may provide the greatest benefit.In conclusion, while routine stenting may not be required for all ESWL patients with proximal ureteric and renal pelvis stones, our findings suggest that there may be specific cases where stenting could still play a beneficial role.

Authors Contribution:
Anum Ansari: Data collection, Analysis and interpretation, Manuscript Drafting
Naresh Kumar Valecha: Conceived original idea, contributed to study design, critical revision of the manuscript, approval of final version for publication.
Arif Ali Shaikh: Supervision of study, critical revision of the manuscript.
Ayesha Khan: input on study design, data interpretation, critical revision of manuscript
Abdul Mujeeb: Provided clinical oversight, reviewed and revised the manuscript for accuracy.
Hassan Siddiqui: Contributed to data collection and assisted in the critical revision of the manuscript

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Original Article **Open Access**

Comparison of Coronectomy and complete extraction for impacted Third Molars in Close Proximity to Inferior Alveolar Nerve

Adnan Haider, Shahid Ali, Shahzad Iqbal Malik, Muhammad Mustafa, Iram Pervaiz, Fatima Imran

ABSTRACT

Objective: To compare the effectiveness and safety of coronectomy versus complete extraction for the removal of impacted mandibular third molars in proximity to the inferior alveolar nerve.

Study Design and Setting: This is a prospective, comparative interventional study that was carried out at the Department of Oral and Maxillofacial Surgery at de'Montmorency College of Dentistry/Punjab Dental Hospital, Lahore. The study occurs within a time frame of six months and begins after the study proposal was approved by the College of Physicians and Surgeons Pakistan (CPSP) and the institutional ethics review board.

Methodology: A total of 160 patients were recruited, with equal allocation into two groups: 80 participants in the coronectomy group and 80 in the complete extraction group. Data collection was done using a structured proforma, and statistical analysis was conducted using SPSS version 27. Independent sample t-tests were applied for comparing mean pain durations, while chi-square tests were used for assessing group differences in paresthesia and swelling. A p-value of = 0.05 was considered statistically significant throughout.

Results: Coronectomy is associated with significantly better postoperative outcomes compared to complete extraction. While both groups were comparable in terms of age, gender, and tooth laterality, the coronectomy group experienced a significantly shorter duration of pain ($p = 0.004$) and markedly lower incidences of paresthesia ($p = 0.0001$) and swelling ($p = 0.0001$).

Conclusion: Coronectomy is associated with fewer postoperative complications, particularly swelling and paresthesia, making it a safer alternative to total extraction in cases where the impacted third molar is close to the inferior alveolar nerve.

Keyword: Alveolar Nerve, Coronectomy, Mandible, Oral Surgical Procedure, Tooth Extraction, Third Molar, Paresthesia

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INTRODUCTION

The third molars, commonly known as wisdom teeth, are arguably the most commonly impacted teeth in the human dentition. The reasons for the impaction of third molars vary, but generally, the impaction is due to limited space in the posterior mandible, an aberration in the eruption path, or anatomic barriers. While some impacted third molars remain asymptomatic for a long period of time, many impactions can develop into clinical issues eventually. These clinical issues can include pain and pericoronitis, or loss of root structure of tooth number 31 or 32 due to resorption of root structure, caries because of food impaction or a combination of the above. For the aforementioned reasons, surgical intervention of third molars in the form of tooth extraction is recommended.

There is a considerable risk of nerve damage when impacted mandibular third molars are extracted routinely, especially if the molar is near the inferior alveolar nerve (IAN). An essential part that travels through the mandibular canal is the IAN, and the IAN's close proximity to the third molar roots increases the risk of trauma during surgical extraction. Paresthesia is a transient or permanent loss of sensation

associated with the lower lip and chin that can be caused by damage to the IAN. Reported rates of IAN injury after third molar extraction vary significantly based on the research methods, ranging from 0.4% to 8.1% in terms of temporary paresthesia, and 0.014% to 3.6% in terms of permanent deficit.

The roles of radiographic assessments with orthopantomogram (OPG) and cone-beam computed tomography (CBCT) are extremely important in assessing the three-dimensional location of third molar roots about the mandibular canal. If this proximity poses a risk (for example, root apex within 1 mm or overlapping the canal), the surgeon must consider a different surgical plan to avoid damage to the nerve.

A coronectomy consists of removing the crown of the impacted third molar while the roots remain undisturbed within the bone. The risk of inferior alveolar nerve trauma is significantly reduced by using coronectomy, and it still allows for the tooth's clinical symptoms or any potential complications to be treated. Coronectomy was first reported in the 1980s, and while the surgical technique is considered uncommon, it emerged as growing evidence confirms a favorable outcome, with significantly lower rates of paresthesia, pain, and swelling compared to complete extraction.

In high-risk circumstances, coronectomy is a safe substitute for total extraction, according to several international studies. Research studies by Hamad et al. (2024) and Kostares et al. (2024) documented a statistically significantly lower incidence of IAN injury following coronectomy. Based on the international body of evidence, it is clear that coronectomy as a surgical technique, whether undertaken as a day case or inpatient, is effective as well as safe.[12]

Unfortunately, the evidence from the Pakistani population remains low. In Pakistan, third molar extraction is a public and private sector enterprise in which the risk of nerve damage must be mitigated through appropriate planning before intervention in patients who are at a greater risk due to proximity to the inferior alveolar nerve (IAN). There is a pressing need to assess coronectomy as an appropriate and evidence-based option within our clinical framework. When we consider patients who have a high-risk anatomical relationship to the IAN, we could therefore adopt a policy of coronectomy versus complete extraction. Whether we can develop appropriate clinical guidelines for practitioners to deliver patient care in a safer surgical capacity or mitigate postoperative complications is another consideration. This study aimed to compare the effectiveness and safety of coronectomy versus complete extraction for the removal of impacted mandibular third molars in proximity to the inferior alveolar nerve.

METHODOLOGY

This is a prospective, comparative interventional studythat was carried out at the Department of Oral and Maxillofacial Surgery at de'Montmorency College of Dentistry/Punjab Dental Hospital, Lahore. The study occurs within a time frame of six months and begins after the study proposal was approved by the College of Physicians and Surgeons Pakistan (CPSP) and the institutional ethics review board and the ERC number is 2222.

One hundred sixty patients were randomly recruited and divided equally into two groups, with 80 participants in the coronectomy group and 80 in the whole extraction group. The sample size has been determined at a 95% confidence level, with 80% statistical power, and a previously recorded prevalence rate of colectomy at 35.9%. The selection of patients was made on a non-probability purposive basis, with 13.

Inclusion criteria were adults aged 22–40 years of either gender with impacted mandibular third molars that were either partially or completely unerupted and located in close proximity to the inferior alveolar nerve (IAN).[13] Proximity was defined radiographically as being less than 1 mm between the root apex and the inferior dental canal on a 100% scale orthopantomogram (OPG). Eligible patients were required to be systemically healthy and unmedicated with antibiotics or NSAIDs in the 2 weeks before surgery. Patients with active infection in their third molars, a systemic medical condition (e.g., diabetes, hypertension, cardiovascular or renal disease) or who were pregnant were not included in the study.

The patients were also excluded in case the affected third molars were destructively pathological, such as root caries, periapical lesions, cystic or neoplastic masses or in circumstances where the retained roots were movable or weak.[14] Additional exclusion criteria included acute infections, diseased conditions in which medicine interfered with surgical procedures (e.g., poorly controlled diabetes, coagulation disorders), and pregnancy or breastfeeding, as well as the unwillingness or incapacity to visit the scheduled follow-up sets of appointments.

All participants had a signed informed consent form and underwent a complete clinical and radiological examination, including OPG and CBCT, to cross-check the diagnosis and anatomical relationship with the IAN. Age, gender, medical, and medication history data were also recorded. The participants were subsequently randomly allocated into the coronectomy or complete extraction group by lottery.

To prevent possible harm to nearby neurovascular structures, the coronectomy group underwent a standardized surgical procedure in which the roots of the mandibular third molar were left in situ and only the crown section was removed. Patients in the complete extraction group, on the other hand, had the entire tooth, including the crown and roots, removed. Under aseptic conditions, skilled oral and maxillofacial surgeons carried out every surgical procedure. (See Figure

1)

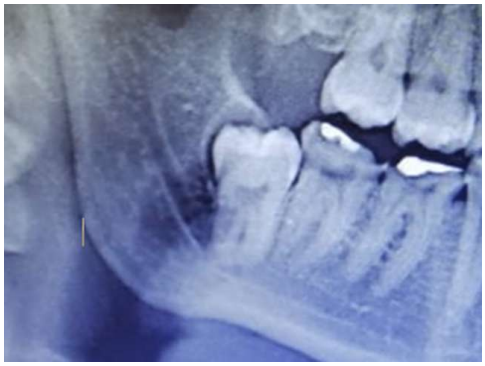
Mean duration of Pain, paresthesia, and swelling/edema were among the postoperative outcomes evaluated. The Visual Analogue Scale (VAS), which goes from 0 (no pain) to 10 (worst conceivable agony), was used to quantify the intensity of the discomfort. Pain duration was recorded in days until the VAS score remained below 1 for more than 24 hours. Paresthesia was evaluated one week after surgery and defined as a burning, tingling, or numb sensation in the IAN distribution area; it was recorded as either present (1) or absent (0). Swelling was assessed by comparing facial measurements taken before surgery and on the 3rd and 7th postoperative days. A difference of 5 mm or more between preoperative and postoperative measurements was considered positive for swelling. Swelling was recorded as present if detected on either follow-up day.

Data collection was done using a structured proforma, and statistical analysis was conducted using SPSS version 27. Continuous variables such as age and pain duration were summarized as means and standard deviations, while categorical variables like paresthesia and swelling were presented as frequencies and percentages. Independent sample t-tests were applied for comparing mean pain durations, while chi-square tests were used for assessing group differences in paresthesia and swelling. Confounding variables such as age, gender, and side of impaction were addressed through stratification and appropriate post-stratification statistical analysis. A p-value of = 0.05 was considered statistically significant throughout.

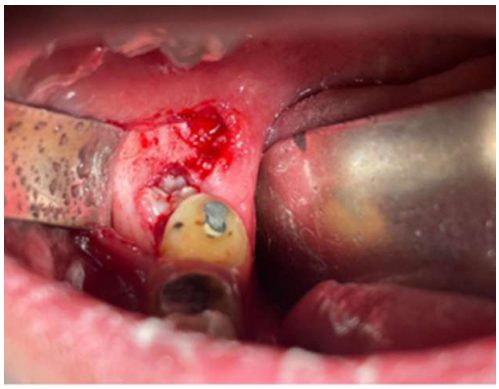
RESULTS

The study included 160 patients in total, who were split equally into two groups: the full extraction group (n = 80) and the coronectomy group (n = 80). Participants in the total

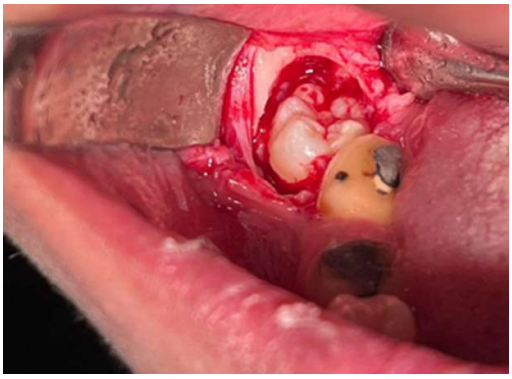
Figure 1: A–E: Sequential steps of coronectomy in a patient with an impacted mandibular third molar in close proximity to the inferior alveolar nerve (IAN). A: Preoperative radiograph showing mandibular third molar in close proximity to the IAN. B: Flap raised with surgical exposure of the tooth. C: Bone removal around the crown to create space for sectioning. D: Completion of coronectomy with crown removal, leaving roots in situ. E: One-month postoperative radiograph showing retained roots without symptoms of IAN injury.



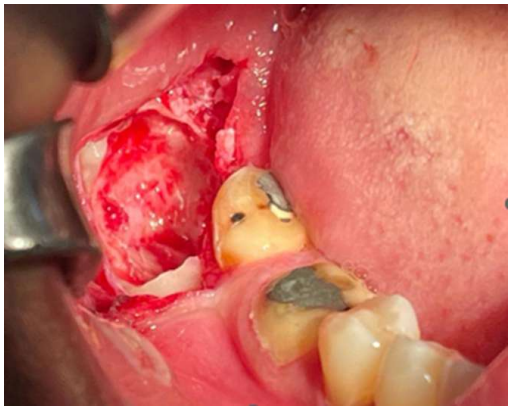
B-Flap raised and exposure done



C-Space around crown made by bone removal



D-coronectomy done



E-1 Month follow up radiograph with no symptoms of IAN injury.

extraction group were 35.9 ± 5.8 years old on average, whereas those in the coronectomy group were 36.2 ± 6.3 years old. The two groups' mean ages did not differ statistically significantly (p = 0.4658), suggesting that they were age-matched. (Table 1)

In terms of gender distribution, the coronectomy group's participants were 46.3% (n = 37) female and 53.7% (n = 43) male. Men made up 48.7% (n = 39) and women made up 51.2% (n = 41) of the entire extraction group. (Figure 2) There was no discernible difference in the gender distribution between the groups (p = 0.526), indicating equal distribution by sex. In a similar vein, the tooth undergoing treatment had almost equal laterality. Of the surgeries performed in the coronectomy group, 47.5% (n = 38) were on the left side and 52.5% (n = 42) on the right. There was no discernible difference in laterality between the whole extraction group's 55% (n = 44) right-sided and 45% (n = 36) left-sided individuals (p = 0.751). (Table 1)

Pain duration was assessed using the Visual Analog Scale (VAS). The mean duration of postoperative pain in the coronectomy group was 2.62 ± 1.96 days, whereas in the complete extraction group, it was 3.42 ± 1.56 days. The difference in pain duration between the two groups was statistically significant (p = 0.004), with the coronectomy group experiencing a shorter duration of pain. (Table 2)

Comparing complications, the coronectomy group showed a noticeably decreased incidence of paresthesia. Compared to 32 patients (40.0%) in the group that underwent a full extraction, only 7 patients (8.8%) in the coronectomy group suffered paresthesia (p = 0.0001). Similarly, just two patients (2.5%) in the coronectomy group complained of edema, but 27 patients (33.7%) in the group that underwent a full extraction did. Additionally, there was a statistically significant difference (p = 0.0001). These results imply that, in comparison to total extraction, coronectomy is linked to a decreased occurrence of postoperative sequelae such as paresthesia and edema. (Table 3)

DISCUSSION

In order to compare the results of coronectomy and full extraction of impacted mandibular third molars that are strongly associated with the inferior alveolar nerve (IAN),

Table 1: Demographic Distribution of Study Participants (n = 160)

Variable	Coronectomy Group (n = 80)	Complete Extraction Group (n = 80)	p-value
Age (Mean ± SD)	36.2 ± 6.3 years	35.9 ± 5.8 years	0.4658[1]
Gender			
Male	43 (53.7%)	39 (48.7%)	0.526[2]
Female	37 (46.3%)	41 (51.2%)	
Laterality of Tooth			
Right side	42 (52.5%)	44 (55.0%)	0.751[2]
Left side	38 (47.5%)	36 (45.0%)	

Figure 2: A Clustered Column Chart showing the Gender Distribution among Both Groups

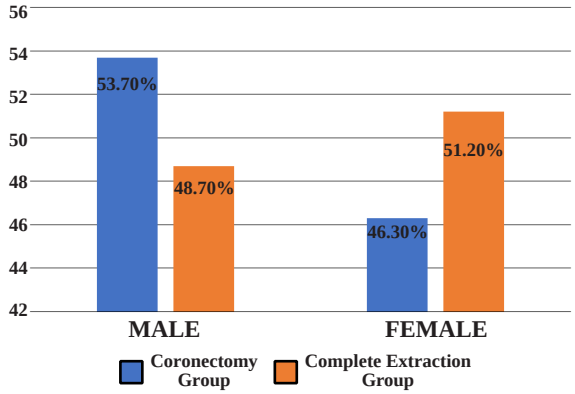


Table 2: Comparison of Postoperative Pain Duration (VAS Score) Between Groups

Group	Mean Duration of Pain (Days)	Standard Deviation	p-value[1]
Coronectomy	2.62	±1.96	0.004
Complete Extraction	3.42	±1.56	

[1] *Independent samples t-test, P=0.05 is considered significant.*

Table 3: Incidence of Paresthesia and Swelling Between Groups

Outcome	Coronectomy Group (n = 80)	Complete Extraction Group (n = 80)	p-value[2]
Paresthesia			
Present	7 (8.8%)	32 (40.0%)	0.0001
Absent	73 (91.2%)	48 (60.0%)	
Swelling			
Present	2 (2.5%)	27 (33.7%)	0.0001
Absent	78 (97.5%)	53 (66.3%)	

this study was conducted.[15] The findings showed that, in comparison to total surgical extraction, coronectomy had a much lower incidence of paresthesia, edema, and postoperative discomfort duration.

The results of our study indicated that the average pain duration was significantly shorter in the coronectomy group (2.62 ± 1.96 days) compared to the complete extraction group (3.42 ± 1.56 days, p = 0.004). Our findings are consistent with those of Abu-Mostafa et al. (2021), who concluded that in the coronectomy group, participants indicated they had lower levels of postoperative pain and subsequently required fewer analgesics in the first week of the postoperative period than those in the full extraction group.[16] Likewise, a study by Baudin et al. (2021) supported these findings, illustrating a quick resolution in pain symptoms for the coronectomy group, presumably due to the preserved root structure and avoiding trauma to the nerve.[17]

One of the most serious complications following third molar surgery is damage to the inferior alveolar nerve, resulting in paresthesia. The current study found a much lower

incidence of paresthesia in the coronectomy group (8.8%) compared to the complete faction group (40%; p = 0.0001). These results reinforce previous findings from Le et al. (2024), who reported that coronectomy significantly reduces the risk of IAN injury when third molar roots are in close anatomical contact with the nerve.[18] Hamad et al. also observed a 0.5% incidence of permanent IAN injury in the coronectomy group, compared to a 5.0% rate in the full extraction group. Our results provide further evidence supporting the nerve-sparing advantage of coronectomy, particularly in cases where radiographic assessments (OPG and CBCT) confirm root proximity to the IAN.

Postoperative swelling was another variable assessed, and our results again favored coronectomy, with only 2.5% of patients experiencing swelling compared to 33.7% in the extraction group (p = 0.0001). This could be attributed to less extensive manipulation of hard and soft tissues during coronectomy. These findings are consistent with the study by Lokes et al. (2024), who reported significantly less swelling and facial edema in patients treated with coronectomy versus complete extraction.[19] By leaving the root intact, coronectomy minimizes trauma to surrounding bone and tissues, thereby reducing the inflammatory response.

The overall safety profile of coronectomy, as observed in our study, is consistent with the conclusions of systematic reviews and meta-analyses. A study by Póvoa et al. (2021) analyzed multiple randomized controlled trials and concluded that coronectomy significantly reduces the incidence of inferior alveolar nerve injury without increasing postoperative complications.[20] Importantly, none of the patients in our coronectomy group required re-operation due to infection or root migration during the study's follow-up period, supporting the long-term stability of the procedure in selected cases.

While some concerns have been raised in the literature regarding root migration or late infection after coronectomy,[21] our study did not encounter these issues within the observed timeframe, possibly due to stringent inclusion criteria (i.e., healthy roots without pre-existing infection) and proper surgical technique. To the best of our knowledge, no previous study from Pakistan has directly compared coronectomy and complete extraction in terms of pain duration, paresthesia, and swelling in mandibular third molars closely associated with the IAN. Therefore, our findings contribute important local data to the global evidence supporting the use of coronectomy as a safer alternative to complete extraction in high-risk cases.

The findings of this study suggest that coronectomy can serve as a safer alternative to complete extraction in patients with impacted mandibular third molars, particularly those at high risk for inferior alveolar nerve damage. With significantly reduced rates of postoperative paresthesia and swelling, coronectomy offers a viable approach that balances surgical success with patient comfort and neurological safety. These results support the inclusion of coronectomy in routine clinical practice where nerve preservation is a priority.

