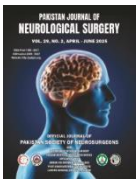

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Original Research

The Availability and Utilization of Minimally Invasive Techniques (MITs), in Neurosurgery in Pakistan

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ABSTRACT

Objectives: This article explores the availability and utilization of these techniques, highlighting their benefits, advancements, and regional variations in practice. The primary goal of this study is to facilitate the adoption of advanced Minimally Invasive Techniques (MITs) in neurosurgery at hospitals in Faisalabad, where traditional open surgical methods, such as craniotomies and craniectomies, are currently predominant.

Material and Methods: This study is designed to bring a pragmatic shift of advanced minimally invasive techniques in neurosurgery to the healthcare system of Faisalabad for improved patient care and surgical outcomes. A total of two District Headquarters Hospitals, DHQs, and two private hospitals are selected in Faisalabad. The sample of N=100 neurosurgeons, technicians, support staff

and hospital administrators were selected randomly.

Results: The perceived adoption of MITs 1st high equipment costs; In public hospitals, 37 participants cited high equipment costs as a barrier to adopting MITs, while 28 in private hospitals did the same. The Chi-square statistic is 3.713 with a P value of 0.000, indicating a significant difference in perceptions regarding equipment costs as a barrier between public and private hospitals.

Conclusion: The study highlights that while both public and private hospitals show positive attitudes toward the adoption of MITs, various barriers such as high equipment costs, insufficient training, and lack of institutional support hinder widespread adoption. Public hospitals are more reliant on traditional surgeries, whereas private hospitals are leading the adoption of advanced surgical techniques.

Keywords: Neurological Surgery, Traditional, MITs, Factors Influencing Adoption, Private and Public Hospitals.

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INTRODUCTION

Until the end of the 20th century, rapid development in neurosurgery through technological innovation and a yet growing emphasis on patient-centered care initiated the current movement toward minimally invasive techniques.[1] One of the significant works happening around this time was introducing neurosurgery with an endoscope. The endoscopic procedures, which include placing a tiny camera-the endoscope-through a small incision, allow neurosurgeons to perform surgeries with minimal damage to surrounding tissues.[2] This was especially useful in the case of pituitary tumors, hydrocephalus, and disorders of the spine.[3]

The 21st century ushered in a new era of innovation, characterized by the integration of robotics, artificial intelligence (AI), and machine learning (ML) into neurosurgical practices. These technologies have enhanced the precision, safety, and outcomes of minimally invasive neurosurgery.[4] AI-powered imaging tools can analyze CT and MRI scans to identify tumors, neural pathways, and blood vessels with remarkable accuracy, enabling surgeons to develop precise surgical plans. Intraoperative AI support can also provide real-time feedback during surgery, helping surgeons avoid critical structures and reduce the risk of complications.[5] The application of robotic systems in neurosurgery has been one of the most significant advancements in recent decades. Robotic systems, such as the ROSA® (Robotic Stereotactic Assistant) and Mazor X, have improved the accuracy of procedures such as intracranial biopsies, placement of spinal instrumentation, and deep brain stimulation (DBS) for movement disorders.[6] These systems enable surgeons to perform highly complex procedures with millimeter precision, reducing human error and improving patient safety.[7] Modern neurosurgery relies considerably on image-guided navigation systems, providing the surgeon with immediate visual feedback of the operated area in real time. Devices based on the integration of MRI or CT with intraoperative imaging allow surgeons to visualize in great detail the exact position of their instruments relative to the patient's brain or spine. This technology has been of particular benefit for minimally invasive procedures, where small incisions limit the surgeon's ability to directly visualize the surgical field.[8]

Today, most neurosurgical procedures are gradually being recognized as the gold standard use of minimally invasive techniques. In light of several advantages that MITs offer, such as less postoperative pain, reduced hospitalization time, and faster recovery time, traditional open surgeries are gradually being replaced in hospitals with MITs.[9] While these procedures are more advanced, trained individuals with them are being employed gradually in various leading hospitals and neurosurgical centers throughout the world, even from the developing region of Pakistan, due to some specific advantages of these latter approaches.[10]