CONCLUSION

Compared to total extraction, coronectomy is linked to fewer postoperative sequelae, especially with regard to swelling and paresthesia. While both methods can be used to treat impacted third molars, coronectomy is a safer option when there is a greater chance of nerve damage due to the tooth's proximity to the inferior alveolar nerve. Additional long-term, multicenter research is necessary to confirm these results and assess the long-term safety and effectiveness of coronectomy.

Authors Contribution:
Adnan Haider: Manuscript Writing Data Collection & Interpretation study design
Shahid Ali: Study Design, Proofread
Shahzad Iqbal Malik: Data Collection, Study Design
Muhammad Mustafa: Data Collection & interpretation
Iram Pervaiz: Data Collection & interpretation
Fatima Imran: Data Collection

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Medical Education - Original Article **Open Access**

Prospects and Challenges of e-learning among Medical Students in Lahore, Pakistan

Shamaila Hassnain

ABSTRACT:

Objective: The main objective was to assess the perception regarding the effectiveness of online learning and factors that affect the education of medical students.

Study design & setting: A cross-sectional study was conducted at Central Park Medical College, Lahore, Pakistan.

Methodology: 386 medical students from the first to final year of MBBS were included in the study by using a simple random sampling technique. A self-designed questionnaire was used. Cronbach's alpha was 0.72. Exploratory factor analysis was used to observe the structure of items in the questionnaire. Responses were given in the form of frequency and percentages. Data was analyzed using SPSS 26.

Results: The mean age of the participants was 22.29 + 1.92. More than half of the medical students who participated in the study favoured online teaching as effective. A statistically significant association was found between the number of hours daily spent on-screen use with self-directed learning and the number of hours spent on Internet Explorer with feelings of confidence about e-learning.

Conclusion: The perception regarding the effectiveness of online learning was found to be moderately effective among the majority of medical students.

Keywords: Learning effectiveness, Medical students, Online learning & teaching.

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INTRODUCTION:

Since late 2019, the novel Coronavirus (SARS-CoV-2) has drastically altered global dynamics, posing significant challenges to nearly all aspects of life. The pandemic, which manifested its devastating impact in early 2020, disrupted physical socialization, affecting sectors such as business, education, healthcare, and the general security of citizens. [1] Multiple safety measures and potentially innovative alternatives have been adopted to cope with the losses and sustain essential operations. [2] Among the most affected sectors, education underwent transformative changes, particularly in medical teaching, where the abrupt and extensive transition from face-to-face learning to e-learning methodologies became essential to ensure academic continuity. [3]

To mitigate these disruptions, innovative strategies and safety measures were adopted, with a notable transformation seen in the educational sector. Medical education, in particular, faced unprecedented challenges, prompting an abrupt and extensive shift from conventional face-to-face learning to e-learning methodologies to continue the academic curricula. [4] This shift, though necessary, demanded significant adaptation by educators and learners. The educational transformation was achieved through technological modernization and digitalization.[5]

E-learning has emerged as a crucial alternative during the pandemic, offering a solution to maintain educational continuity while ensuring safety. It facilitates the efficient dissemination of information to large audiences, leveraging digital platforms to bridge gaps between learners and institutions. [3] However, e-learning has inherent limitations, particularly in its inability to replicate the practical and interactive experiences central to medical education. Evaluating student performance and ensuring hands-on learning opportunities remain significant challenges. [6] The nature of online learning also differed fundamentally from traditional classroom settings. Online learning is more student-centred, focusing on individual engagement and self-directed efforts, whereas traditional classroom learning emphasizes instructor-led teaching. [7] The transition, while accelerating technological adoption, highlighted the importance of developing robust digital infrastructures within academic frameworks. E-learning fostered flexibility and allowed students to progress at their own pace. On the other hand, it lacked the immediacy and direct communication inherent to physical classrooms, often leaving students feeling isolated.

In Pakistan, the adoption of e-learning faced resistance from

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both faculty and students, primarily due to infrastructural, technological, and socio-cultural barriers. Educational institutions, particularly in resource-constrained settings, were hesitant to transition from their established traditional approaches. Faculty members, while recognizing the potential benefits of e-learning, expressed concern about the lack of fair evaluation techniques and practice opportunities available to students. [8] Students, on the other hand, acknowledged the flexibility and accessibility of e-learning but highlighted several issues, including unreliable internet connectivity, high dependency on self-motivation, and a lack of direct interaction with instructors and peers. [5] These challenges were further compounded by socioeconomic disparities in access to technology, particularly in underprivileged areas of Pakistan.

The pandemic also highlighted the critical role of a conducive learning environment in shaping educational outcomes. A positive and supportive environment fosters student engagement, enhances comprehension, and equips learners to face future challenges with confidence. Conversely, a negative or resource-deficient environment can impede academic performance and demotivate students. [9] Educational institutions responded to these challenges by integrating advanced technologies, adopting new digital platforms, and providing faculty training to enhance the effectiveness of online education. [10] Many academic institutions that were previously hesitant to advance their traditional pedagogical approach were completely switched to online teaching and learning during the pandemic. [11] However, a lot of institutions faced many difficulties in the implementation phase of online learning, either in the form of accessibility, lack of prior experience, internet connectivity issues, insufficient infrastructure, or lack of computer availability by both teachers and learners. [12]

Globally, e-learning was embraced to ensure uninterrupted education during the pandemic, but socioeconomic disparities significantly influenced its effectiveness. Students of high socioeconomic status faced fewer barriers as compared to middle- or low-socioeconomic status countries [13] due to better access to resources, including high-speed internet, advanced gadgets, and conducive learning spaces. In contrast, learners from middle- and low-income countries experienced greater challenges, such as financial constraints, lack of technological access, and less robust internet infrastructure. These disparities contributed to the resistance and hesitancy among educators and learners to fully adopt online learning systems. Despite these obstacles, the pandemic underscored the importance of integrating e-learning into traditional education systems as a complementary approach. The experience also paved the way for the development of hybrid models, combining the strengths of both conventional and online learning to address the limitations of each approach. This blended approach holds particular promise for medical education, where theoretical knowledge and practical skills must be balanced. Hybrid models can harness the strengths of both methods to address their respective limitations, paving the way for a more resilient and adaptive educational framework.

The challenges associated with e-learning also spurred innovations in teaching methodologies, such as the use of interactive online tools, virtual simulations, and multimedia content to enhance student engagement. These methods aimed to compensate for the lack of physical interaction and practical training inherent in e-learning systems. Additionally, efforts to provide equitable access to technology became a priority, with some institutions offering subsidized devices and internet packages to students in need. Despite these initiatives, long-term solutions are necessary to ensure sustainable and inclusive education.

The pandemic also spurred innovations in teaching methodologies. Interactive online tools, virtual simulations, and multimedia content were increasingly employed to enhance student engagement and compensate for the lack of physical interaction. These innovations not only enriched the e-learning experience but also demonstrated the potential of technology to transform education. For instance, virtual reality (VR) and augmented reality (AR) technologies enabled students to participate in simulated clinical scenarios, bridging the gap between theoretical knowledge and practical application. Similarly, collaborative tools such as discussion forums and group projects foster peer interaction and teamwork in virtual settings. In Pakistan, the pandemic acted as a catalyst for a broader conversation about the future of education. Policymakers and educators began exploring the potential of blended learning models, which integrate the personalized interaction of face-to-face instruction with the scalability and flexibility of online platforms. These models are particularly relevant in medical education, where practical skills and theoretical knowledge must be balanced. By combining the best aspects of both approaches, blended learning has the potential to address the limitations of each while preparing students for dynamic and technologically advanced professional environments. These discussions emphasized the need for a strategic vision to integrate digital technologies into educational systems sustainably. The experience of the pandemic highlighted the importance of institutional resilience, adaptability, and inclusivity in shaping the future of education.

Additionally, the pandemic underscored the importance of institutional support in facilitating the e-learning transition. This included providing consistent technical support, fostering a collaborative learning atmosphere, and addressing the mental health challenges faced by both students and educators. Many learners reported increased stress and anxiety due to isolation, lack of peer interaction, and uncertainty about academic performance. The lack of physical cues and immediate feedback in virtual classrooms added to their stress, necessitating mental health support and capacity-

building programs. To address these issues, educational institutions implemented several supportive measures. Workshops on digital pedagogy and mental health were conducted to equip educators with the skills and resilience needed to navigate the transition. For students, institutions offered counselling services, peer support groups, and virtual interactive sessions to mitigate feelings of isolation and enhance engagement. These initiatives emphasized the need for a holistic approach to education that considers both academic and psychological well-being. In response, some institutions provided subsidized devices and internet packages to students in need, demonstrating the potential of targeted interventions to bridge digital divides. However, these efforts remain insufficient in addressing the systemic barriers to education in resource-constrained settings. Long-term solutions, such as investments in digital infrastructure and policies promoting universal access to technology, are essential to ensure sustainable and inclusive education. Similarly, educators faced the dual challenge of adapting to new technology while maintaining the quality of education. Workshops and mental health support services were critical in mitigating these issues, emphasizing the need for holistic approaches to education during crises.

This study intends to explore the perceptions of medical students from diverse backgrounds and residential locations regarding the effectiveness of online learning and the factors influencing their educational experiences during the COVID-19 pandemic at Central Park Medical College (CPMC), Lahore. A questionnaire-based survey was employed to capture insights into the challenges and opportunities associated with educational transformations prompted by the pandemic. The findings of this study will contribute to a deeper understanding of how educational systems can better adapt to crises and leverage e-learning to enhance medical training. Furthermore, the study seeks to provide evidence-based recommendations for improving e-learning practices and integrating them effectively into traditional educational frameworks, ensuring resilience in the face of future disruptions. By investigating the experiences of medical students during this unprecedented period, the study aims to shed light on the broader implications of e-learning for educational equity, quality, and sustainability. It emphasizes the need for a comprehensive approach to education that balances technological innovation with human-centred pedagogy, preparing students to navigate the complexities of a rapidly evolving professional landscape.

METHODOLOGY:

A cross-sectional study was conducted at a private medical college from October 2021 to March 2022 to observe the effectiveness of the online learning program. The data was collected from 386 medical students enrolled before 2020. The minimum sample size was calculated as 320 using the WHO sample size calculator by taking a 5% margin of error and 29.5% as the percentage of students who find online programs effective in a study. [14] The data was collected using a simple random sampling technique. All students from the first to the final year of MBBS were included in the study. Only those who did not give consent were excluded.

For the data collection purpose, a self-designed questionnaire was used. After obtaining informed consent, the data were collected by using a questionnaire with two distinct sections. The first section collects demographic and academic information, including the academic year, age, gender, internet availability, and use of the internet, time duration for the screen, modes of assessing online education, and various emotional or health issues as a consequence of e-learning. The other section considered the main section of the questionnaire, in which twelve statements were asked about comfort, participation, effective communication, and motivation during online lectures.

The questionnaire was pretested to ensure its reliability, achieving an overall Cronbach's alpha of 0.72. The initial draft was based on twelve statements measured on a Likert scale with responses ranging from "strongly disagree" to "strongly agree." The scores were calculated by coding "strongly agree" equals 5 and "strongly disagree" equals 1. Before proceeding with the final data collection, the first section of the questionnaire was reviewed and expanded to reflect students' attitudes and interests in online learning.

SPSS version 26.0 was used for data analysis purposes. The results are given in the form of frequencies and percentages. Crosstabulations analyzed the relationship between the number of hours spent each day on-screen activities and the perception of online learning. A chi-square test of association was applied to assess the association. Exploratory Factor Analysis (EFA) was performed to examine the factor structure of the questionnaire. Additionally, effectiveness scores were categorized into four levels, ranging from least effective to very effective. Graphical representation through line charts for academic years and box plots for individual responses was also given. The study protocol, including ethical considerations, was approved by the institutional ethical review board (CPMC/IRB-No/1306), ensuring adherence to research standards. Data confidentiality and participant anonymity were maintained throughout the study.

RESULTS:

The data was collected from 386 students enrolled in a private medical college, in Lahore, Pakistan. Data was collected using a self-designed questionnaire to measure the effectiveness of online learning. The mean age of the participants was 22.29 + 1.92. Approximately 50% of the students on average explore the internet or use the screen for 1-5 hours a day (Table: 1). The most common mode was mobile phone among students. More than half of students said that using screens and exploring the internet for long hours is harmful to their health. Most of the students favored that method of learning become more self-directed. Learning

method to become more self-directed was significantly associated with number of daily hours screen used (Table 2). Comparatively more students were not confident in applying skills they learned online in hospitals. Exploratory factor analysis (EFA) was used to see the factor structure of the designed statements. Significance of KMO and Bartlett's test of sphericity allowed for factor analysis. Principal Component Analysis (PCA) was used with varimax rotation. The threshold for Eigenvalues was set at 1.0. EFA extracted four factors with reasonable explained variance. The extracted factors were named as comfortable effective learning, environment, motivation, and teaching methodology. More than half of the medical students who participated in the study favored that online teaching was effective considering environment, communication, and teaching methodology are building concepts (Table 3). Scores were calculated for each participant that ranged from strongly disagree **(=1)** to strongly agree **(=5).** The code was reversed for negative statements. The actual score was obtained by adding the codes for the particular response. The scoring system was used to assess the effectiveness of online learning through items. More than one-third of the students favored that online learning was moderately effective (Table: 4). Nearly one-fourth of the students said it was least effective. About 62.7% of the students said that online learning is mild/ moderately effective. Most of the students in final year find online learning moderately effective. Comparatively more students from third-year MBBS said that online learning is least effective among all years (Figure 2). A small proportion of advanced-level students favoured that online learning is very effective. Most of the students agreed with the effectiveness of online learning.

Table 1: Frequency Distribution of Gender and Factors related to the use of the Internet

Variables	Categories	n	Percentage
Gender	**Male**	194	50.3%
	Female	192	49.7%
Availability of internet	**No**	28	7.2%
	Yes	358	92.8%
Mode	**Laptop**	132	34.2%
	Mobile Phone	233	60.4%
	Desktop	21	5.4%
Estimated hours for screen use	**< 1 hour**	92	23.8%
	1-5 hours	191	49.5%
	6-10 hours	86	22.3%
	> 10 hours	17	4.4%
Estimated hours for exploring internet	**< 1 hour**	53	13.7%
	1-5 hours	205	53.1%
	6-10 hours	90	23.3%
	> 10 hours	38	9.9%
Total		386	100%

DISCUSSION:

During this pandemic of COVID-19, e-learning and its effectiveness for possible integration into the education system as a reliable learning method are raising challenges and opportunities. One of the main advantages of e-learning observed among respondents of our survey was the ease of access to education from the comfort of their homes. This flexibility has been a game-changer for many, enabling uninterrupted learning despite global disruptions. The

Figure 1: Exploratory Factor Analysis of Online Effectiveness

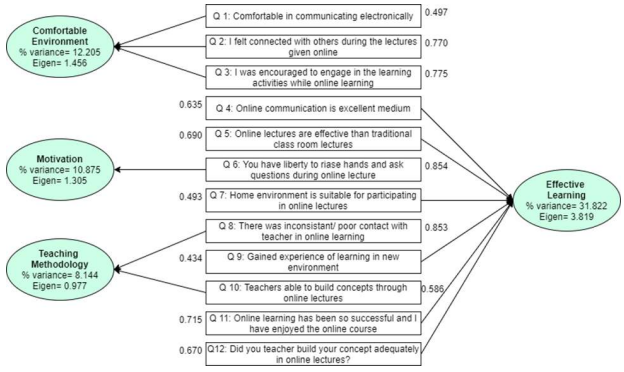


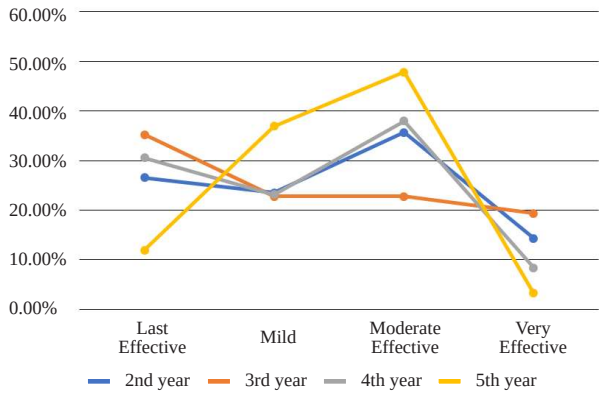
Table 2: Crosstab of the estimated number of hours spent each day on-screen use and exploring the internet with perception about online learning

Factor	Category	Less than 1	1-5	6-10	More than 10	p-value	Less than 1	1-5	6-10	More than 10	p-value	Total
Self-directed	Yes	36	110	56	18	0.22	51	118	44	07	0.02	220
	No	08	32	16	07		09	29	22	03		63
	May be	09	63	18	13		32	44	20	07		103
Feel confident	Yes	21	68	29	15	0.05	25	69	34	05	0.57	133
	No	20	89	28	19		38	76	34	08		156
	May be	12	48	33	04		29	46	18	04		97
Effect to health	Yes	26	122	56	18	0.38	53	111	47	11	0.97	222
	No	16	42	15	12		19	42	20	04		85
	May be	11	41	19	08		20	38	19	02		79

Table 3: Frequency and Percentages of the responses for scaled items

Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I am comfortable in communicating electronically.	56 (14.5%)	38 (9.8%)	74 (19.2%)	93 (24.1%)	125 (32.4%)
In general, I felt connected with others during the lectures given online.	37 (9.6%)	28 (7.3%)	56 (14.5%)	191 (49.5%)	74 (19.2%)
I felt I was encouraged to engage in the learning activities while online learning.	50 (13.0%)	39 (10.1%)	59 (15.3%)	172 (44.6%)	66 (17.1%)
Online communication is an excellent medium for learning.	68 (17.6%)	38 (9.8%)	66 (17.1%)	140 (36.3%)	74 (19.2%)
Online lectures are effective than traditional/ live class room lectures.	69 (17.9%)	51 (13.2%)	59 (15.3%)	115 (29.8%)	92 (23.8%)
Were you given the liberty to raise hands and ask questions to clear your doubts during online lecture?	43 (11.1%)	58 (15.0%)	62 (16.1%)	124 (32.1%)	99 (25.6%)
Home environment is suitable for participating online lectures.	59 (15.3%)	43 (11.1%)	78 (20.2%)	100 (25.9%)	106 (27.5%)
There was inconsistent/ poor contact and communication with teachers.	43 (11.1%)	36 (9.3%)	66 (17.1%)	114 (29.5%)	127 (32.9%)
Gained experience of learning in a new online environment.	58 (15.0%)	71 (18.4%)	96 (24.9%)	72 (18.7%)	89 (23.1%)
I feel that face-to-face contact with teacher is necessary to learn.	46 (11.9%)	31 (8.0%)	67 (17.4%)	134 (34.7%)	108 (28.0%)
Overall, online learning has been successful and I have enjoyed the online course.	78 (20.2%)	60 (15.5%)	86 (22.3%)	78 (20.2%)	84 (21.8%)
Did your teachers able to build your concepts adequately through online lectures?	46 (11.9%)	96 (24.9%)	84 (21.8%)	86 (22.3%)	74 (19.2%)

Figure 2: Effectiveness of Online Learning across Various Years of MBBS



majority of students accessed online lectures via mobile phones, which have proved to be the most preferred and convenient means of communication in comparison to laptops and desktops, as observed in other studies conducted in India, China, and other countries as well,[15] perhaps owing to the general prevalence of usage of phones among the average age group of 23 years taken into consideration in these studies.

Surprisingly, students demonstrated confidence in their ability to effectively apply the obtained clinical knowledge through online platforms in their practice as well. This positive outlook existed despite acknowledging the shortcomings and challenges posed by the new system vis-a-vis satisfactory student-teacher interaction, [16] personal engagement, conceptual certitude, and fair assessment techniques. [17] This finding was inconsistent with studies

Table 4: Scores of Effectiveness of online learning

Effectiveness	Least Effective (12-28)	Mild Effective (29-36)	Moderate Effective (37-44)	Very Effective (45-60)	Total
No. of students fall	101 (26.2%)	102 (26.4%)	140 (36.3%)	43 (11.1%)	386

conducted in medical schools in Jordan, Poland, and other countries, [18] where students expressed grave concerns regarding the lack of hands-on interaction with patients, which they deemed crucial for their professional training. This discrepancy highlights the diverse perceptions and adaptations of e-learning across different educational and cultural contexts.