From technological constraints to economic barriers, training of health professionals, and general health infrastructure, various factors come into play while adopting and utilizing MITs in neurological surgery. Most hospitals in less-developed regions of Pakistan still use traditional surgical tools because access to most modern medical technologies is prohibitively costly. High-end systems, robotic systems, image-guided navigation platforms, and stereotactic radiosurgery devices are very expensive, with their adoption restricted to basically well-endowed hospitals across the largest cities.[11] The initial fees required to acquire and maintain these technologies of MIT, including robotics-assisted surgery platforms and advanced imaging equipment, are way beyond the budgets of most especially those in the public sector. Ahmad, 2024, presents that the out-of-pocket health system is a major system adopted in Pakistan, where limited insurance coverage is available for most of its citizens.[12] A shortage of special training programs for neurosurgeons and other related professionals

remains a key barrier to the adoption of MITs in Pakistan. The majority of neurosurgeons were initially trained in traditional work in open surgery; though MITs require specialized expertise, advanced training opportunities are limited.[13] Thus, health care in Pakistan is highly out-of-pocket, with minimal insurance to cover the majority. In terms of minimally invasive surgeries, the need for a higher cost prices patients out, which in turn can prevent hospitals from developing such technologies because of low demand.[14] The inability of many patients to afford the increased costs associated with minimally invasive surgeries then causes the hospitals to shy away from investing in these technologies due to very low demand.[15]

This article determines the current landscape of MITs in neurological surgery in Pakistan. Further, the comparison of the traditional neurosurgery versus MITs in neurosurgery effectiveness in public and private settings was examined. Moreover, it also explored the factors influencing the adoption and utilization of MITs.

MATERIALS & METHODS

The outlines of the present methodology structured and promoted the adoption of advanced minimally invasive techniques (MITs) in neurosurgery within selected hospitals in Faisalabad. It specifically targets the reliance on traditional neurosurgery versus MITs in neurosurgery procedures. Earlier initiating the adoption of MITs, it is essential to conduct a comprehensive needs assessment to understand the current state of neurosurgical procedures in hospitals in Faisalabad.

Study Design/Setting and Duration

A qualitative research design was used to assess the current practices and facilitate the adoption of MITs. The study involved the population of neurosurgeons, surgical teams, and administrative staff from two District Headquarters (DHQ) hospitals and two private hospitals in Faisalabad over 3 months, from June 2024 to August 2024, with a one-year follow-up period. IRB-7793-5 approved dated 01/10/2024.

Sample & Sampling Strategy

Neurosurgeons, technicians, support staff, and hospital administrators were selected from the DHQ Allied Hospital, DHQ Civile Hospital, Fatimah Hospital & Medical College, and Faisal Hospital Faisalabad. Approximately 100 participants were selected randomly for surveys, with around 30 individuals selected for in-depth interviews.

Inclusion Criteria

Neurosurgeons, assistant surgeons, and other members of the surgical team (such as anesthesiologists and operating room nurses) with a minimum of 3 years of experience in neurosurgery. Hospital administrators and decision-makers are involved in the planning, resource allocation, and management of surgical services, medical technologies, and equipment.

Exclusion Criteria

Neurosurgeons or surgical team members working temporarily, part-time, or as visitors without ongoing involvement in the neurosurgery department. Professionals with less than 3 years of experience in neurosurgery or healthcare resource management. Individuals are unwilling to participate in the study's surveys, interviews, or discussions on MIT adoption.

Data Collection

Develop a structured questionnaire focusing on current practices, attitudes towards MITs, perceived barriers to adoption, and knowledge of AI applications in neurosurgery. Distribute surveys electronically or via paper forms to all participating hospitals. Conduct semi-structured interviews with key stakeholders (neurosurgeons, surgical teams)

to gain insights into their experiences with open procedures versus MITs.

Data Analysis

Use statistical software R to analyze survey data. Employ descriptive statistics to summarize participant demographics and responses; inferential statistics chi-square tests compared attitudes towards MITs across different hospitals.

Ethical Considerations

Approval from an institutional review board (IRB) was obtained before study commencement. Informed consent was secured from all participants involved in interviews or observational studies. Data confidentiality and participant anonymity were maintained throughout the research process.

RESULTS

Study Participants Demographic Characteristics

At selected hospitals, researchers found the study participants there were 20(20%) neurosurgeons, technicians 30(30%), support staff 30 (30%), and hospital administrators 20(20%). among the years of experience 3-5 years were 13(13%), 6-10 years in majority 47(47%) and > 10 years 40(40%). Furthermore, demographic was hospital type there were 50(50%) public and private 50(50%) in (table 1). There were equal numbers of neurosurgeons (10 each) in both public and private hospitals, indicating a balanced representation of surgical expertise across hospital types. The count of technicians is also equal in both hospital types (15 each), totaling 30. Similar to technicians, support staff were evenly distributed across public and private hospitals, with 15 individuals in each category. Again, there is an equal distribution of hospital administrators (10 each) in both types of hospitals. Only 1 neurosurgeon has between 3-5 years of experience, indicating that this group is relatively small. The majority (13 out of 20) fall into the 6-10 years category, suggesting a significant number of mid-career professionals. There were 6 neurosurgeons with more than ten years of experience, indicating a presence of seasoned professionals in this field. A total of 8 technicians have between 3-5 years of experience. There were also 13 technicians in the mid-experience range. The group includes 9 technicians with over ten years of experience. There were 4 support staff members with relatively less experience. The largest group (15 out of 30) falls within this range. There were also a notable number (11 out of 30) with over ten years of experience. No administrators fall into this category, indicating that new entrants to administration may be less common in this field. There were only 6 administrators with moderate experience. A significant number (14 out of 20) have more than ten years of experience, suggesting that many administrators were seasoned professionals who likely bring valuable insights to hospital management.

Table 1: *Demographic Characteristics of Study Participants.*

Demographic	Frequency/Percentage
Profession	
Neurosurgeons	20 (20.0%)
Technicians	30 (30.0%)
Support Staff	30 (30.0%)
Hospital Administrators	20 (20.0%)
Years of Experience	
3-5 Years	13(13.0%)
6-10 Years	47(47.0%)
> 10 Years	40(40.0%)
Hospital Type	
Public	50(50.0%)
Private	50(50.0%)

Compression of Traditional Surgeries Versus MITs

Further analysis reveals a clear distinction in

surgical practices between public and private hospitals regarding traditional surgeries and minimally invasive techniques. Public hospitals performed a total of 40 traditional surgeries, while private hospitals conducted 31. This indicates that public hospitals are more reliant on traditional surgical methods compared to private hospitals. In contrast, private hospitals have a higher number of MITs performed (19) compared to public hospitals (10). This suggests that private hospitals may be more progressive in adopting advanced surgical techniques, possibly due to better access to resources, training, and technology. The calculated χ^2 value is 3.934. The P value obtained is 0.03. The statistically significant results from the Chi-square test underscore the need for further investigation into factors influencing these differences, such as resource availability, staff training, and institutional policies. Promoting the adoption of MITs in public hospitals may enhance patient care and align surgical practices with contemporary standards in neurosurgery.

Table 2: *Hospital type-wise compression of traditional surgeries versus MITs.*

Hospital Type	Traditional Surgeries	MITs	Total
Public	40	10	50
Private	31	19	50
Total	71	29	100

χ^2 3.934a P Value 0.03*

Likewise, analysis reveals significant differences in attitudes towards minimally invasive techniques (MITs) based on hospital type, profession, and years of experience (Table 3). A total of 43 participants expressed a positive attitude towards MITs, while 7 were neutral or undecided. The high number of positive responses indicates a favorable perception of MITs among staff in public hospitals. In private hospitals, 42 participants reported positive attitudes, with 8 being neutral or undecided. The attitudes are similarly favorable.