Another critical aspect of e-learning is internet accessibility. In our study, internet service was accessible to 92.75% of students, which proves the general implementation of e-learning is plausible, considering it could be a major inconvenience encountered in different geographical areas, especially in developing countries like Pakistan and their rural areas. [19] Limited internet connectivity in such areas can hinder the equitable implementation of online education and must be addressed to ensure inclusivity.

We observed a statistically significant trend in students' inclination towards self-directed learning [20] and its positive relation to their tendency of increased duration of exposure to phone screens and internet surfing [19] for educational purposes, averaging to about 1-5 hours daily in these activities. The majority of students, as also observed in a study done in India, albeit at the cost of adverse health effects [21] including eye strain, reported findings of increased motivational challenges and psychological fatigue. [22]

Recent findings by Peine et al. found that self-directed e-learning can outperform traditional face-to-face learning in some contexts. [23] This is probably a major contributory factor to students' self-confidence [20] and the growing acceptance of e-learning. [24] However, the success of e-learning is not solely attributed to technology but also to the adaptability of students and educators, along with the integration of innovative pedagogical methods. Nevertheless, these developments should not obscure the inherent limitations of e-learning. Despite its advantages, e-learning cannot replicate the tangible experiences and interpersonal connections of the classroom, hands-on training, and clinical learning environments.

The study also highlighted the necessity for comparative studies to evaluate the outcomes and performances of students trained through online education versus those trained through traditional methods. [25] Such studies could provide valuable insights into the effectiveness of e-learning and guide its strategic integration into educational systems. While e-learning offers several benefits, including flexibility and accessibility, its absolute effectiveness remains debatable. Practical considerations, such as the need for hands-on training, suggest that e-learning should be viewed as a complementary rather than a replacement method for classroom learning, and claims of its absolute effectiveness could be misleading. [26]

To ensure the sustainable integration of e-learning, it is crucial to address the identified challenges. These include enhancing interactive components, providing equitable access to digital resources, and developing hybrid models that combine the strengths of both online and traditional learning. By doing so, education systems can harness the potential of e-learning while preserving the irreplaceable value of face-to-face interactions and experiential learning.

In conclusion, e-learning has proven to be a viable and innovative approach to education during the COVID-19 pandemic, particularly for its accessibility and adaptability. However, its limitations must be carefully considered, and efforts should be made to create a balanced and inclusive educational framework. Future research should focus on long-term implications, comparative effectiveness, academic outcomes, and professional competence gained through e-learning versus traditional methods. Such insights could guide the strategic integration of e-learning into educational systems. Additionally, fostering a supportive learning environment and addressing mental health concerns remain paramount for the success of e-learning.

CONCLUSION:

The perception of e-learning's effectiveness was moderately positive among most medical students. While most students found the system accessible and adaptable, certain groups, such as 3rd-year MBBS students, reported comparatively lower satisfaction. Mobile phones emerged as the primary tool for e-learning, demonstrating their utility and convenience. The findings underscore the need to refine e-learning systems, ensuring they complement traditional teaching while addressing existing challenges.

Authors Contribution:
Shamaila Hassnain: Concept of article and design, Drafting the article, Review of article critically, Final changes of the version and submission

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Students Insight of Formative Assessment via the Learning Management System (LMS) in Forensic Medicine

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ABSTRACT

Objective: This study aims to assess students' perceptions of an online formative assessment conducted via the LMS Moodle platform in the subject of Forensic Medicine.

Study Design and Setting: This descriptive cross-sectional study was conducted at FRPMC in Karachi, involving 183 MBBS students from the 3rd and 4th years.

Methodology: A 13-item structured questionnaire with a 5-point Likert scale was used to collect students' opinions on online formative assessments, following their consent and ethical approval from the institutional review board. Only fully completed responses were analyzed. Data was processed using SPSS (version 26), and descriptive statistics, along with Cronbach's alpha, were used to assess reliability.

Results: The findings revealed that most respondents had a positive view of the online formative assessments. Approximately 68.8% found the assessments to be well-organized and relevant, while 60% felt that the learning objectives were aligned. Around 65% believed the exam helped in recalling forensic medicine knowledge, and 70% found the questions challenging. However, 41% reported technical issues, and 69-70% felt the exam's duration and difficulty were insufficient. The Cronbach's alpha of 0.893 indicated strong internal consistency, although the Kaiser-Meyer-Olkin test suggested insufficient sampling for certain items.

Conclusion: FRPMC students responded positively to online formative assessments using LMS-Moodle quiz. Rectification of technical issues and appropriate assessment conditions are crucial for future improvements.

MeSH Keywords: Assessment, Formative, Forensic Medicine, learning, Perception

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INTRODUCTION:

Teaching and learning in medical education involve various activities for students, among which assessment plays a pivotal role for both students and teachers, especially in the subject of Forensic Medicine.[1] Forensic Medicine holds significant importance in the medical curriculum of 3rd-year MBBS students, as contact hours must be covered according to PMDC guidelines. In this modern era of science and technology, our teaching and learning methods have evolved significantly, utilizing available resources to modernize the quality of education. The specialty of Forensic Medicine has also incorporated E-learning methods alongside traditional classroom teaching to keep pace with the changing environment of learning and teaching.[2] Among the use of digital technologies into higher education, Learning Management Systems (LMS) such as Moodle have become central to delivering course content, facilitating communication, and assessing student performance. One widely used feature of LMS platforms is the online formative assessment quiz, which serves as a tool to promote active learning, provide timely feedback, and gauge students' understanding of course material.

Formative assessment has become an essential component of assessment methodologies used in the integrated curriculum. Unlike summative assessment, which focuses on final evaluations, formative assessment promotes student learning by providing feedback that enables students to

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improve and further enhance their learning process. This method of assessment allow teachers to frequently monitor their students' progress and evaluate the effectiveness of their own teaching practices.[3] It helps teachers identify areas of the curriculum where instructional strategies may need modification and where additional academic support may be necessary for students. Moreover, it has emerged as a crucial pedagogical tool in medical education particularly in Forensic Medicine align with the constructivist approach to learning, enabling students to build new knowledge based on their existing understanding through active engagement.[4] Formative assessment also fosters self-regulation in learning, encouraging students to become more independent and reflective in their approach to studying.[5]

Feedback mechanisms in formative quizzes contribute to the development of a growth mindset. When students receive feedback on their mistakes, particularly when the feedback emphasizes effort, strategy, and improvement rather than innate ability, they are more likely to believe that their intelligence can grow with practice and perseverance. Moreover, personalized feedback enables teachers to adjust teaching methods and materials to accommodate the varying needs of students within a classroom. For example, a teacher might provide additional resources or suggest alternative learning strategies to a student who struggles with a particular concept.

Effective feedback fosters a positive and supportive teacher-student relationship. When students receive timely and constructive feedback, they feel that their teachers are actively involved in their learning and care about their progress. One of the key principles of formative assessment is its focus on continuous improvement rather than final judgment.

As education continues to evolve, the integration of effective feedback mechanisms in formative assessment will remain a cornerstone of high-quality teaching and learning. Educators and institutions should prioritize the development of feedback systems that are timely, clear, constructive, and supportive, ensuring that all students can maximize their potential and achieve long-term success in their academic pursuits.

Several studies have emphasized the beneficial and long-lasting effects of formative assessment in medical education.[6-8] Formative assessment is instrumental in facilitating self-directed learning and enhancing students' ability to apply theoretical knowledge in clinical settings.[9] This is especially relevant in Forensic Medicine, where students must integrate knowledge from various medical and legal disciplines to understand and solve complex cases involving criminal investigations, autopsies, and the determination of cause of death.

Furthermore, the dynamic nature of Forensic Medicine, with its reliance on evolving legal and medical standards, makes formative assessment an ideal tool for keeping students updated with the latest developments in the field. Shumway and Harden highlight the role of formative assessment in promoting lifelong learning for medical professionals, who must continually update their knowledge and skills throughout their careers.[10] The multidisciplinary and dynamic nature of Forensic Medicine demands not only theoretical knowledge but also practical skills in areas such as pathology, toxicology, and legal procedures

The curricula of many medical schools focus primarily on final exams or practical assessments, which may create gaps in the ongoing evaluation of students' understanding and skills development. Moodle quiz used for formative assessment can address this gap by evaluation of student's performance during the ongoing academic activities in the curriculum.[11] It also encourages student's active learning by engaging students in regular assessments and feedback. Instead of passively absorbing information, students are prompted to critically evaluate their own work, question their assumptions, and engage in self-reflection.[12]

The significance of studying students' perceptions of formative assessment using LMS-Moodle quiz in forensic medicine lies in its potential to improve both teaching practices and learning outcomes. Understanding how students feel about and respond to these assessments can help instructors refine their methods, provide more meaningful feedback, and ensure that students are better prepared for the challenges they will face in their professional careers. Ultimately, this research offers a pathway to more effective, student-centered education in a crucial and specialized field.

Despite the widespread adoption of Moodle quizzes, there remains a need to understand students' perceptions of their effectiveness, usability, and impact on learning outcomes—especially in the context of Forensic Medicine. Students' attitudes toward online assessments significantly influence their engagement and academic performance, and exploring these perceptions can guide educators in optimizing assessment strategies for better educational outcomes. Although the importance of formative assessment Moodle quiz in medical education is clear, its specific application in forensic medicine course has been underutilized and few studies have explored their specific impact in Forensic Medicine. This study, therefore, aims to assess the medical students' perception of online formative assessment conducted via the LMS Moodle platform in the subject of forensic medicine at FRPMC.

METHODOLOGY

Formative assessment of 3rd- year MBBS students in forensic medicine at Fazaia Ruth Pfau Medical College is conducted every 3rd Friday of the month after pharmacology and pathology respectively. It is conducted 3-4 times in a 12 week block of two modules and there are three blocks in a year, so covering the whole subject. Each assessment covers all topics taught in the last two weeks and we have used assessment quizzes of one block. The online formative

assessment quiz was administered through Moodle quiz. Feedback of quiz is embedded in the grade section in which each student sees his own score and description of right and wrong answers with explanation and reasoning. In addition to this, there was a post-quiz discussions in class room where facilitators discuss the keys and queries raised by the students and were asked to explain their choices of marking.

This descriptive, cross-sectional study was conducted at Fazaia Ruth Pfau Medical College (FRPMC), Karachi. A total of 183 medical students from the 3rd and 4th year MBBS programs participated in this study. The study was conducted during the period from 5th October,2024 to 30th November, 2024. Fazaia Ruth Pfau Medical College, Faisal Base, Shah rah-e- Faisal Karachi. Prior to the commencement of the study, approval was obtained from the institutional ethical committee of Fazaia Ruth Pfau Medical College (Ref. No: FRPMC-IRB-2024-79). All participants voluntarily took part in the research, and written consent was obtained from each participant. To ensure data security, all data will be kept under strict custody using a lock-and-key system in a separate location, with access restricted to the investigator.

Exclusion and Inclusion Criteria: Students who participated to fill the questionnaire with complete responses were included in the study. These were those students of 3rd and 4th year who have attended formative assessment quizzes in one block of their respective year on Moodle and completed this activity. The students who have not attended online Moodle quiz and unable to complete full responses in the questionnaire were excluded from study. Students of 1st, 2nd and final year were also excluded as initial two classes do no study forensic medicine and formative assessment on LMS-Moodle was not routinely used at the time of final year batch.

Sample Size Calculation: The sample size of this study is 183 out of 200 medical students from 3rd and 4th year MBBS classes. Estimation was done with a convenient sampling technique as this is educational research. Convenient sampling allows us to take all samples whichever is available, therefore in our case all students were added from two class which make our sample size 183 out of 200 students fulfilled our criteria .

Data Collection: A structured 5-point Likert scale questionnaire with 13 items was used as the primary data collection instrument. The questionnaire was designed to capture students' perceptions and experiences related to online formative assessments. It consisted of five options, ranging from "Strongly Disagree" to "Strongly Agree," with a neutral point allowing respondents to neither agree nor disagree. Data collection was carried out using an online Google Form. The link was shared with students, who then filled out the form and submitted it online.

Data Analysis: The collected data was analyzed using Statistical Package for the Social Sciences (SPSS, version 26). Descriptive statistics, including frequencies, mean values, standard deviations, and factor analysis, were calculated for each variable. Cronbach's alpha value was also calculated to assess the reliability of the questionnaire.

RESULT

Table 1 show majority of respondents either agreed or strongly agreed with most variables, indicating overall positive perception for all the items in the questionnaire. 68.8% of respondents were in agreement (19.1% strongly agree, 49.7% agree) that the online formative assessment activity was organized and relevant to their subject. 60% of students agree that learning objectives were aligned with online formative exams. Approximately 65% of students believes that the on line formative exam helps in recalling knowledge of forensic medicine subject, while70% of students thought that the exam question was challenging and thought provoking. However nearly 41% of students expressed concern over technical issues occurring during the online exam. Moreover 69 to 70 percent students thought the duration of exam was not sufficient and level of difficulty was not appropriate. 65% of students think that this mode of exam is fair for evaluation and can be used in future.

Fig no:1 show percentage of Likerst scale for each responses obtained from each item or question on 5-point likert scale questionnaire, As this chart clearly depict that for each question in questionnaire most the responses for category of Strongly agree came out to be more than 70 percent which also been validated by the table 1 given above. Cronbach's á value came out to be 0.893 which shows good level of internal consistency and indicates an acceptable level of reliability of items in the questionnaire.

We assumed below Hypothesis to identify whether underlying structure in data i.e. factors exist or not. Null Hypothesis (Ho): There is no underlying structure in the data i.e., no factors exist. Alternative Hypothesis (H1): There is an underlying structure in the data i.e., factors exist.

Below are the results of our detail analysis of data: Table 2: The Kaiser-Meyer-Olkin (KMO) value i.e. 0.916 indicates the appropriateness of the factor analysis for the data. Also Bartlett's Test of Sphericity shows a significant value that indicates there is an underlying structure in the data i.e., factors exist. As per Exploratory Factor Analysis results shown in table III, we can say that there is a structure of the relationship between the variable & respondent.

DISCUSSION:

Formative assessment provides valuable support to students by enhancing their ability to track ongoing learning. For learning assessments, formative evaluations typically give students guidance and feedback on their own performance. These kinds of evaluations are usually conducted in tandem with education. Additionally, formative assessment facilitates student learning by identifying and correcting mistakes,

Table-1: Frequency Distribution Of Students` Responses On 5-Point Likert Scale (n = 183)

Questions/Items	Strongly Agree (%) (n)	Agree (%) (n)	Neutral (%) (n)	Disagree (%) (n)	Strongly Disagree (%) (n)	Mean
Organization and Relevance	19.1 (35)	49.7 (91)	24.6 (45)	6.0 (11)	0.5 (1)	3.80874
Support for Learning Goals	15.3 (28)	45.9 (84)	25.1 (46)	10.9 (20)	2.7 (5)	3.60109
Recall of Forensic Medicine Knowledge	18.6 (34)	46.4 (85)	27.3 (50)	4.9(9)	2.7 (5)	3.73224
Challenge and Thought-Provocation of MCQs	18.0 (33)	48.1 (88)	28.4 (52)	4.9 (9)	0.5 (1)	3.78142
Clarity of MCQs	7.1 (13)	31.1 (57)	35.0 (64)	20.8 (38)	6.0 (11)	3.12568
Sufficiency of Time Allocation	18.0 (33)	53.0 (97)	22.4 (41)	4.4 (8)	2.2 (4)	3.80328
Appropriateness of Difficulty Level	14.2 (26)	50.8 (93)	28.4 (52)	4.9 (9)	1.6 (3)	3.71038
Ease of Following Steps	17.5 (32)	53.6 (98)	23.5 (43)	4.4 (8)	1.1(2)	3.81967
Technical Issues	8.7 (16)	33.3 (61)	27.9 (51)	21.9(40)	8.2 (15)	3.12568
Satisfaction with Responsiveness	13.7 (25)	53.0 (97)	21.9 (40)	7.7 (14)	3.8 (7)	3.65027
Aid of Immediate Feedback	17.5 (32)	49.2(90)	24.0 (44)	7.1(13)	2.2 (4)	3.72678
Fairness of Evaluation	13.7 (25)	49.7 (91)	29.0 (53)	4.4 (8)	3.3 (6)	3.6612
Recommendation for Future Use	20.8 (38)	44.8 (82)	24.0 (44)	6.0 (11)	4.4 (8)	3.71585

Figure 1: Responses against questions related to effectiveness of formative assessment in Forensic Medicine

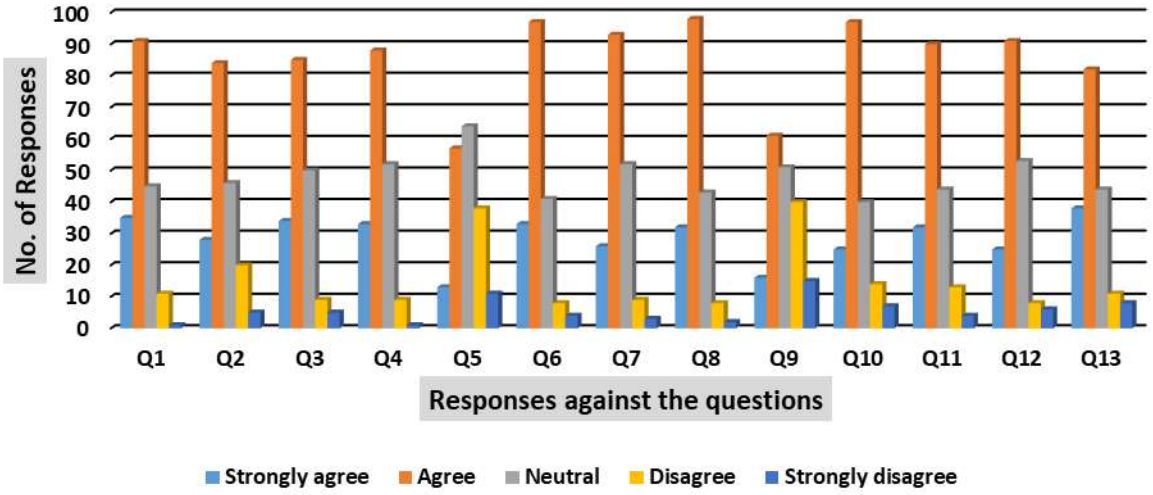

Table 2: KMO and Bartlett's test

Kaiser – Meyer –Olkin Measure of sampling adequacy		.916
Bartlett's Test of Sphericity	Approx. Chi-Square	1449.958
	df	78
	Sig.	.000

thereby improving performance through repeated practice. A study conducted by Couto LB and Durand concluded similar findings, demonstrating that formative assessment has a productive impact on learning and on the results of final module and professional MBBS summative exams.[17]Therefore, it supports all teaching and learning activities planned by the facilitator.[18]

Our study revealed an overall positive perception by students regarding ongoing formative assessments in forensic medicine on Moodle. Most students expressed satisfaction, stating that formative assessment plays a vital role in their learning process and significantly impacts their preparation for the final examination. The majority of students also reported that the online formative assessments were well-organized, relevant to their forensic medicine syllabus, and aligned with their learning objectives. This aligns with previous research by Anderson, which indicates that well-designed and effectively implemented formative assessments can significantly reinforce learning and improve subject matter retention.[19] The students valued how Moodle allows them to feel free to respond honestly, receive prompt feedback, and have teachers gather statistics about them in real time. Alvarez and Villamane (2024) supported that use of Moodle

Table 3: Exploratory Factor Analysis

Rotated Component Matrix[a]	Component	
	1	2
Did the immediate feedback from the online formative assessment aid your learning in forensic medicine?	.837	
Did the structure of the online formative assessment support you in achieving your learning goals in forensic medicine?	.819	
Was the online formative assessment well organized and relevant to forensic medicine syllabus?	.819	
Did the online formative assessment improve your ability to recall forensic medicine knowledge?	.817	
Do you feel that online formative assessment was a fair evaluation of your forensic medicine knowledge?	.811	
Were you satisfied with the responsiveness of online assessment system?	.790	
Was the difficulty level of online MCQs appropriate for your understanding?	.778	
Were the steps for completing online formative assessment easy to follow?	.775	
Do you recommend online formative assessments for other students?	.767	
Was the time allocated for online formative assessment sufficient?	.743	
Were the MCQs in the formative assessment challenging and thought-provoking?	.718	
Was any MCQ in the formative assessment unclear or confusing?		.798
Did you encounter any technical issues during the online formative assessment?		.785

for formative assessment is very beneficial, as it has built in learning management system features.[20] The literature claims that Moodle has become a well-recognized platform that is appropriate for usage in higher education.

These findings highlight the successful integration of online formative assessments into the curriculum, demonstrating their role in supporting students' understanding and application of forensic medicine knowledge.[21]

A notable 65% of students felt that the online formative exams were effective in helping them recall knowledge in forensic medicine. Additionally, 70% found the questions challenging and thought-provoking, suggesting that the assessments were designed to encourage critical thinking and deeper engagement with the material. Many studies, including one by Senadheera, are consistent with the principles of formative assessment, emphasizing the importance of challenging students to enhance their learning and critical thinking skills.[22] The alignment of assessment questions with learning goals ensures that students are not only reviewing their knowledge but also applying it in meaningful ways.

Despite the overall positive feedback, concerns were raised regarding technical issues, with nearly 41% of students expressing dissatisfaction. Technical difficulties can undermine the effectiveness of online assessments and detract from the learning experience. These issues may also contribute to student anxiety, negatively impacting performance and overall satisfaction. A significant proportion of students (69-70%) felt that the exam duration was insufficient and that the difficulty level of the questions was not always appropriate. These concerns highlight the need to refine the logistical aspects of online assessments to ensure they are both fair and effective. Berisha's study similarly pointed out that challenges such as technical glitches or inappropriate difficulty levels in online formative assessments can negatively impact their full and effective implementation within the medical curriculum.[23]

The reliability of the questionnaire, as indicated by a Cronbach's alpha of 0.893, suggests a high level of internal consistency among the items. This demonstrates that the questionnaire is a reliable tool for capturing student perceptions.[24] However, the factor analysis results indicated that some items (e.g., clarity of MCQs and technical issues) had lower communalities, suggesting potential areas for improvement in the assessment instrument. Statistical technique called exploratory factor analysis (EFA) finds groups of variables that have a tendency to correlate with one another in order to reveal the underlying structure of a set of variables. It is often used in the early stages of research to gather information about the interrelationships among a set of variables. As per Exploratory Factor Analysis results, we can say that there is a structure of the relationship between the variable & respondent. The Kaiser-Meyer-Olkin (KMO) value i.e. 0.916 indicates the appropriateness of the factor analysis for the data. Also Bartlett's Test of Sphericity shows a significant value that indicates there is an underlying structure in the data i.e., factors exist.[25]

The positive feedback from students regarding the fairness and potential future use of online formative assessments (65% agreed that this mode of examination is fair and could be used in the future) underscores their acceptance of this assessment method. This acceptance suggests that online formative assessments have the potential to become a valuable component of the medical curriculum, provided the identified issues are addressed. For future implementations, it will be crucial to enhance technical support, ensure appropriate exam duration, and calibrate the difficulty level of questions to better align with students' abilities and learning objectives.

Moreover, incorporating student feedback into the design and implementation of online assessments can lead to iterative improvements and a more refined assessment process.[26] Future research should explore strategies to mitigate technical issues and optimize assessment conditions to enhance the overall effectiveness of formative assessments.

CONCLUSION

Online LMS-Moodle quiz for formative assessments have been positively received by students at FRPMC, with many reporting benefits in terms of enhancement of learning. However, to fully realize the potential of these assessments, it is essential to address technical and logistical issues and ensure that the assessments are appropriately challenging and fair. Future research could explore strategies to improve the technical infrastructure and assessment design to better support student learning and address the limitations identified in this study.

Authors Contribution:
Syed Zubair Ahmed Tirmizi: Visualize Initial concept, made research question, contribute in introduction writing
Muhammad Adil: Develop Methodology, contribute in data collection and analysis and develop result
Muhammad Faisal Rahim: Contribute in discussion writing, contribute in data collection
Hadiqa Sahar: Contribute in introduction writing, contribute in data collection
Asghar Mehdi: Revise article and references critically

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Medical Education - Original Article **Open Access**

Assessment of Professionalism Mini-evaluation exercise (P-MEX) among Students in a Private Dental College of Karachi

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ABSTRACT:

Objective: This study aimed to evaluate professionalism among final-year dental students using the Professionalism Mini-Evaluation Exercise (P-MEX).

Study Design and setting: A cross-sectional study was conducted at a private dental college in Karachi, Pakistan.

Methodology: This study assessed professionalism among 42 final-year dental students using the Professionalism Mini-Evaluation Exercise (P-MEX). The students were selected through convenience sampling method after obtaining approval from the Ethical Review Board (ERC reference: 8430224NAOMS). A total of 12 dental faculty members, who served as evaluators, were included, from the departments of Oral surgery, operative dentistry, prosthodontics and periodontics. The data was collected using the P-MEX tool to assess key domains of professionalism, including doctor-patient relationships (8 items), reflective skills (5 items), time management (3 items), and interprofessional relationships (8 items), totaling 24 items. The evaluators observed the clinical encounters of final year dental students with patients while taking history and during oral examinations and scores were provided on the P-MEX tools. Descriptive statistics were computed, and the mean score of each domain was calculated.

Results: The P-MEX was found to be a reliable instrument for evaluating professionalism in dental students. The mean score of dental students for P=MEX was 2.70 ± 0.21. However, students demonstrated lower levels of professionalism in the doctor-patient relationship (2.70 0.33) and reflective skills domains (2.56 0.45)

Conclusion: The study concludes that final-year dental students exhibit deficiencies in certain aspects of professional behavior. Regular assessment, structured feedback, and capacity-building initiatives are recommended to enhance professional competencies in these areas.

Keywords: Assessment, Dental students, Professionalism, Professionalism Mini-Evaluation Exercise (P-MEX)

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INTRODUCTION

Professionalism is a fundamental competency in medical education, serving as the cornerstone for nurturing compassionate and ethical practitioners.[1] However, due to its conceptual nature, defining professionalism within the field of medicine can be challenging.[2] The Royal College of Physicians describes professionalism as a set of beliefs, actions, and interactions that enable the public to trust the doctors.[3] It is intrinsically linked to core values, ethical standards, and behavior analysis.[4]

As an essential skill required of doctors, professionalism aims to outline the attitudes, behaviors, and qualities expected within the medical profession.[5] The development of professionalism in dental students is a complex process influenced by various elements, including personal values, attitudes, duties, clinical and non-clinical experiences, and the educational environment.[6] Additionally, it should ensure that every practitioner acquires the necessary skills and knowledge for practicing medicine and develops a professional identity that enables them to think, feel, and

act like a doctor.[6]

More importantly, the characteristics of professionalism vary across different cultures. Professionalism has different definitions, instruments, and approaches designed to gauge and evaluate it in one culture, which may not be acceptable or feasible in another. In the same way, the definition of professionalism may not be accurately conveyed in other languages. For these reasons, validity and reliability studies should be conducted before using any scale in a different language or culture.[7]

Professionalism is a multifaceted process that includes personal values, beliefs, and commitments to both clinical and non-clinical experiences as well as their surroundings. In medical education, the term "professional identity formation" (PIF) is new and refers to the experience of learning professional principles, attitudes, and actions within an already-existing identity.[4]

Globally, literature has explored the experiences of professionalism among healthcare professionals, suggesting that professional incompetence can compromise healthcare quality and increase the risk of conflicts, disciplinary actions, and dissatisfaction.[7] In the past 25 years, the focus on professionalism has elevated its significance in both undergraduate and graduate curriculum within Dental discipline.[8] The American Dental Education Association identifies eight components of professionalism in dentistry, which encompass providing patients with effective clinical services, acquiring specific knowledge, and demonstrating proficient behavior—all of which must be continuously developed and maintained through qualified professional engagement.[9] Cultivating a professional identity and fostering professional growth should be achieved through both formal and informal educational opportunities.[10]

Evidence suggests that efforts to teach professionalism can significantly influence students' behavior and professional status. Consequently, formal training in professionalism, along with the rationale for maintaining it, is being increasingly integrated into medical curricula. Professionalism should be taught at all levels, with training encompassing essential areas such as conflict management, feedback, supervisory skills, and assessment.[11] Teaching professionalism necessitates not only a clear core curriculum that covers the entire medical education spectrum, but also extra effort to transmit non-cognitive abilities. In this process, reputable role models are crucial. Providing a secure space for students to reflect on real-life experiences is likely one of the best resources available.[11]

Moreover, the evaluation of professionalism is also crucial in guiding students' professional behavior within medical and dental schools. Developing an appropriate assessment system aligned with learners' career expectations is essential. Professionalism in dentistry can be assessed via written exam, performance-based assessment, competency-based assessment, and portfolios. An effective evaluation system involves a comprehensive, long-term assessment incorporating workplace-based evaluations and multiple observations .[12]

One of the practical tools for assessing professionalism in clinical training is the Professionalism Mini-Evaluation Exercise (P-MEX). It is used to evaluate learners in various settings, such as clinics, emergency rooms, clinical rounds, and small group sessions.[13, 14] The P-MEX was initially developed from the mini-CEX (clinical evaluation exercise) to assess professionalism during observed clinical encounters. It is considered one of the most effective tools for evaluating medical professionalism as it measures objectively observable behaviors and demonstrates high validity and reliability.[15] However, research indicates that an assessment of professionalism using the P-MEX has not yet been conducted among final-year dental students in Karachi, Pakistan. Hence, further research is required for it. Thus, in this study, the 24-item P-MEX has been utilized to assess professionalism among dental students of a private University of Karachi Pakistan.

METHODOLOGY

This cross-sectional study was conducted at a private dental college in Karachi, Pakistan, to assess professionalism among final-year dental students using the Professionalism Mini-Evaluation Exercise (P-MEX). The time duration for this study was of 6 months, beginning from May 2024 till October 2024. A total of 42 students were selected for the study through convenience sampling. This type of sampling allows gathering data from sources that are conveniently accessible hence it ensured the inclusion of the entire final year batch in the study, that was 42 students. This study was conducted after obtaining approval from the Ethical Review Board. The ERC reference no is 8430224NAOMS. Inclusion criteria was that all the final year dental students of that Private Institute who consented for the study and were attending the clinical rotations during their final year of Dentistry were included in this study. Whereas the students who did not consent for the study were excluded. Written informed consent was obtained from all participants prior to data collection and their responses were kept confidential and anonymous. The participants were also informed that the evaluations made are only for the purpose of the study and the scores will not be included in their summative assessment. A total of 12 dental faculty members were included, from the departments of Oral surgery, operative dentistry, prosthodontics and periodontics and they served as evaluators. Evaluators were included in the study on the basis of their knowledge regarding the concept of professionalism and its essential elements. Those with at least a teaching experience of five years were included in the study. These faculty members attended a workshop where they received hands-on training on the use of P-MEX to ensure consistent and reliable assessments. The aim of the study, the features of

the P-MEX tool, and the evaluation procedure were all covered in this training session.

Data Collection: The Professionalism Mini-Evaluation Exercise (P-MEX) is a structured assessment tool designed to evaluate various dimensions of professionalism in healthcare education. It consists of 24 items, each focusing on a distinct aspect of professional behavior. These items are categorized into four major domains: doctor-patient relationships (8 items), reflective skills (5 items), time management (3 items), and interprofessional relationships (8 items). [13] The P-MEX has been widely validated in medical and dental education, demonstrating strong internal consistency with a Cronbach's alpha of 0.88, indicating a high level of reliability. [14]

In this study, P-MEX assessment forms were distributed among 12 faculty members, all of whom were experienced evaluators with expertise in clinical teaching and student assessment. These faculty members were responsible for observing and assessing final-year dental students during their clinical rotations in the dental outpatient department (OPD). The evaluations were conducted in real-time, ensuring an authentic assessment of students' professional behavior during patient interactions.

The assessment process specifically focused on students' history-taking and oral examination skills, along with their adherence to professional standards. Faculty members utilized the P-MEX tool to score students on all 24 items, using a five-point rating scale: 4=exceeded expectation, 3= met expectation, 2=below expectation, 1=unacceptable, 0=not applicable.

Each student was evaluated based on their ability to demonstrate professionalism across various clinical encounters. By employing direct observation, the study ensured that students were assessed in an objective and structured manner. The collected data provided valuable insights into students' strengths and weaknesses, helping to identify areas requiring further improvement.

Statistical analysis: The statistical analysis was conducted using IBM SPSS Statistics version 20. Descriptive statistics, including mean and standard deviation (SD), were calculated for continuous variables. Additionally, categorical variables were analyzed using frequency and percentage distributions to provide a clear overview of the dataset.

RESULTS

The results revealed that a total of 12 faculty members out of which 8 were female (66%) and 4 were male (33%) with a mean age of 55 evaluated the final year students of dentistry on the P-MEX form. Around 42 final-year students of dentistry participated out of which 28 were females (66%) and 14 were males (33%). Their mean age was 24 years, with a range of 20 to 26 years. The average score of final-year students of dentistry for P=MEX was 2.70 ± 0.21. The scores for interprofessional relationship skills were the highest (2.80 ± 0.31) and reflective skills were the lowest (2.56 ± 0.45). The doctor-patient domain had a mean score of 2.70 ± 0.33 whereas time management had a mean of 2.74 ± 0.30. The finding revealed that there was no significant difference between male and female final-year students of dentistry (P value= 0.21). Table.1 shows the mean scores for the four domains of the P-MEX tool. Whereas, Table 2. Shows the mean scores of students for each item of the P-MEX.

DISCUSSION

Upholding professional values and conduct is essential for graduates and professionals in the medical field, as it significantly influences the quality of clinical care provided to patients, their families, and the broader community.[16] Although the core concepts of professionalism are included in dental curricula, there is a need for greater emphasis on educational development to strengthen these values among dental students.[9,12] In Pakistan, medical colleges do not prioritize professional development, making it difficult to teach this skill effectively. [17] Incompetency in this can lead to poor quality of healthcare and higher rate of dissatisfaction of patients and the provider.[7] Dental professionals must have a solid sense of professionalism and ethics. It emphasizes how these ideas affect patient trust and the general standard of care in addition to directing clinical decision-making.[12]

Key challenges within educational systems include establishing robust standards for professionalism and developing appropriate assessment tools.[18] The working group on professionalism at the International Ottawa Conference has explored prevalent definitions and methods for assessing professionalism[18], leading to the introduction of several tools aimed at evaluating the professionalism of healthcare workers.[10] By improving the abilities and competences of dental students, their future practice is impacted by the assessment of their professionalism, which eventually results in better patient care. A thorough grasp of professionalism encourages moral conduct and personal development, which is advantageous to the individual as well as society.[2,13]

In this study the P-MEX tool was used to assess the professionalism of final-year dental students, providing valuable insights on their competencies and opportunities for improvement. Overall, the mean scores suggest that students have a basic understanding of professional behaviour, with evident strengths in certain areas and potential for

Table-1 Final year students of dentistry mean score on the four domains of P-MEX form

Domains of P-MEX form	Mean	Standard deviation
Doctor-patient relationship	2.70	0.33
Reflective skills	2.56	0.45
Time management	2.74	0.30
Interprofessional relationship	2.80	0.31

Table 2: The score of final year students of dentistry on 24 items of PMEX-form

Items	Mean	Standard deviation
Doctor-patient relationship		
Listened actively to patient	2.85	0.43
Showed interest in the patient as a person	2.71	0.51
Showed respect for the patient	2.80	0.46
Recognized and met patient needs	2.71	0.40
Accepted inconvenience to meet patient needs	2.52	0.51
Ensured continuity of patient care	2.59	0.51
Advocated on behalf of a patient and/or family member	2.60	0.46
Maintained appropriate boundaries with patients/colleagues	2.79	0.42
Reflective skills		
Demonstrated awareness of limitations	2.48	0.51
Admitted errors/omissions	2.61	0.54
Solicited feedback	2.51	0.53
Accepted feedback	2.54	0.53
Maintained composure in a difficult situation	2.64	0.49
Time management		
Was on time	2.76	0.43
Completed tasks in a reliable fashion	2.73	0.41
Was available to patients or colleagues	2.72	0.31
Interprofessional relationship skills		
Maintained appropriate appearance	2.91	0.31
Addressed own gaps in knowledge and skills	2.71	0.52
Demonstrated respect for colleagues	2.99	0.34
Avoided derogatory language	2.71	0.31
Assisted a colleague as needed	2.81	0.51
Maintained patient confidentiality	2.78	0.37
Used health resources appropriately	2.76	0.41
Respected rules and procedures of the system	2.75	0.32

improvement in others. The results of this study indicate that final-year dental students demonstrated lower professionalism, particularly in the domains of doctor-patient relationships and reflective skills. This aligns with findings from a study conducted in Iran, which reported that dental students' ethical abilities were below average, highlighting shortcomings in the educational system.[19] It also aligns with the study of Maryam Kazemipoor who evaluated the professionalism of dental residents using the Professionalism Mini-Evaluation Exercise (P-MEX). The findings of her study showed the reflective skill domain had the lowest scores i.e., 2.59 0.49. Her study's findings indicated that learners varying professionalism scores were influenced by the absence of a structured instructional program and feedback systems.[20]

The findings also revealed that the lowest score (2.52 0.51) in doctor-patient relationship domain was of "accepting inconvenience to meet patient needs". However, the reflective skill domain got the lowest score in the item demonstrating awareness of one's own limitations in the domain of reflective skill (2.48 0.51). These gaps could indicate difficulties in balancing clinical duties with patient-centered care and self-reflection. This mirrors the findings of Graskemper JP et al., who noted that it is often difficult in dentistry to prioritize patients' needs and well-being.[21] These findings also align with Ozar's study who suggested that prioritising patient needs and addressing patients' well-being were identified as challenges in dentistry.[22]

Moreover, low scores were also seen for the items of solicited and accepted feedback. These findings are similar to the work of Maryam Kazemipoor who found out that Dental residents received the lowest scores for solicited and accepted feedback.[20] The Farah-Franco study also found that general dental students had the lowest scores for admitting individual faults and accepting feedback.[23] These findings are also similar to Asma Razzaq's study where she assessed the professionalism of pediatric residents using P-MEX and the participants scored lowest for solicited feedback.[17] To

overcome this, Fox in his study suggested that the coaching approach should be introduced, which involves delivering feedback to learners, allowing them to reflect on their experiences and build their skills.[24]

A high mean score was seen for demonstrating respect for colleagues, patients and keeping appropriate boundaries with patients and colleagues. This demonstrates the students' grasp of professionalism, which is crucial for fostering trust and effective communication in the doctor-patient interaction. This finding is consistent with the research, where Järvinen and Kessing (2021) emphasis on the relevance of professional boundaries in healthcare settings. According to these authors, maintaining professional boundaries is more than just establishing barriers; it's also about managing relationships in a way that builds trust and respect.[25] Farah-Franco et al. also demonstrated in her study that the highest scores were seen for avoiding insults, respecting peers, and upholding one's boundaries with others, which is consistent with the findings of the current study. [23] Furthermore, these findings are also supported by the study of Asma Razzaq where the residents secured highest mean scores for maintaining appropriate boundaries and demonstrating respect for colleagues.[17]

A mean score of 2.61 0.54 suggested that however most of the students performed well on the item “admitted errors’ but there was still room for improvement. The fact that they can still do better, nevertheless, suggests that their professional behavior does not yet fully incorporate this talent. This emphasizes how important it is for educational establishments to create a culture that values candor regarding errors. This could indicate the need to develop a culture of openness and accountability without fear of being judged. This fear of students, of being judged, when they admit their mistakes can be lessened by fostering an environment of transparency. Instead of concealing errors, such an atmosphere would encourage learning from them. In result it will ultimately improve the standard of patient care.[2, 24] This is consistent with the findings of Fox who recommended that as long as dentists are reluctant to acknowledge their mistakes for fear of punishment and other legal repercussions, and this fear will be transmitted to the next generation.[24] A culture of silence concerning mistakes can be sustained by this fear, which can be passed down to future generations of dentists. In order to break the loop and advance a more open healthcare system, this issue must be addressed.[24]

The initial step towards fostering professional behavior involves cultivating ethical sensitivity. Studies worldwide have shown a tendency for student’s professional behavior to decline during their academic years.[13] Therefore, it is recommended that students displaying unprofessional behavior should be closely monitored. Students are able to comprehend the standards and expectations in their area when clear ethical rules are established and communicated. Consistent ethical behavior and decision-making are supported by this clarity and should be given immediate feedback provided by supervisors to enhance their professional sensitivity.[13, 27] It is also observed that the unprofessional conduct among students may be attributed to the lack of a structured curriculum, assessment, and feedback system. For meaningful change in professional relationships, a sustained commitment to cultural transformation is necessary.[21, 27] To support behavioral change and encourage professionalism, resources such as remediation, monitoring, and reflection have been introduced.[28] By Promoting open discussions with students regarding moral dilemmas enables teachers to exchange viewpoints and experiences, leading to a better comprehension of moral dilemmas. Regular ethics-focused team meetings, seminars, and workshops can all help to foster these kinds of conversations. Consequently, supervisors and academic leaders are encouraged to cultivate a culture of self-reflection and reflective practice within educational settings.[29] Kazemipoor et al. emphasize that the P-MEX promotes reflection and recognition of professional behaviors, which are essential for developing a comprehensive understanding of professionalism in clinical practice.[20] The feedback provided through the P-MEX is instrumental in guiding students toward recognizing their strengths and weaknesses. Alam et al. argue that integrating the P-MEX into the curriculum not only enhances the assessment of professionalism but also fosters a culture of continuous improvement among students. [30]

A major strength of this study is its comprehensive approach to evaluating professionalism from multiple perspectives. By analyzing professionalism in dental education, the study underscores its critical role in shaping future healthcare professionals and ensuring high-quality patient care. Additionally, it highlights the dynamic nature of professionalism, emphasizing the need for continuous evolution in educational strategies to align with the demands of modern medical practice. The study also demonstrates methodological rigor by incorporating well-established assessment tool (P-MEX), enhancing the validity and reliability of its findings. The use of this standardized evaluation instrument allows for a more precise and objective measurement of dental students' professionalism. Moreover, the study suggests integrating the P-MEX tool into educational curricula, advocating for continuous monitoring and structured feedback mechanisms to enhance professional development.

Despite its strengths, the study has some limitations. The primary constraint is its small sample size, which limits the generalizability of the findings. Larger and more diverse participants would provide a broader representation of professionalism in dental education. Additionally, the study is confined to a specific setting, which may not capture variations in professional behavior across different institutions, regions, or cultural contexts.

To strengthen future research, multi-center studies involving diverse educational institutions and healthcare settings are recommended. Such studies would allow for a more comprehensive assessment of professionalism among healthcare professionals. Moreover, longitudinal studies tracking students' professional development over time could provide deeper insights into the effectiveness of different educational interventions.

CONCLUSION

The study indicates that while students possess a foundational understanding of professional behavior, there are evident gaps that must be addressed through enhanced teaching methodologies and continuous assessment. The Professionalism Mini-Evaluation Exercise (P-MEX) has proven to be an effective tool for evaluating professionalism, providing valuable insights into students' strengths and areas requiring improvement. The findings emphasize the necessity of ongoing instruction and structured feedback systems to foster professionalism among final-year students throughout their academic journey. Specifically, the study highlights deficiencies in reflective practice and doctor-patient relationship skills, indicating key areas that require targeted intervention. To bridge these gaps, it is crucial to implement structured educational strategies and periodic evaluations that assess and reinforce professional behaviors. A well-designed framework for continuous education and assessment will not only enhance students' professional competencies but also better prepare them for real-world clinical practice.

Authors Contribution:
Nameera Agha: Designed the study and collected data and major contributor in writing manuscript.
Syeda Maryam Tanweer: Major contributor in writing the manuscript and designing of study.
Hamda Syed: Performed data analysis and interpretation of results
Fatima Khaleeq: Data collection and analysis
Farzeen Tanwir: Supervision and critical review.
Tauqeer Bibi: Data collection and proof read.

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Medical Education-Original Article **Open Access**

Assessment of Self-directed Learning (SDL) Readiness among Medical and Dental Students, in a Private University.

Narmeen Ahmed, Iram Khursheed

BSTRACT

Adult learners have the proven capability of self-directedness when provided with the appropriate learning environment. Self-directedness foster continuing medical education and stimulate medical students to become lifelong learners which is essential to provide evidence-based patient care.

Objectives: The objectives of this study were to assess the self-directed learning readiness of students and identify the impact of student-centered teaching strategies on their readiness level.

Study Design & Setting: This study was conducted at 2 colleges of Ziauddin University. All students of 1st & 2nd year MBBS and BDS program were included in the study (N=325). This was a cross-sectional study conducted from May-June 2023, at the middle of the Professional Year.

Methodology: After taking the informed consent, students were provided with a valid questionnaire, based on a Likert-scale, developed by Williamson, to measure students' readiness for their SDL level.

Results: The response rate was 35% (n=114/325), with the majority of participants from the MBBS program (88.5%, n=101) and females (67.5%, n=77). The overall mean SDL readiness score was 234.58 (±23.94). Students form Year 1 and Year 2 both predominantly scored high levels (76.3%) with mean SDL scores of 233.5 (±24.56) and 235.2 (±23.63) respectively. The scores reflected the positive impact of student-centered teaching strategies that are being used in their curriculum.

Conclusion: Overall, the study supports the idea that active teaching methods significantly enhance self-directed learning readiness of students. This reinforces the importance of integrating such strategies into medical and dental education curricula to foster lifelong learning and independent knowledge acquisition.

Keywords: Continuing medical education, learning, medical students, dental students

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INTRODUCTION:

Self-directed learning (SDL) is an autonomous and dynamic educational process in which the responsibility for acquiring knowledge and skills is borne by the students themselves and they maintain their cognitive state according to their own pace of learning.[1,2]

When the students are self-directed from their initial years of study, they realize their responsibility of learning and improvising, fostering continuing medical education and become more self-disciplined.[1,3,4] Self-directed learning is generally defined as "learning on one's initiative, with the learners having subsequent involvement in curricular planning, designing, and evaluating the entire program". [3,5]

Self-directed learning inculcates better time management, team work, reflective writing skills, promotes clarification of theoretical concepts and ability of self-evaluation.[3,6] However, certain criteria and structure are required to optimize the benefits of this strategy.[7]

According to the adult learning principles suggested by Knowles, adult learners have the ability to determine what to learn and how to learn in a conducive learning environment.[8] They have the proven capability of being accountable for identifying their learning needs, planning their study time accordingly and using multiple resources to understand the content deeply.[9,10,11] They are also capable of monitoring their learning progress thus striving towards continuing medical education.[8,12]

Medical profession is a field that requires continuous learning and upgradation regarding the innovations and technological advancements in healthcare delivery system to provide quality and evidence-based patient care.[11,13] It is important

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that medical professionals maintain the quality to learn throughout their professional careers and become lifelong learners.[2,10,11]

Studies also suggest that self-directed learners perform better as compared to traditional lecture group learners.[14] To promote the competency of self-directed learning amongst students, it is necessary that they possess analytical and problem-solving skills and to develop these skills, appropriate teaching strategies need to be implemented in the medical curricula.[1,2,8] Furthermore, self-directed learning can grow into self-determined learning which is termed as Heutagogy. The foundation of heutagogy lies on the concept of SDL but it fosters more autonomy in the learners and develops essential competencies in students.[15]

Literature states that student-centered learning strategies, like PBL, CBL and flipped classroom, motivate students towards being self-directed and lifelong learners.[9,16] In fact, it is stated in literature that the success of SDL depends on the learning strategies used in the curriculum.[3] Problem-based learning, which involves learning in an authentic and social context, is one of the most popular learning strategies that promote SDL.[6,17] Evidence exists that PBL stimulates SDL ability because during PBLs, learners are accountable to plan, supervise and evaluate their own learning process.[18] In PBLs, students also learn to work collaboratively in teams which is essential for them as they have to become a part of the larger community of practice in the future to solve larger problems.[4,6] Thus, PBL promotes SDL which is primarily considered as a higher order active learning technique that promotes self-efficacy of the students.[19]

The significance of being a self-directed lifelong learner can be judged by the fact that various accreditation bodies all over the world, including the National Medical Commission have now labelled this as a core competency that should be developed in all medical and dental students.[1,20,21] According to the Accreditation Standards by Pakistan Medical & Dental Council 2024, all medical institutes should incorporate teaching strategies that enhance self-directed and independent learning.[20]

There is a scarcity of literature that assesses the readiness levels of students regarding self-directedness in learning in medical institutes of Pakistan, though literature states the increasing importance of implementing SDL slots in their curriculum.[22]

Various instruments are available internationally that assess the readiness level of students regarding the self-directed learning. The most common instruments, SDLRS by Guglielmino 1978 and by Fischer et al 2019 have been widely used for this purpose.[23,24] However, there are a few validated instruments that relate the effect of learning strategies and activities with the level of self-directedness like Williamson 2007.[12] This scale was further updated by Cadorin et al 2013.[25] It is significant to assess the readiness level of students in order to evaluate the impact active teaching strategies have on them.

METHODOLOGY

After obtaining the consent from ERC at Ziauddin University (Reference Code: 6740223NADED, the study was conducted at 2 colleges of Ziauddin University- Ziauddin Medical College (ZMC) and Ziauddin College of Dentistry (ZCD). Students enrolled in MBBS and BDS program participated in the study after filling the e-consent form.

As per the PMDC guidelines, ZMC and ZCD ensured timely accommodation of self-directed learning hours throughout the duration of the 5-year MBBS and 4-year BDS programs respectively. These self-directed learning slots are sometimes task-driven, that is, students are given specific tasks/ assignments for which they have to conduct research and collect data to produce authentic results. Usually, such SDLs are scheduled between PBL sessions so that students can organize their learning according to the learning objectives decided in the first PBL-Session. However, in some SDL slots, students are independent to determine their own learning needs, making a continuous effort to achieve the desired learning outcomes themselves.

In both the MBBS and BDS programs, the initial 2 years are pre-clinical followed by clerkship period. For the pre-clinical years at ZMC and ZCD an integrated (modular system) curriculum is being followed where the basic theoretical knowledge is taught with relevance to clinical practice. The primary goal of this integration is acquisition of skills and competencies through the progressive development of concepts and their application.[22]

The 1st and 2nd year MBBS and BDS students are provided with real-life case scenarios in their PBL sessions with the aim to stimulate their problem-solving and critical thinking abilities. Each PBL case is Peer-Reviewed by a panel of subject experts and medical educationist.

There are 2 PBL sessions, incorporating the 7-Jumps of PBL. An SDL slot is scheduled in between these two sessions to address Jump # 5 where students study independently and achieve their desired learning goals.

Sample size: All year-one and year-two students of the ZMC and ZCD were included in the study. N=325

Inclusion criteria: MBBS & BDS students who were enrolled in ZMC & ZCD of either gender.

Students who gave consent to fill the questionnaire. Exclusion criteria: 1st & 2nd year medical and dental students who did not gave consent were excluded from the study. Medical & dental students from clinical years and students from other colleges of Ziauddin University were not included in the study.

Sample size: Purposive Sampling was done as data had to be collected from specific population only.

n=22 students participated from 1st year MBBS and BDS program, n=92 students participated from 2nd year MBBS and BDS. Total 114 students participated. Design & duration: This was a cross-sectional study and the data were collected in May-June 2023, mid-year of the 1st and 2nd Professional Year.

A valid questionnaire, based on a Likert-scale, developed by Williamson was used to measure students' readiness for their SDL level. The questionnaire consisted of 60 questions assessing the students' level of self-directedness in learning and they were organized in five domains: self-awareness, learning strategies, learning activities, self-evaluation, and interpersonal skills. Although many rating scales are available online but Willaimson SRSSDL is one of the few scales that is comparatively more comprehensive and includes learning strategies and relates its significance to the self-directed learning readiness of students. The scale proved to be reliable with Cronbach's alpha coefficient for each domain to be lying in between 0.71 and 0.79. [,22]

Students' level of self-directedness in learning was ranked as low SDL (if they score within 60–140 range), medium SDL (141–220 score), or high SDL (221–300 score)[2].

Data collection process: After taking the informed consent, students were emailed with the consent form and the link to the questionnaire.

Analysis: Quantitative data was analyzed using IBM SPSS version 20. Mean and standard deviation of students' SDL scores were computed. Independent t-tests were used to investigate if there was a difference between the means of the scores obtained from students of different academic years, gender or programs.

RESULTS:

The response rate was 35% (n=114/325), with the majority of participants from the MBBS program (88.5%, n=101) and vastly were females (67.5%, n=77) as shown in Table 1. SDL Readiness Scores: The overall mean SDL readiness score was 234.58 (±23.94). Year 1 and Year 2 students both predominantly scored high levels (76.3%) with mean SDL scores of 233.5 (±24.56) and 235.2 (±23.63) respectively. A total of 23.6% of students had moderate-level scores (Figure 1). Comparison of Subscale Scores & individual items: When comparing the subscale scores of SRSSDL between 1st-year and 2nd-year students using independent t-tests, no significant gender-based differences were found as shown in Table 2. However, some individual SRSSDL items did show significant gender-based differences. Among 1st-year students, males scored higher in relating experiences with new information, while females scored higher in taking breaks and being inspired by others' success (Table 3a). Among 2nd-year students, significant differences were observed, with females generally scoring higher in various areas (Table 3b).

DISCUSSION

The findings of this study indicate that the majority of 1st

Table 1- Demographic Data

Year	Program N(%)		Gender N(%)		Age (Mean± S.D)
	MBBS	BDS	Male	Female	
1st (n=22, 19.2%)	77.3%	22.7%	22.7%	77.3%	19.5 ±0.8
2nd (n=92, 80.7%)	91.3%	8.7%	34.8%	65.2%	20.62 ±0.8

Figure-1

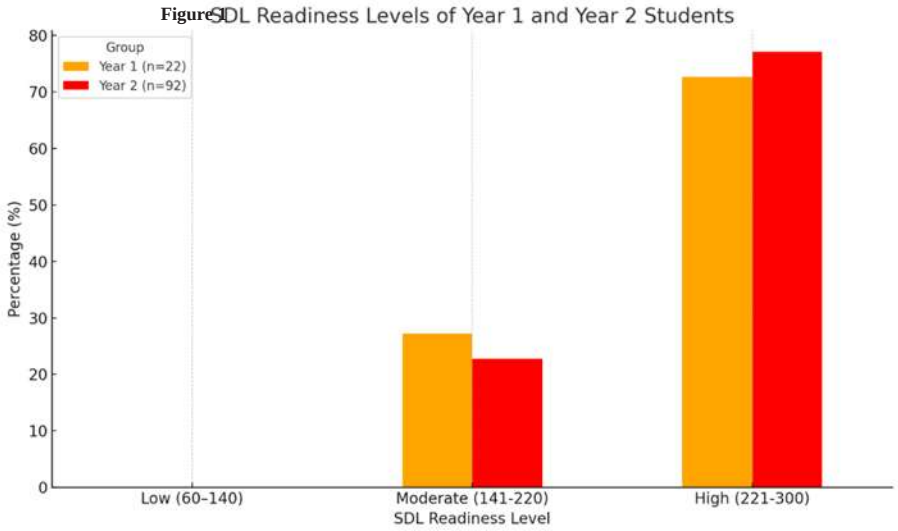

Table 2: Comparison of mean scores of self-directed learning readiness (subscale scores) in 1st and 2nd year students using independent t test.

Subscale SRSSDL	Gender	1st Year				2nd Year			
		Mean	Std. Deviation	T	P-value	Mean	Std. Deviation	T	P-value
Awareness	Male	6.8	1.48	-1.149	0.26	4.1	0.4	1.369	0.175
	Female	7.8	1.81			4.0	0.4		
Learning strategies	Male	3.9	0.79	0.037	0.97	3.7	0.6	-0.591	0.556
	Female	3.9	0.50			3.8	0.6		
Learning activities	Male	4.0	0.54	0.255	0.80	3.8	0.4	-1.566	0.121
	Female	3.9	0.47			4.0	0.5		
Evaluation	Male	3.6	0.41	-1.847	0.08	3.8	0.5	-1.436	0.155
	Female	4.0	0.44			4.0	0.6		
Interpersonal skills	Male	3.9	0.59	-0.064	0.95	3.9	0.5	-0.109	0.914
	Female	3.9	0.45			3.9	0.5		

Table 3a- Significant associations of SRSSDL items (1st year students)

SRSSDL items	Gender	Mean	(Mean± S.D)	P-value
I relate my experience with new information	Male	4.4	4.4 ± 0.9	0.03
	Female	3.5	3.5 ± 0.7	
I prefer to take any break in between any learning task	Male	2.6	2.6 ± 0.9	0.03
	Female	3.9	3.9 ± 1.1	
I am inspired by others' success	Male	3	3 ± 1.6	0.04
	Female	4.2	4.2 ± 0.9	

Table 3b- Significant associations of SRSSDL items (2nd year students)

SRSSDL items	Gender	Mean ± Std. Deviation	P-value
I am responsible for identifying the areas I need training in	Male	4.6 ± 0.6	0.03
	Female	4.3± 0.6	
I have a break during long periods of work	Male	4.5 ± 0.7	0.04
	Female	4.2 ± 0.8	
I find 'role play' is a useful method for complex learning	Male	2.9 ± 1.1	0.02
	Female	3.4 ± 1.0	
I rehearse and revise new lessons	Male	3.5 ± 1.0	0.01
	Female	4.1 ± 0.8	
I use concept mapping/outlining as a useful method of comprehending a Wide range of information	Male	3.6 ± 1.1	0.01
	Female	4.1 ± 0.9	
I raise relevant question(s) in teaching-learning sessions	Male	3.0 ± 1.1	0.05
	Female	3.4 ± 1.0	

and 2nd-year students at Ziauddin Medical College (ZMC) and Ziauddin College of Dentistry (ZCD) demonstrated a high level of readiness for self-directed learning (SDL), with a mean SDL score of 234.58 (±23.94). One of the anticipated reasons could be the inclusion of active learning strategies in the curriculum of both colleges. This aligns with the results of study by Patra S and Hill M who stated that when students are exposed to active learning strategies like problem-based learning methods, they are encouraged to critically think and come up with solutions that they might not develop if teacher-centered strategies are used.[14,21]. A similar study conducted in India by Dulloo P and Kar et al also observed high levels of SDL readiness among medical students exposed to student-centered learning strategies.[11,26] Premkumar et al. found that medical students demonstrated greater SDL readiness after being taught with active learning techniques such as PBL and interactive discussions, similar to our findings.[5] He concluded that active learning strategies promote independent learning, critical thinking, and problem-solving which are essential components of SDL readiness

and further fosters continuing medical education. Study by Liu TH indicated that active, student-centered learning strategies, like PBL, CBL and flipped classroom, motivate students towards being self-directed and lifelong learners.[9,16] Similarly, in the study by Buch AC and Hill M, it was also stated that PBL helps develop self-directedness in students and boost students' self-confidence.[3,21]

The results of our study showed no substantial difference between first- and second-year students, with both groups predominantly scoring in the high SDL readiness range, further suggesting that the teaching methods used in both years are consistently fostering SDL skills. As stated in the study by Khan EH, when students are exposed to active learning activities, they are bound to become self-directed in their learning, irrespective of their Academic year.[22]

Interestingly, while there were no significant differences in overall SDL readiness scores between genders, some specific SDL behaviors revealed gender-based differences. For example, among 1st-year students, males scored higher in relating their experiences to new information, while females performed better in taking breaks and being inspired by others' successes. In the second-year cohort, females scored significantly higher in areas like rehearsal and revision of new lessons and the use of concept mapping. These variations suggest that although both genders are generally well-prepared for SDL, certain aspects of their learning processes may benefit from gender-specific teaching interventions or support mechanisms. Similar findings were seen in the study by Roberts M which also highlighted that gender-related differences in the readiness level are present in the end of 1st year medical students, specifically related to self-determination.[13] This may be due to the difference in self-rating assessment between boys and girls.

The study highlighted the effectiveness of the integrated curriculum and active learning strategies such as PBL at ZMC and ZCD, which were specifically designed to promote self-directed learning. In Ethiopian medical schools, Kidane et al. reported that students exposed to innovative curricula that emphasized SDL techniques like PBL showed high levels of self-directedness.[9] The study revealed how SDL helps students become lifelong learners and builds their confidence in identifying and addressing learning gaps. The findings align with our study, as both demonstrate that student-centered methods boost SDL readiness.[9]. Since medical profession requires continuous upgrade of competencies and skills according to the innovations being done for better patient outcome, individuals who learn to organize their own learning transform into better lifelong learners which is a prerequisite for the medical profession, as stated in the study by Patra S. [14]

A study by Bhandari et al also signified that SDL strategies improve self-efficacy and promote independent learning skills, particularly when PBL are integrated into the curriculum.[19]

In contrast to our findings, a study conducted at KIST Medical College in Nepal found that students did not show significant improvements in SDL readiness despite the introduction of a PBL-based curriculum.[18] Also, in a study by Anil D., SDL levels were not significantly related to learning activites.[8] While some students benefited from PBL, the overall readiness levels remained moderate. This suggests that other factors, such as institutional support and faculty engagement, may influence SDL effectiveness.[18] Also, this may be due to lack of training of faculty and students on how to conduct PBLs appropriately.

In Pakistan, Zeb et al. reported that self-directed learning readiness among medical students was relatively low, particularly among students not adequately supported with structured SDL slots or guidance.[24] Their study indicated that without proper implementation of SDL strategies, students may struggle to achieve high levels of self-directedness, which supports our findings that most ZMC and ZCD students demonstrated high SDL readiness due to the availability of structured SDL slots for them.[24] This supports the discussion stated in literature that incorporation of SDL requires more than just curriculum changes. It depends on curriculum organization along with students' motivation and self-regulation.[27]

SDL slots provide opportunities to students to identify their strengths and limitations with reference to their studies. Once students recognize their needs, their motivation, awareness and confidence level also boosts. A study by Yang C had similar findings which stated that students SDL ability is interlinked with their confidence level, as in our study interlinked with the awareness level. [10]

In contrast to the findings of our study, Dulloo P stated that only active learning strategies do not affect the readiness level of students.[11] There are other factors as well that can affect the SDL readiness level. However, this study does emphasize the need of including student-centric strategies in the curriculum to promote the mastery of the approach of SDL.

In contrast to our findings, a study by Roberts M. stated that quantitative longitudinal studies have failed to provide consistent results regarding SDL readiness in medical students.[13] This may be due to lack of organization and administration of appropriate surveys or due to the fact that quantitative surveys alone may not be the most appropriate method to assess students' readiness.

CONCLUSION

This study found that most of the students from the 1st and 2nd year medical and dental programs had a high readiness level of self-directed learning likely because of the incorporation of active learning strategies used in their curricula, PBL being one of them. The consistent use of

these strategies throughout the curricula of both years have significantly fostered the lifelong learning abilities of the students. Although there were no significant differences observed between the readiness scores of different academic years but some gender-based differences were noted in their learning behaviors reflecting their different learning processes. This study emphasizes the importance of structured integration of SDL slots in medical and dental programs to increase awareness and motivation amongst students.

Authors Contribution:
Narmeen Ahmed: Contribute in discussion writing, contribute in data collection
Iram Khursheed: Contribute in introduction writing, contribute in data collection

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Review Article **Open Access**

Artificial Intelligence in Surgery: Learning and Applications

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ABSTRACT

Artificial intelligence (AI) has transformed the field of surgery; using machine learning algorithms in domains like computer vision and operative robotics can fundamentally alter patient screening, diagnosis, risk assessment, treatment, and follow-up procedures in operating rooms and both before and after surgery. This quick review summarized AI-assisted surgical learning and applications in various surgery sectors. We explained the usefulness of AI in all aspects of surgery learning and competency. Our review focused on implementing AI in several aspects of patient care, including early screening, intra-operation robotics, post-operation monitoring, and follow-up. Horizon scanning of AI technologies in surgery identifies developments that can improve medical procedures and transform future norms. Thus, over the next ten years, experimental progress will quickly translate into practical applications. In comparison, AI may necessitate a change in work procedures. It will also improve surgical safety, learning, and surgical quality for patients while offering surgeons and health systems substantial benefits.

Keywords: Artificial intelligence; surgery learning; AI-assisted surgery; robotics

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INTRODUCTION

The healthcare sector is being revolutionized by artificial intelligence (AI). The term AI refers to a broad range of computational methods that allow computers to completely evaluate clinical studies on their own. Operational robotics, augmented reality, computer vision, and machine learning of organized data are some of these methods.[1,2] AI is the imitation of human intellect in computers. Like human intelligence, the systems can perform tasks such as decision-making, speech recognition, language processing, visual perception, and pattern identification. AI can advance healthcare research by assessing and decoding data from clinical projects to find hidden but significant trends that go beyond conventional wisdom. It can also enhance patients' treatments by assisting in correct decisions.[3]

Machine learning is the process of using programs to anticipate data as well as get better with time. Machine learning is further classified as supervised, un-supervised, and reinforcement learning. In supervised learning, systems are trained using labelled information to forecast an outcome. Conversely, unsupervised learning makes use of unlabeled information to enable systems to investigate unidentified trends or results. Lastly, a trial-and-error method similar to operating conditioning is referred to as reinforced learning.[1,4] Another type of machine learning is deep learning, which makes use of artificial neural networks to examine big data and resolve challenging issues. Deep learning's diagnostic capabilities in medical imaging are among the primary uses that have demonstrated its exceptional capacity for identifying intricate patterns.[5] Computer vision and natural language processing (NLP) are additional subfields that are especially pertinent to surgery. NLP includes the process of turning generated spontaneous language into automated structured text.[4]

All these machine learning techniques have occasionally shown remarkable results in challenging problems like natural language translation and picture categorization.[6] However, these machine learning systems are frequently underreported (no better performance of machine learning over logistic regression)[7], do not show better predictive accuracy than conventional statistical methods for prognostication in traumatic brain injury[8], or predicting major chronic diseases[9], or for discriminating type 1 and

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type 2 diabetes in young adults.[10]

AI has been exploited in precision medicine, drug development, imaging and diagnosis, genomics, and risk stratification. More recently, AI has been implemented in surgery. AI methods concentrate on recognizing features and automated interventions for before- and after-surgery planning. Numerous supervised algorithms have been created in previous years, including statistical classifiers, atlas-based techniques, and active-shape models.[11] The development of more advanced AI models, for example, AlexNet, has made it possible to use automatic data descriptors for clinical image interpretation. These descriptors have demonstrated better universality and resilience than handcrafted models. As the use of automated machines in surgery grows, AI has the potential to alter the discipline by creating complex functionalities that link robotic control and real-time sensing.[11]

Surgical routes provide concrete and established metrics for performance and outcomes that prioritize patients. They are also clearly defined, evidence-based, and frequently technically enabled at inception. These elements are probably in charge of the high degrees of model stability and the quantity of software (considered as medical devices) that have received regulatory approval and are located at crucial points throughout the surgical process.[4] For example, radiomic gadgets are used for internal scanning and diagnostics, some AI models are used in risk prediction by utilizing extensive clinical information, robot surgical devices assist surgery, few AI models are used that maximize the effectiveness of surgery pathways, and AI systems are used for making correct decisions after surgical procedures and follow-ups. As a consequence, there is a growing likelihood that AI-based workflows will develop across a wide range of surgical fields, backed by data showing improved results and cost reductions.[4]

According to World Health Organization (WHO) and the Coalition for Health AI criteria, AI programs must be testable (enable algorithms and results to be impartially confirmed), useable (easy to use, have no impact on clinical operations, and suitable to patients as well as doctors), reliable (patients and doctors should rely on them to deliver consistent outcomes), beneficial (effective in clinical trials, and must improve patient care. and operable (adequate operator education to assure that operator skill or expertise won't be a barrier to technology adoption).[12,13] The current review article comprehends the use of AI in surgical learning, surgical robots, and preoperative, intraoperative, and postoperative phases. Finally, we summarize the prospects of AI in the field of surgery.

Surgery learning

Clinical outcomes could be improved by using AI in surgical learning to improve training effectiveness and quality. It is very possible that the use of AI in surgical training will grow in popularity as both technology and the surgical industry continue to progress. As AI's potential and skills continue to develop, this integration is probably going to happen in ways that are currently hard to predict or understand. AI in surgical education has the potential to completely transform the way surgeons are taught and significantly raise the standard of surgical care overall. The growing application of AI in this industry, however, also raises several practical and ethical concerns that should be taken into account. AI can be incorporated into surgical education to help students become more proficient in surgery and enhance patient care. Collaboration among the surgeon, ethicists, and researchers is also necessary for this integration in order to guarantee the technology's efficacy, safety, and equity. Despite its enormous potential, artificial intelligence has drawbacks, and there hasn't been any clinical use of it up to this point. The growing incorporation of AI into surgical training requires constant observation, assessment, and adjustment.[3]

Competence in surgery includes a broad variety of skills. The elements of understanding, abilities, and mindsets are traditionally considered to be part of competence. AI has the ability to significantly decrease the process of learning for surgical operations and contribute to the growth and enhancement of all aspects of surgical competency, including surgical skills. Training via simulations (SBT) is particularly well-suited for AI.[14,15] In surgical education, SBT has become indispensable, as it enhances students' confidence and performance. AI can offer surgical trainees an accurate and secure setting to practice and refine their technical abilities through the use of simulation software. With the use of SBT, students can practice and become more confident when carrying out procedures without running the danger of endangering real patients.[16] Additionally, SBT can assist the learner remember the abilities and apply them successfully in real-world scenarios. AI can also offer real-time assessment and suggestions, enabling more effective and individualized skill improvement.[17]

AI has demonstrated its usefulness in evaluating movements of the hands and offering advice on how to enhance proficiency using motion-based analysis. It can also identify parts of the process that could need more training.[18-20] Through AI-powered simulation-based training, surgeons can enhance their technical expertise while simultaneously honing non-technical abilities like handling crises and taking decisions under duress. AI could help physicians make clinical decisions by speeding up the procedure and assisting them in comprehending linguistic meanings.[21] A thorough review of present-day standards and scientifically supported approaches to surgical operations can be obtained by using AI-techniques like the processing of natural language to gather and analyze enormous quantities of information from articles.[22]

AI-linguistic processing devices can help with presenting and interpreting difficult study material in ways that are tailored to each trainee's demands and language proficiency.

AI may also help create customized learning resources and study schedules depending on the requirements and understanding gaps of each trainee. AI can be used to evaluate a trainee's progress on mock examinations in order to pinpoint areas of incompetence and provide study guides specifically designed to help them do better in those particular areas. By using AI to analyze learning, educators can target assets derived from traditional evaluation to particular instructional deficiencies. Due to the quick development of AI-applications, educators must stay up to date on the latest developments in AI as well as also modifying their lesson plans to incorporate cutting-edge techniques.[3]

AI can improve mindset training by providing simulated instances of patients and circumstances that let learners hone their analytical and interpersonal abilities while strengthening their capacity to manage challenging ethical dilemmas.[23] Trainees can gain the ability to evaluate many possibilities and successfully convey the choices they make to patients and coworkers by using modelled scenarios. It can keep an eye on the performance of learners throughout training sessions online, though it could be challenging for an educator to watch and give immediate input. It may also give learners immediate advice and guidance on general skills like teamwork and management, as well as assisting them in forming the mindset and habits necessary for achievement in the surgery industry. Since no contemporary surgeon operates alone, they must be taught to collaborate with others from an early age. The learners can get the expertise and compassion necessary to establish a connection and confidence with patients through interacting with AI-generated simulated situations. This will help them traverse the societal and emotional components of surgeries.[24-26]

The precision and effectiveness of clinical diagnosis could be greatly increased by AI. In order to find trends and forecast the best likely diagnosis, algorithms for machine learning can examine vast volumes of information that come from multiple sources, including laboratory test results, patient histories, and medical images.[5,27] Clinicians can make more precise and reliable diagnoses by such algorithms that have been developed on huge databases to identify behaviors and patterns. Particularly in radiology, these algorithms have been shown to give doctors outcomes that are consistent.[28-30]

ChatGPT is currently taking over the realm of the public because of their remarkable capacity for processing and creating narrative prose.[31] Neural networks and NLP models are used by ChatGPT to produce output that is human-like in response to a range of inputs.[32] It could completely change the way that medical education is conducted. Examples of applications for robotic learning procedures include evaluation assessments, instructional assistance, performance of learner's estimation, immediate feedback, and lesson creation. ChatGPT gives trainees and students quick access to clinical data and training materials in an intuitive manner, allowing them to expand their understanding. Surgeons can also provide patients with superior surgical care with the help of produced diagnosis and management recommendations.[33]

Applications of AI surgery

Pre-operation

Hazards prediction

A number of particular to patients and operating variables have led to the development of preoperative risk instruments as crucial supplements to help patients and physicians anticipate the potential hazards of surgery. APACHE-III (mechanism for predicting the death of people in dangerous situations), ACS NSQIP (hazards calculator), and POSSUM (for death and illness) are one of the most commonly used AI instruments for surgical hazards prediction. Nevertheless, renowned tools frequently employ personal input or anticipate linear correlations among factors in their models of mathematics, that is not true in the clinical settings.[34] New advances can increase the prediction power of hazard tools by utilizing machine learning's abilities to analyze vast, varied information and simulate irregular correlations. The danger estimator for urgent laparotomy sufferers uses an machine learning associated optimum categorization tree and outperforms the ACS NSQIP in predicting pre-operation danger for the patient group.[35] Similarly, a study created another machine learning hazard prediction tool named My-Risk-Surgery. It was employed to forecast major complications and death after surgeries.[36]

Screening and Diagnosis

AI tools have been utilized more in breast tumor image analyzing. A variety of AI-powered lesion identification tools, such as Transpara, INSIGHT MMG, and ProFound AI software, have been authorized for use in mammogram testing. Two significant future studies are presently being conducted by INSIGHT MMG and Transpara, both of which have produced encouraging initial results indicating that they are not inferior than two radiologists double reading.[37,38] Thus, it is easy to see a time soon when deep learning algorithms (DLAs) will be used directly as an additional or secondary readers in breast tumors screening. It will increase the probability of breast cancer identification as well as decrease workload of radiologists. Likewise, AI-powdered tools for colorectal and lung cancer detection are also under progress.[39,40] The incorporation of AI-powered tools in the field of molecular biology is still at its early stages. For instance, machine learning model was developed and tested against tumor DNA ML-driven model was tested and independently validated on moving tumor DNAs to identify early stage of hepatocellular via somatic copy number aberrations.[41]

These DLAs have been developed for an accurate diagnosis of various diseases, such as diabetic retinopathy, retinal disease, colorectal polyps, fractures, prostate cancer, intracranial hemorrhages, aneurysms, thyroid cancer, small

bowel obstruction, pancreatic disease, and aortic dissection.[34]

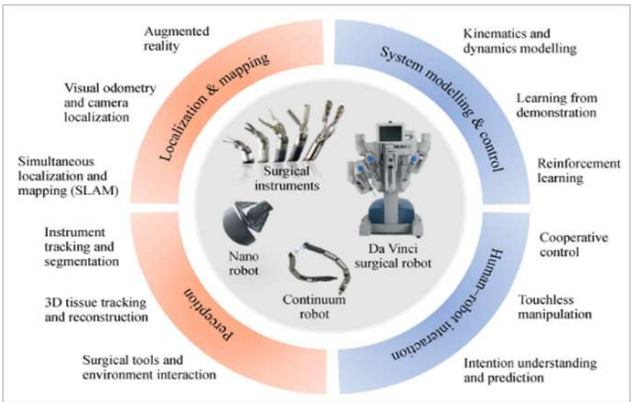
Intra-operation

Surgical robots

In the scientific literature, there has been plenty of debate about using machine vision in surgery video analysis. However, this is now feasible because video-associated, less-invasive surgery methods, including endoscopic, laparoscopic, and robotic, have become widely used. Many regular surgery video recordings can offer an extensive worldwide database of AI algorithms that read, combine, categorize, and evaluate procedural movies. These algorithms rely primarily on advanced machine-learning approaches. Additionally, specialists find it time-consuming to annotate practice sets. There rarely exists unanimous agreement on the actions that should be taken throughout a procedure.[11,42]

A technique of semantic segmentation was utilized to develop DLAs for demonstrating secure or risky areas during special surgeries, such as laparoscopic cholecystectomies, laparoscopic sleeve gastrectomy cataract surgery, and endovascular aneurysm repair. AI-powered three-dimensional anatomical reconstruction can aid preoperative planning and intraoperative navigation of complex operations.[43-46] Recently, the Food and Drug Administration (FDA) authorized an AI tool named as Cydar EV Maps. It was employed to create a complete patient-specific map of arteries anatomy via pre-operation mapping and real-time intraoperation fluoroscopic imaging. It has been demonstrated to lower radiation doses and enhance the effectiveness of difficult aortic aneurysm endovascular reconstruction.[47] Numerous intraoperation advantages come with integrating robotic surgery, such as enhanced agility, design, and an accurate amplified three-dimensional vision. Since then, over 12 million operations have been carried out by 60,000 doctors globally using the Da Vinci surgical robot (**Figure 2**) alone, making robotic surgery the preferred less-invasive method for routine surgeries in comparison to laparoscopy.[4,47] There are 6 stages of autonomy for robotic surgery (**Table 1**). Skin-to-skin surgeries using completely self-contained robots are currently mainly theoretical, but potential advantages involve establishing surgical techniques, stability, precision, removing the possibility of human fatigue, anxiety, and prejudice, and conducting surgery in areas that are considered dangerous or inaccessible to human beings, such as inaccessible regions or battlefields.[4]

Figure 1: AI-assisted surgical robots and their surgery techniques



Post-operation

Discharge and follow-up

Post-operation problems raise morbidity and death rates, lengthen hospital stays, and result in substantial expenses, all of which add to the load on medical systems.[48] Yet, employ traditional statistical methods to forecast the frequency of complications after surgery is inadequate because their root causes are frequently complex in structure.[49] With the help of its strong algorithms and capacity to use many data sources, AI might assess data that includes a variety of patient and process characteristics in order to forecast difficulties. For instance, a study developed machine learning-forest model to forecast anastomotic leakage following anterior resection for rectal cancer.[50] Similarly, such machine learning models were developed for surgical site infections, bleeding after surgery[51,52], complications after bariatric surgery[53,54], and monitoring after surgy of colorectal, liver, and pancreas.[55] On the other hand, a planned and tailored release plan using AI algorithms, such as DESIRE (**Table 2**), can shorten hospital stays, decrease recurrence, and improve patient satisfaction. Similarly, AI algorithms can be utilized in patients' follow-up. For example, a study designed AI system (**Table 2**) for orthopedic patients recovering from surgery via machine learning and voice simulation.[56]

LIMITATIONS

AI has many advantages and enhances surgical education, but it also has drawbacks (**Table 3**). Doctors' roles as

Table 1: Six stages of autonomy for robotic surgery.

Autonomy Stage	Explanation
Stage 0	No autonomy – human operator performs all functions.
Stage 1	Robot assistance – human retains continuous control.
Stage 2	Task autonomy – human has discrete control, with specific tasks given to robot.
Stage 3	Conditional autonomy – human selects autonomous strategy performed by robot.
Stage 4	High autonomy – robot makes decisions but under supervision of human.
Stage 5	Full autonomy – procedure fully performed by robot with no human supervision required.

Table 2: Recently developed AI algorithms for discharge and follow-up of patients.

AI-system	Methods	Results	Reference
DESIRE (Discharge after surgery using artificial intelligence)	The study externally validated the machine learning concept in gastrointestinal and oncology surgery patients admitted to 3 nonacademic hospitals in Four forest models were locally trained and evaluated with respect to area under the receiver operating characteristics curve, sensitivity, specificity, positive predictive value, and negative predictive value.	This study showed that a previously developed machine learning concept can predict safe discharge in different surgical populations and hospital settings (academic versus nonacademic) by training a model on local patient data. Given its high accuracy, integration of the machine learning concept into the clinical workflow could expedite surgical discharge and aid hospitals in addressing capacity challenges by reducing avoidable bed-days.	**57**
AI-assisted follow-up model	The AI-assisted follow-up system was adopted in the Orthopedic Department of Peking Union Medical College Hospital in April 2019. A total of 270 patients were followed up through this system. Prior to that, 2656 patients were followed up by phone calls manually. Patient characteristics, telephone connection rate, follow-up rate, feedback collection rate, time spent, and feedback composition were compared between the two groups of patients.	The effectiveness of AI-assisted follow-up was not inferior to that of manual follow-up. Human resource costs are saved by AI. AI can help obtain comprehensive feedback from patients, although its depth and pertinence of communication need to be improved.	**56**

professional interpreters are altered by AI, which is thought to focus on patients and may be prone to overlooking minute details in patient-doctor interactions. Furthermore, AI needs lifetime supervision for appropriate medical use because it is still far from being suitable for autonomous operation.[58] Additionally, AI may not yet be able to interpret verbal indications, which could aid in directing conversation to the specific levels most appropriate for providing each patient with knowledge in a customised manner.[59] Large volumes of data are necessary for machine learning algorithms to facilitate sound decision-making. The low number of precise diagnoses in certain surgical specialties makes it difficult to apply machine learning in certain scenarios. Large volumes of data are also necessary for machine learning algorithms to learn and perform better. Accurately gathering and labelling this data can be challenging, which could affect how well the AI system performs. Many physicians are not conversant with the vocabulary used in the current medical literature about AI, which may hinder clinical implementation and adaption.[60]

Future Prospects and Challenges

In the future, conversational large-language models (LLMs) that combine NLP, deep learning, and speech recognition, technology may be utilised to respond to questions, counsel patients, and conduct consults with patients on their own. These algorithms may finally recommend proper diagnosis as well as a treatment strategy. Crucially, these AI algorithms will be empathy-based in order to maintain the human dimension in the consultations.[61] Microbots, endoscopic, bioinspired, and stereotaxic robots are the various types of operating robots that have been developed independently. In the far future, these robots might even provide a better substitute for professional-led solutions and represent the pinnacle of best practice, eliminating the requirement for human oversight or management.[62]

AI can help intelligent educational programs by offering guidance and immediate input throughout simulations. These

Table 3: Limitations of AI in medical field.

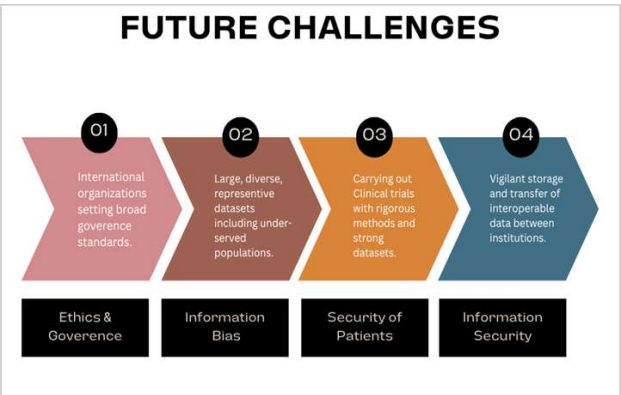
Limitations	Consequences
Lack of human judgment	Decisions are based on data, rules, and prior experience, but lacks ability to understand context and nuances
Lack of domain expertise	AI systems may lack deep knowledge and experience, risk of incorrect diagnoses and treatment plans
Bias in data	AI systems rely on the data they are trained on; if data are limited, decisions have weak background and may be biased
Need for interpretability	The decisions made by AI systems may be difficult to interpret and thus trust
High cost	AI systems are expensive to develop, implement, and possibly also to maintain

technologies could evaluate performance metrics, such as tissue interaction and tool motion, to offer thorough and impartial assessments of surgical competency's mindset aspect and skill improvement. AI can also be used to construct guidance systems for medical diagnosis and therapy, which could assist them stay up to date by offering suggestions for optimal procedures. These guidance systems have the potential to simplify the screening and therapeutic process, cutting down on the period of time and assets needed to arrive at a diagnosis and making use of those resources.[3,63,64]

Robots of the future will become smaller in order to be used in a larger range of applications. In the future, assistive technology such as robots powered by AI may be used to carry out confident surgical operations. Practical activities like stitching, incisions, and closure of wounds may fall under this category, freeing up the surgeon to concentrate on the key elements of operation. However, both present and future generations of doctors cannot yet operate entirely automatic surgical robots. Therefore, surgical robots continue to function as tele-manipulator systems under the supervision of skilled doctors.[65,66] These surgical robots can also be operated remotely by the surgeons. In addition to robotic surgery, telemedicine can be utilised for more basic medical care, where AI and machine learning can aid provide medical services in difficult-to-reach places.[67,68]

AI development has been revolutionizing current surgery by enabling more accurate and self-governing interventions for the treatment of both acute and chronic ailments. Significant advancements have been made in surgical robots, intraoperative guidance, and preoperative planning by utilizing these methods. AI holds enormous potential and countless revolutionary applications beyond those mentioned thus far. It's crucial to moderate any hopes that AI will be a magic bullet that will resolve every issue facing the medical field. Since the fundamentals of AI technology have not been explored before, careful preparation will be necessary to integrate them into established healthcare structures safely and morally (**Figure 2**).

Figure 2: Obstacles and difficulties in integrating AI technology into surgical execution



CONCLUSION

The enormous potential of AI in surgery has been described in this paper, with the goal of enhancing or revolutionizing every facet of surgical patient care. AI-assisted surgical learning and its applications in the field of surgery were summed up in this brief article. We discussed the value of AI in every facet of surgical proficiency and learning. Our review concentrated on applying AI to a number of patient care domains, such as early screening, intra-operative robotics, post-operative monitoring, and follow-up. Innovations that have the potential to enhance medical practices and change future standards are found through horizon scanning of AI technology in surgery. The field of surgery has always aimed to innovate, from carrying out intricate procedures that were previously thought to be difficult to accomplish to bringing about the advent of surgical procedures using minimally technologically enabled instruments. AI has the potential to usher in an entirely novel phase of medical care, and the surgery community worldwide has to welcome it.

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Case Report **Open Access**

Dermatofibrosarcoma Protuberans - Delayed diagnosis in a Young Male

Tarteel Siddiqui, Komal Faheem, Mahrukh Shafiq, Nausheen Ferozuddin, Pirhay Fatma

ABSTRACT:

The dermatofibrosarcoma Protuberans is a cutaneous tumor that grows slowly. It is commonly misdiagnosed as other common abdominal swellings, such as fibromas or lipomas. Recurrence is frequently seen. A male patient, 27, presented with a complaint of Right iliac fossa (RIF) swelling that had persisted for 17 years. A lumpectomy was performed on the patient because of its growing size. Histopathology verified the presence of Dermatofibrosarcoma Protuberans (DFSP). A Wide Local Excision (WLE) with mesh repair was performed, biopsy revealed elongated monomorphic spindle cells that extended in a storiform pattern into the deeper subcutaneous fat with negative margins. Immunohistochemistry verified that it was DFSP. A 17-year diagnosis delay is highlighted in the current report. Delays are further exacerbated by the asymptomatic nature and lack of knowledge among community physicians. For any chronic, asymptomatic, indolent parietal wall swelling, local physicians should take DFSP into consideration as a differential diagnosis.

KEYWORDS*:* CD34 Antigen, Dermatofibrosarcoma Protuberans, Soft Tissue Neoplasms, Local Excision, Surgical Mesh

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INTRODUCTION:

The cutaneous soft tissue sarcoma known as Dermatofibrosarcoma Protuberans (DFSP) is a rare, low to moderate-grade tumor that originates from the dermis. It is a locally aggressive skin tumor that rarely spreads and tends to recur after removal.[1] Previously thought to be of fibroblastic origin, recent immunohistochemical evidence suggests it may originate from dendritic cells in the skin.

The overall incidence is 6.25 per million with significantly higher rates in darker-colored individuals.[2] The trunk region accounts for 40–60% of cases of DFSP, followed by the proximal extremities (20–30%) and the head and neck (up to 15%). Nonetheless, unusual sites including the scalp, breast, and toes have been the site of incidents. Similar to other soft tissue sarcomas, DFSP shows gender predominance, with a higher correlation with the male gender.[3] As the name suggests, DFSP can grow to enormous proportions, resulting in large, protuberant nodules, causing significant local damage that needs complex tissue reconstruction.[4]

A young male patient with dermatofibrosarcoma of the right iliac fossa is described in this article. Incorporating a review of relevant research, it seeks to highlight the difficulties in managing this disease in situations with limited resources. The case report is consistent with SCARE 2023 criteria.[5]

CASE REPORT:

A male patient, age 27, was referred to the outpatient clinic due to a 17-year-old mass in his right iliac fossa. At the age of ten, the patient first became aware of it. It was indolent, measuring about 7 cm x 10 cm. For a long time, he did not seek medical attention. It was asymptomatic, but within the past three years, it has grown to a size of around 10 × 10 cm, which was uncomfortable. (Figure 1)

Upon physical examination, there was no sign of localized heat or redness and a big, hard, painless, multinodular, mobile mass with irregular margins was noted. No inguinal lymph nodes could be palpated. The patient was sent to the general surgeon since the lump became increasingly uncomfortable. Baseline and Ultrasound was done which revealed hypoechoic mass with peripheral projections and increased vascularity. An excisional lumpectomy was done. The post-operative phase went smoothly, and there was no surgical site infection.

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The removed mass was submitted for histology which showed subcutaneous tissue exhibiting cellular dermal proliferation of spindle cells extending into subcutaneous fat arranged in a storiform pattern with no atypia or mitoses. The sample was determined to be Dermatofibrosarcoma, and a wide local excision (WLE) was intended to achieve definite, clean margins due to the uncommon diagnosis. Although metastasis is a rare possibility, to be sure there were no underlying secondary masses, CT scans of the chest, abdomen, and pelvis were conducted that were deemed unremarkable. During the WLE, a 5 cm tumor-free margin was ensured through frozen section, which was effective in achieving a distinct perimeter around the resected tissue in all directions (Figure. 2). In the same procedure, and a 15 x15 cm prolene mesh was inserted for reinforcement of anterior abdominal wall. Immunohistochemistry of the sample demonstrated that the cells were CD34 positive further confirming the diagnosis of DFSP. Post-op recovery was unremarkable.

Figure 1: RIF Mass before Lumpectomy.

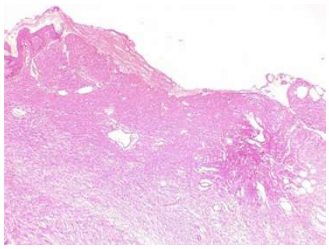

Figure 2: DFSP cells extending from dermis up to epidermis

DISCUSSION:

Prevalence in patients with DFSP were reported as 67.6% were Caucasian, 14.5% were Africans, 4.2% were Asian, 11.2% were Hispanic, and 2.4% were others. It is noteworthy that there was no difference in tumor size, treatment regimen, initial tumor location, or gender between the racial groups when compared to all other demographic factors. One protective factor against metastasis was a higher socioeconomic position.[2,6] There were no appreciable differences in tumor size or the types of treatment (chemotherapy, radiation, or surgery) across the various racial and ethnic groups. Surgery alone was performed on the majority of patients (75.7%), followed by surgery plus radiation (13.4%).[6]

DFSP typically begins as a tiny, painless, flesh-colored or brown nodule or papule. It can progress to either a sluggish nodular phase or a plaque phase, which can result in sclerosis or atrophy. It often moves about and becomes adherent to the skin above but not the tissues underneath. It may gradually penetrate adipose tissue and affix itself to deeper tissues like muscle and fascia. Telangiectasias may be seen at the edges or on the surface. A history of different traumas is frequently linked to the development of DFSP. This covers scars from surgery, injuries, burns, radiodermatitis, vaccination sites, central venous line placements, and bug bites.[7] Cachexia, like with other neoplasms, is rare. Early-stage lipomas, dermatofibroma, keloid, epidermal cysts, and nodular fasciitis should all be included in the differential analysis. Similar to the protuberant stage, additional soft tissue sarcomas such as Kaposi Sarcoma and Pyogenic Granuloma may be taken into consideration.[8]

Microscopically, it is often a well-differentiated sarcoma with large, elongated nuclei, modest mitotic activity, and a uniformly dense proliferation of spindle cells with CD34 positive marker. In addition to cells arrayed in the traditional storiform pattern, the stroma may have varying amounts of collagen and capillaries. [9] (Figure 3) A cartwheel-like arrangement of the cells may be formed by their radial arrangement around a central fibrous core. Areas with high-grade fibrosarcomatous change (FS-DFSP) may coexist with the traditional DFSP. When examined at low magnification, the fibrosarcomatous zones are distinguished by a fascicular, herringbone pattern of development. These regions usually exhibit mitotic figures, cytologic atypia, and enhanced cellularity. (Figure 4).

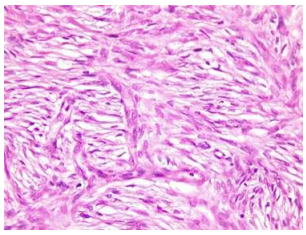

Figure 3: Classic Storiform Pattern seen in DFSP.

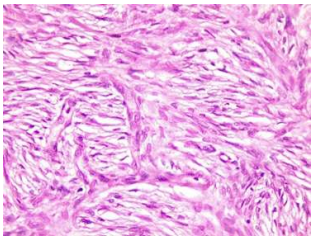

Figure 4: Herringbone Pattern at low magnification.

DFSP that exhibit symptoms of fibrosarcomatous transformation, a complete investigation is typically necessary even though distant metastases are uncommon. An ultrasound of the lymph nodes, a chest radiograph, and an abdomen ultrasound or CT scan are required for the diagnosis of metastatic illness. Although MRI and ultrasound may not guide about tissue infiltration, they can be helpful for the surgical plan, especially for individuals who have significant recurring lesions. The American Musculoskeletal Tumor Society (MSTS) approach, which assesses tumor grade and compartmentalization, is used to stage DFSPs and DFSP-FSs. Stage IA indicates no extension beyond subcutaneous compartment, Stage IB indicates involvement of the underlying fascia or muscle.[10]

Table 1: Musculoskeletal Tumor Society Surgical Staging

Stage	Grade	Local Extent	Metastasis
I-A	Low	Intercompartmental	-
I-B	Low	Extracompartmental	-
II-A	High	Intercompartmental	-
II-B	High	Extracompartmental	-
III	Any	Any	Present

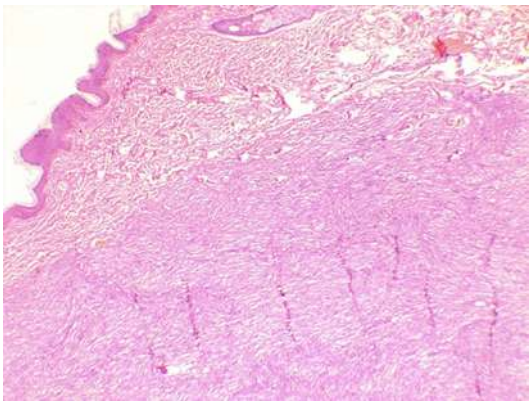

Figure 5: Dermal-based tumor with uniform, spindle-shaped cell

After partial excision, the recurrence rate is quite high. Thorough planning is necessary for the surgical treatment of dermatofibrosarcoma protuberans (DFSP), taking into account variables such tumor size, margin control techniques, location, and cosmetic results. The initial excision is the most hopeful for a cure since the likelihood of establishing primary wound closure decreases with each further excision unless there are efficient reconstructive solutions available. Wide local excision (WLE) with surgical margins of 1–5 cm of healthy, uninvolved skin is the standard of care. In order to identify and eliminate any "tumor pseudopodia" at the margins and reduce the chance of recurrence, a comprehensive pathological analysis of the material is essential. In certain situations, radiotherapy in surgical beds can reduce recurrence.[12]

CONCLUSION:

A delayed diagnosis and thus, a delayed treatment action may result from DFSP's asymptomatic, inactive character. The tumor often spreads to the periphery after originating in the dermis. But in this case, the tumor only spread to the skin and subcutaneous tissue. There may be a correlation between a higher risk of recurrence and certain histological variations of DFSP. Mohs micrographic surgery may be the preferred treatment with the advantages of maximum tissue preservation, improved functional and cosmetic results, and accelerated recovery. However, wide local excision is the unquestionable treatment that may be coupled with radiation to minimize recurrence.

Authors Contribution:
Tarteel Siddiqui: Conception and design of work, acquisition analysis drafting of work
Komal: Drafting of work, final approval of version to be published
Mahrukh Shafiq: Design and acquisition of work
Nausheen Ferozuddin: Drafting of work
Pirhay Fatma: Interpretation of data for work

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Case Report Open Access

Chronic use of Proton Pump Inhibitor Leading to Iron Deficiency Anemia in a Middle Aged Women

Qurat ul Ain, Eeraj Saeed, Nadia Noreen, Nagina Asgher, Umer Farooq

ABSTRACT

Iron deficiency anemia (IDA) is one of the most common hematological disorders. Proton pump inhibitors (PPIs) are widely used to treat various gastrointestinal diseases; however, their prolonged use has been increasingly associated with nutrient deficiencies, including iron deficiency. The underlying mechanism involves the alteration of the acidic gastric environment, resulting in impaired iron absorption. This case describes a case of a 43-year-old female who presented with fatigue and hair loss. She had a history of hypothyroidism, migraine, and gastroesophageal reflux disease (GERD), and had been taking omeprazole for the past eighteen years. Investigations revealed microcytic hypochromic anemia, characterized by low serum iron and ferritin levels. Other causes of iron deficiency anemia were ruled out through clinical assessment and laboratory workup. Oral iron therapy was poorly tolerated; however, intravenous iron led to symptomatic and hematologic improvement. This case highlights the underrecognized risk of iron deficiency associated with prolonged PPI use. In the absence of established guidelines, it further advocates for routine monitoring of iron status in long-term PPI users. Judicious prescribing and regular follow-up can help prevent avoidable nutritional deficiencies in patients requiring extended acid suppression therapy. The case is unique and rare in a country like Pakistan, as only a few similar cases have been reported in the literature. Moreover, PPI usage is often overlooked while investigating iron deficiency anemia.

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INTRODUCTION

Approximately one-third of the global population is affected by anemia, with iron deficiency responsible for about half of these cases.[1] Iron depletion may be attributed to various factors, including inadequate dietary intake, blood loss, impaired absorption, or increased body requirements. Patients with iron deficiency often present with nonspecific symptoms such as fatigue and exertional dyspnea. Management involves addressing the underlying cause and providing iron supplementation. Proton pump inhibitors (PPIs) are commonly prescribed for the treatment of conditions like gastroesophageal reflux disease (GERD), erosive esophagitis, duodenal ulcers, and hypersecretory disorders.[2] Over the past two decades, their use has significantly increased in clinical practice. PPIs work by inhibiting the H?/K? ATPase pump in gastric parietal cells, which results in suppression of both basal and stimulated gastric acid secretion. Non-heme iron requires an acidic environment for its absorption.[2,3] Prolonged PPI use reduces gastric acid secretion, impairing the absorption of essential vitamins and minerals, including iron.[4] Although PPIs are primarily intended for short-term use, they are frequently prescribed for long-term maintenance therapy, contributing to potential nutritional deficiencies.

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Case report

A 43-year-old female resident of Jhelum presented with fatigue and hair loss for the past couple of months. She reported persistent fatigability without evening exacerbation and no history of body aches and pains, fever, shortness of breath or weight loss.. She was a known case of hypothyroidism, gastroesophageal reflux disease (GERD), and migraine. Her current medications included tablet thyroxine 100 µg OD, tablet Inderal 20 mg BID for migraine prophylaxis, and omeprazole 40 mg OD. Her migraine attacks were well controlled and responded well to paracetamol. There was no history of nonsteroidal anti-inflammatory drug (NSAID) use. Notably, she did not have

any symptoms suggestive of uncontrolled hypothyroidism, such as constipation, sleepiness, cold intolerance, or weight gain. She had no history of passage of worms. Her diet included red meat, dairy products, and leafy vegetables. She never experienced per rectal bleeding or melena. Her menstrual cycles were regular, with no episodes of menorrhagia. Given her history of hypothyroidism, other autoimmune conditions that could cause fatigue—such as Addison's disease, celiac disease, and pernicious anemia—were considered. There were no features suggestive of cortisol deficiency, such as muscle cramps, vomiting, or hyperpigmentation of the skin or creases. She had no history of loose stools, abdominal pain or flatulence, suggestive of celiac disease. Additionally, there were no signs of autoimmune disorders, such as fever, rash, joint pain, photophobia, or mouth ulcers.

Her past medical history revealed that she had been suffering from GERD and gastritis for 18 years. Initially, she was prescribed omeprazole 20 mg OD, but her dose was increased to 40 mg OD over the past year due to worsening GERD symptoms. On examination, she appeared mildly pale and overweight but was not jaundiced. Her vital signs were: pulse rate 86 beats per minute, blood pressure 110/82 mmHg, and respiratory rate 14 breaths per minute. Her BMI was 29. Systemic examination was unremarkable.

Her laboratory investigations showed:
- CBC: Hb 10.6 g/dL, MCV 71 fL
- Serum iron: 33ug/dL (50-170)
- Serum ferritin: 22 ng/mL. (24-307)
- TIBC: 454ug/dL (250-450)
- Thyroid function tests (TFTs): Within normal limits
- Stool for occult blood: Negative
- H. pylori stool antigen (HpSA) test: Negative
- HbA1c: 5.4%
- Celiac disease autoaantibodies: Negative
- Ultrasound abdomen: Grade 1 fatty liver

She was advice to undergo an upper GI endoscopy, but she refused. She was initially prescribed oral iron supplements; however, she developed nausea and constipation. Subsequently, intravenous iron replacement in the form of iron sucrose was administered. Her symptoms improved, and at one month follow up her Hb increased to 12.2 g/dL. Her omeprazole dose was reduced to 20 mg OD, and she was advised on weight reduction and lifestyle modifications.

DISCUSSION

Anemia is diagnosed when hemoglobin levels fall below 13 g/dL in males and below 12 g/dL in females. Iron deficiency anemia (IDA) is the most prevalent form of anemia globally and is characterized by a reduction in hemoglobin synthesis due to inadequate iron availability. It commonly arises from chronic blood loss, insufficient dietary intake, impaired iron absorption, or increased physiological demands, such as during pregnancy or growth spurts. Clinically, IDA manifests as fatigue, pallor, exertional dyspnea, and decreased physical performance. Diagnostic evaluation typically reveals microcytic hypochromic anemia with low serum ferritin, reduced serum iron levels, and elevated total iron-binding capacity.

Dietary iron has two forms; heme iron and nonheme iron with 32% and 68% contribution. Heme iron exists in a ferrous state ($Fe^{2?}$), which is readily absorbed after being released from globin by pancreatic enzymes.[3] Non-heme iron is present in the ferric state ($Fe^{3?}$). It is commonly found in cereals, vegetables, and beans and its absorption depends on an acidic gastric environment. Gastric acid enhances its solubility and facilitates its reduction to the ferrous state for absorption.[3] Various medical and surgical conditions, as well as factors affecting gastric acidity, can impair this process and lead to iron deficiency.

Worldwide, more than 25% of the population is affected by acid-related conditions, including dyspepsia and gastroesophageal reflux disease (GERD). Proton pump inhibitors (PPIs) are presently considered the first-line therapy for acid-related conditions like gastroesophageal reflux disease (GERD).[5,6] They rank among the top ten most commonly prescribed medications globally. PPIs reduce gastric acidity by inhibiting the production of hydrogen ions ($H^?$) by blocking the hydrogen/potassium ATPase pump in the parietal cells of gastric mucosa. This limits the conversion of $Fe^{3?}$ to $Fe^{2?}$, resulting in impaired intestinal iron absorption.[7] While PPIs provide prompt and effective symptom relief, their prolonged use has raised concerns due to potentially rare but serious adverse effects. These include an increased risk of osteoporotic fractures, interstitial nephritis, chronic kidney disease, infections, rebound acid hypersecretion, and deficiencies in essential nutrients such as iron, vitamin B12, and magnesium.

In one study, a systematic review and meta-analysis assessed the link between proton pump inhibitor (PPI) use and iron deficiency anemia (IDA). Findings from nine studies showed a significant association, with PPI users having more than twice the risk of developing IDA (RR 2.56; 95% CI, 1.43–4.61; $p < 0.00001$).[8] The study recommends cautious long-term PPI prescribing and regular monitoring of patients' iron levels to mitigate the risk of IDA.

A large case-control study utilizing the UK Clinical Practice Research Datalink (CPRD) database examined the association between PPI use and the risk of iron deficiency (ID). The study assessed the first occurrence of ID in PPI full users (PFUs) and PPI limited users (PLUs) compared to non-users (PNUs). The adjusted odds ratio for ID was 3.60 (95% CI [3.32–3.91]) in PFUs and 1.51 (95% CI [1.44–1.58]) in PLUs compared to PNUs.[9] Additionally, a positive dose-response and time-response relationship was observed.

An observational study conducted in Lodhran, Pakistan, investigated the association between proton pump inhibitor use and iron deficiency anemia. Serum ferritin and iron concentrations were assessed both at the initiation of PPI

therapy and after 8 months of continued use. The mean serum ferritin level significantly declined from 68.72 ± 30.41 ng/ml at the start of treatment to 27.45 ± 16.26 ng/ml after 8 months ($p < 0.001$). Similarly, the mean serum iron level decreased from 18.28 ± 6.54 µmol/l to 15.86 ± 5.72 µmol/l over the same period, also showing a significant difference ($p = 0.001$).[10]

Patients with conditions such as Barrett's esophagus, severe esophagitis, a history of bleeding gastrointestinal ulcers, or those on long-term non-steroidal anti-inflammatory drugs (NSAIDs) often require prolonged PPI therapy. Therefore, these individuals should be closely monitored for potential adverse effects related to extended PPI use.[11]

Currently, no guidelines or recommendations exist for monitoring body iron stores in patients on long-term PPI therapy. The American Gastroenterological Association advises using non-pharmacological approaches and histamine-2 receptor blockers to alleviate the gastrointestinal symptoms of gastroesophageal reflux disease, reserving proton pump inhibitor (PPI) therapy for cases with a clear clinical indication.

The patient had been using proton pump inhibitors (PPIs) continuously for 18 years, with high-dose intake over the past year. She had no history of overt blood loss, including menorrhagia or per rectal bleeding. Stool occult blood and *Helicobacter pylori* stool antigen (HpSA) tests were negative. Serological tests for celiac disease were also negative. Although upper gastrointestinal endoscopy was recommended, the patient declined the procedure. No evidence of other endocrinological or autoimmune disorders was found. Given the absence of other identifiable causes, her iron deficiency was attributed to long-term PPI use. She was treated with intravenous iron sucrose, resulting in noticeable clinical improvement within a few days. She was advised to undergo regular monitoring with complete blood count (CBC) and iron studies every three months.

CONCLUSIONS

IDA or iron depletion due to prolonged exposure to PPI is more common than previously recognized. As the number of long-term PPI users continues to rise and the duration of PPI use extends, new PPIs with stronger acid suppression are also being developed and introduced. Consequently, the prevalence of iron deficiency anemia among long-term PPI users is expected to increase globally. Therefore, it is crucial to limit prolonged PPI use when possible and to consider it as a potential contributor in the differential diagnosis of iron deficiency anemia among long-term users.

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Qurat ul Ain: Conceptualization, Literature research
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Case Report **Open Access**

Inguinal Dermoid Cyst in a Young Boy with un-descended Testis;

Mohammad Osama, Muhammad Humayun, Noman Ullah, Mahroosha Noor Khan, Musawir Khan, Nawazish Ali

ABSTRACT:

Groin lumps have various differential diagnoses, including hernias and lymphadenopathies. Dermoid cysts, occasionally found on the face or scalp, rarely can occur in the inguinal canal. Dermoid cysts are rare benign lesions in the inguinal canal, though inguinal hernias are more common. Despite their rarity, dermoids should be considered in the differential diagnosis of groin lumps. Ultrasound is the preferred diagnostic tool for dermoid cysts, with 58% sensitivity and 99% specificity. However, misdiagnoses (e.g., intramuscular hematoma) or inconclusive results can occasionally occur. Diagnosing these cysts requireshigh suspiciondue to their rarity in the inguinal region. Clinically, they can mimic common conditions like hernias or lipomas, making diagnosis challenging. Inguinal dermoid cysts are extremely rare, with only 12 documented cases. These congenital cysts contain tissues from at least two germ layers. Timely investigations and preoperative suspicion can prevent intraoperative surprises and help avoid potential complications. Complete excision is essential for treatment. This case report is the first documented instance of an inguinal dermoid cyst from Dera Ismail Khan, Pakistan.

Keywords: Benign skin lesions, dermoid cyst, Inguinal canal, un-descended testis,

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INTRODUCTION:

Groin lumps are frequently seen by general practitioners, emergency departments, and surgeons. Although hernias and lymphadenopathies are the most common causes of groin lumps in all age groups, there exists a wide range of differential diagnoses. Differential diagnoses may include pre-peritoneal lipoma, pectineus bursitis, internal oblique hematoma, varicocele, undescended testis, lymphadenopathy, and unusual cystic lesions.[1] Cutaneous and subcutaneous dermoid cysts are most commonly found on the face, neck, or scalp; however, they can also occur in less common locations such as the intracranial, intraspinal, perispinal regions, and the anterior abdominal wall. Dermoid cysts as a cause of inguinal canal lumps are extremely rare.[2] Dermoid cysts, or mature teratomas, in the inguinal canal are uncommon. These congenital cysts contain mature tissues derived from at least two germ layers. While they are typically found in the gonads, they can also occur in areas such as the anterior mediastinum, para-coccygeal zones, pineal region, intracranial regions, neck, and abdominal areas.[3] Unusual locations, such as the inguinal canal, pose diagnostic challenges. Notably, dermoid cysts of the inguinal canal or spermatic cord are extremely rare, with only 12 well-documented cases reported in medical literature.[4] We hereby report a case of Inguinal dermoid cyst with un-descended testis of young patient, which to the best of authors knowledge, is the first documented instance of an inguinal dermoid cyst from Dera Ismail Khan, Pakistan.

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Case Report:

An 18 year old male patient presented to the Surgical Out-Patient Department from Wana , Waziristan with the chief complaint of left inguinal swelling for the last 2 months. The swelling being unilateral, gradual in onset associated with pain and non-reducible. The pain is gradual in nature, diffuse in character, associated with activity, not relieving by medications. There was no history of trauma. The Patient denies any associated symptoms like fever, nausea, vomiting. Examination revealed a firm, tender, and irreducible swelling in the left inguinal region, with an empty left scrotum, giving an impression of undescended testis. The differential diagnosis

of left inguinal Hernia was made initially for inguinal swelling as being the most common. The patient was evaluated by further Investigations including Basic Laboratory Investigations, Ultrasound Abdomen & Pelvis and Scrotal ultrasound. The ultrasonography report validated Left empty Scrotal sac having no testicle, a hypoechoic structure measuring more than 3.7 x 4.73 cm in the left inguinal region, right sided testicle being normal in size, echotexture and in scrotal sac. Given the patient condition, the patient was scheduled for elective open exploration of the inguinal canal in the Surgical Unit the following day and was admitted to the ward for pre-operative care. Intra-Operative findings included a well circumscribed structure along the cord in inguinal canal. The structure was released gently and removed intact. Left undescended Testicle was evaluated and was found to be healthy with intact blood supply. The Structure containing a thick, white, putaceous, malodorous paste-like substance with incorporated hair. The sac was meticulously dissected from the inguinal cord, and no hernial communication was identified. The sac was completely excised, and the attenuated posterior wall, likely resulting from chronic pressure, was reinforced with 2-0 polypropylene suture. In the same setting, Orchiopexy was also performed. The clinical diagnosis of Dermoid Cyst was established. Post operatively, the patient was treated with Analgesics, IV antibiotics and suture were removed on the 11th Post-operative day. The patient underwent regular follow-up appointments to track his progress, identify potential issues, and monitor for recurrence. His latest evaluation showed satisfactory healing with no complications or recurrence.

DISCUSSION:

Epidermoid cysts are typically benign, but their occurrence within an inguinal hernia is rare as was observed in our case. These cysts usually develop when the ectoderm does not fully separate from the neural tube or when surface ectoderm fails to detach correctly at embryonic fusion points.[5] Diagnosing these cysts requires a high level of suspicion

Figure 1: Dermoid cyst in Inguinal canal

Figure 2: Dermoid cyst excised intact from inguinal canal

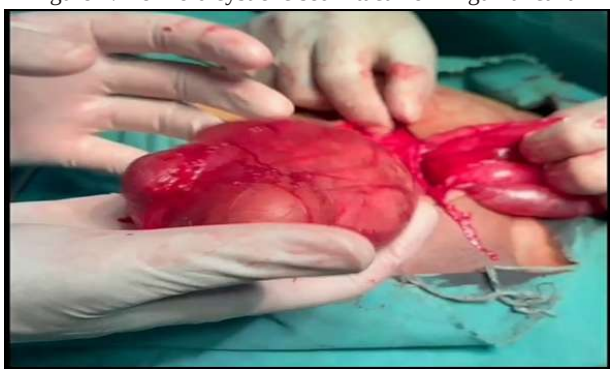

Figure 3: USG showing hypoechoic structure measuring more than 3.7 x 4.73 cm in the left inguinal region, with left un-descended testis

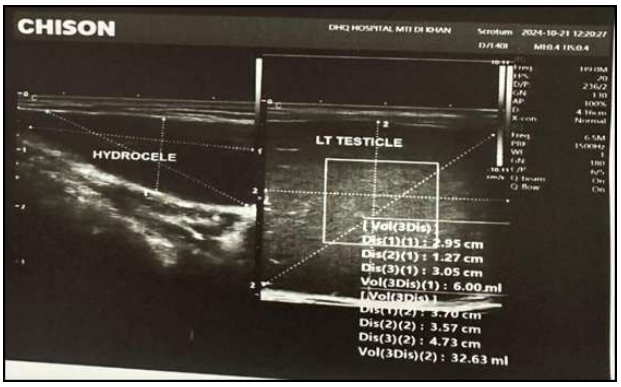

Figure 4: Dermoid cyst on exploration identified white, putaceous material and hair

due to their rarity in the inguinal region. Because clinically, these lesions can resemble more typical inguinal conditions like hernias or lipomas, making diagnosis challenging.[6] Ultrasound has been the preferred diagnostic tool for dermoid cysts, offering 58% sensitivity and 99% specificity in detecting these cysts.[7] However, sometimes misdiagnoses such as intramuscular hematoma or inconclusive studies can occur. The results of a scrotal ultrasound scan may not be entirely diagnostic, but they may distinguish the cyst from its surrounding structures with a smooth contour, a hyperechoic bulk, and a hypoechoic rim.[8] Dermoid cysts are lined with keratinising squamous epithelium, filled with keratinous debris. The cyst walls usually contain eccrine glands, sebaceous glands or hair follicles.[9] Histological the exterior layer of a dermoid cyst is composed of highly differentiated squamous epithelium, while the fibrous connective tissue beneath it is packed with hair follicles, hairs, blood vessels, and sebaceous, eccrine, and apocrine glands.

The existence of dermal tissue and its associated structures in dermoid cysts serves to differentiate them from both epidermoid and sebaceous cysts, while the lack of any components that are not intrinsic to the skin (such as cartilage, respiratory epithelium, or gastrointestinal mucosal lining cells) serves to distinguish them from benign cystic teratomas located in the ovarian, testicular, retroperitoneal, and sacrococcygeal regions.[10] Dermoid cysts, particularly those located intra-abdominally, can rarely lead to serious complications, including torsion, spontaneous rupture, hemorrhage, infection, and, in extremely rare cases, malignant transformation. To date, there exists a conspicuous absence of documented instances pertaining to these complications in cysts that specifically manifest within the inguinal region as was seen in our patient. Our case was unique, as with a 2-month history of untreated increasing inguinal swelling that was left untreated initially but due to increasing pain worsened with activity, accompanied by undescended testis, no trauma history and an intra-operative surprise of dermoid cyst in the inguinal canal.

In females, dermoid cysts are primarily located in the ovaries, while in males, they may occasionally develop in the inguinal region as found in our case.[11] These lesions are characterized by their gradual growth, often going unnoticed until the person is in their second or third decade. A large dermoid cyst in the inguinal canal can potentially lead to a direct inguinal hernia. This occurs due to the prolonged, constant pressure exerted by the cyst, causing thinning and weakening of the posterior wall of the inguinal canal. Dermoid cysts often have a classic appearance, making diagnosis evident during surgery, and their benign nature means malignant transformation is rare. When completely removed intact as done in our case, recurrence risk is minimal. There is a good correlation between clinical diagnosis and ultimate pathological diagnosis of epidermoid cyst. The intraoperative transection of a resected specimen may increase diagnostic confidence. Where classical features are present clinically and on excision, the specimens do not require histological examination.[12] In resource-limited settings, omitting routine histopathology for clinically unambiguous cases where cyst is excised completely without rupture, margins are not in question, making pathological analysis less critical and can optimize resources without compromising patient care.

In order to distinguish between more common and uncommon presentations, this case highlights the importance of thorough clinical evaluations combined with strategic diagnostic techniques. Clinicians should be more cautious when diagnosing and treating similar cases after discovering a dermoid cyst in an inguinal region. The recommended treatment for dermoid cysts is complete surgical excision of the lesion.

CONCLUSION:

Rarely found in the inguinal canal, dermoid cysts are common benign developmental anomaly lesions. Inguinal hernias are common, but other pathologies, including rare dermoid cysts, should be considered in differential diagnoses of groin lumps and completely excised if found. A high index of suspicion and timely investigations can help diagnose rare conditions like inguinal dermoid cysts, avoiding intraoperative surprises and potentially life-threatening complications if left undiagnosed or mismanaged.

Authors Contribution:
Mohammad Osama: Analyzed, Literature Search, Interpret the data as well as wrote the manuscript
Muhammad Hamayun: Analyzed, Literature Search, Interpret the data as well as wrote the manuscript.
Noman Ullah: helping in analysis, interpretation and maintaining the record
Mahroosha Noor Khan: Analyzed, Literature Search, Interpret the data as well as wrote the manuscript.
Musawir Khan: helping in literature search, interpretation, review manuscript
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Letter to Editor **Open Access**

Reproductive Rights and Ethical Conflicts in Conservative Societies: A Call for Global Discourse

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Horror stories amongst gynecologists, with their prevalence, have now become dinner-time conversation—slowly normalizing situations that should never be considered routine. This kind of acceptance leads to ambiguous and varying moral stances taken up by health professionals, ones not merely dictated by medical ethics but also overshadowed by the cultural norms of conservative societies in South East Asia.

In emergency rooms, the patient assumes a passive role, while it is the practitioner who decides—on behalf of the patient—the appropriate management plan. This view is in accordance with the technocratic model of birth, which views a pregnant woman as an object and the practitioner as someone with the authority to provide care from outside.[1] This objectification is deeply rooted in the pre-hospital experiences of patients and is manifested through indicators of sexual violence, multiple forced pregnancies, and the pervasive stigma surrounding genital comorbidities. Common emergency situations seen by attending doctors in clinical settings include repeated pregnancies at a young age, hymen reconstruction, and complications from untreated genital trauma.

Clinical complexity aside, doctors also face the reluctance of the majority of women to be appropriately treated—forcing them to navigate ethical burdens exacerbated by systemic and cultural constraints. Many practitioners report facing extreme professional pressure, not only due to high patient loads but also from societal expectations that they prioritize family dynamics over clinical judgment, leading to compromises in patient care.[2] This potential lapse, in an ideal world, goes against basic medical ethics but is often masked by a superficial respect for patient autonomy—even when such autonomy is shaped more by patriarchal structures than by informed consent.

Furthermore, the increasing association between genital conditions and psychological or physical violence has led many gynecologists to adopt protective biases.

The tension between professional judgment and cultural accommodation leaves many walking a moral tightrope. In these situations, doctors may choose treatment paths not purely for medical precision, but for what they believe might shield the patient from harm. Knowing that certain conditions make women more vulnerable to abuse, they may adjust their clinical approach accordingly—avoiding recommendations that could provoke backlash from family members or society.[3] While such decisions stem from a place of concern, they often come at the expense of optimal care, becoming morally ambiguous acts that weigh heavily on the conscience and integrity of otherwise capable practitioners.

The broader implications of this issue demand urgent attention from the global medical community, as these ethical challenges highlight the intersection of cultural norms and clinical practices, emphasizing the need for advocacy, education, and systemic change to safeguard both patient welfare and professional integrity. Workplace stress, institutional neglect, and lack of administrative support further push gynecologists into moral and professional crises, often leading to burnout and ethical lapses.[4]

Hence, medical training should include modules on ethical decision-making in culturally complex contexts. Institutions must create safe spaces for practitioners to report pressures without fear of judgment. Above all, health systems must prioritize structures that protect both patient autonomy and professional integrity.

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