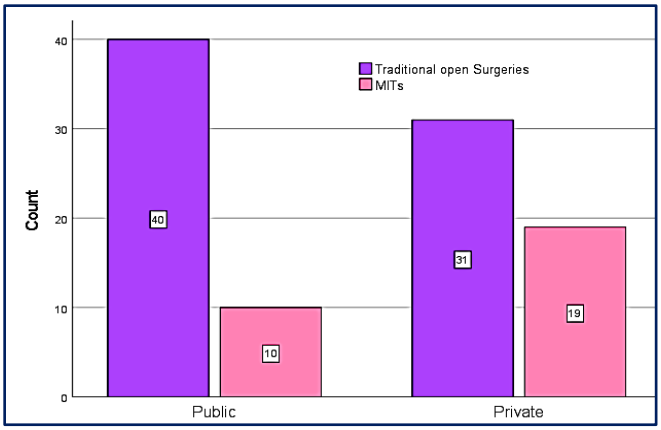

Figure 1: *Compression of Traditional Surgeries Versus MITs.*

Factors Influencing the Adoption and Utilization of MITs

but slightly lower than those in public hospitals. The Chi-square statistic for hospital type is 0.078, with a P value of 0.005, indicating a statistically significant difference in attitudes between public and private hospitals regarding MITs. Moreover, Attitudes by Profession; Among neurosurgeons, there were 18 positive responses and only 2 neutral or undecided. This indicates strong support for MITs within this professional group. Both technicians and support staff showed similar positive attitudes (24 each) with relatively few neutral responses (6 each). Hospital administrators had a total of 19 positive responses and only 1 neutral response, indicating strong support as well. The Chi-square statistic for profession is 3.137, with a P value of 0.001, indicating a highly significant difference in attitudes based on profession. Attitudes by Years of Experience; Participants with this level of experience showed only 9 positive attitudes against 4 neutral, indicating some hesitance or uncertainty about MITs. This group had the highest positive responses (43) compared to only 4 neutral, showing strong support for MITs among mid-level experienced professionals. Those with over ten years of experience also demonstrated significant support with 33 positive responses but had more neutral responses (7) compared to the previous

Group. The Chi-square statistic for years of experience is 4.284, with a P value of 0.003, indicating that years of experience significantly influence attitudes toward MITs.

In the end, data presents a crosstabulation of factors influencing the adoption and utilization of minimally invasive techniques (MITs) in neurosurgery across different hospital types, along with Chi-square test results for statistical significance (Table 4). The perceived adoption of MITs 1st high equipment costs; In public hospitals, 37 participants cited high equipment costs as a barrier to adopting MITs, while 28 in private hospitals did the same. The Chi-square a statistic is 3.713 with a P value of 0.000, indicating a significant difference in perceptions regarding equipment costs as a barrier between public and private hospitals. 2nd is lack of funding; The lack of funding is noted by 8 public and 12 private participants, suggesting that funding issues are perceived as more problematic in private settings. 3rd is maintenance costs; only 5 public participants and 10 private participants expressed concerns about maintenance costs, indicating that this is a lesser issue compared to equipment costs.

Table 3: *Some compression of attitudes towards MITs.*

Hospital Type	Positive	Neutral/ Undecided	Total	χ^2	P Value
Public	43	7	50		
Private	42	8	50	.078a	.005
Total	85	15	100		
Profession					
Neurosurgeons	18	2	20		
Technicians	24	6	30		
Support Staff	24	6	30	3.137a	.001*
Hospital Administrators	19	1	20		
Total	85	15	100		
Years of Experience					
3-5 Years	9	4	13		
6-10	43	4	47	4.284a	.003
> 10 Years	33	7	40		

Technological factors adoption of MITs 1st Lack of Equipment; Both public (29) and private (28) hospitals report similar concerns regarding the lack of equipment. The Chi-square statistic is 0.041, with a P value of 0.005, indicating that this factor significantly influences MIT adoption. 2nd Outdated Infrastructure; A similar number of participants from both hospital types reported outdated infrastructure (21 public vs. 22 private), suggesting that infrastructure issues are prevalent across both settings.

Training and Expertise Factors Adoption of MITs 1st Insufficient Training Programs; Public hospitals reported 30 instances of insufficient training programs compared to 25 in private hospitals. The Chi-square statistic is 1.295, with a P value of 0.006, suggesting that training programs are viewed as inadequate in both settings but may be more pressing in public hospitals. Resistance to Change & Long Learning Curve; The responses indicate moderate resistance to change and long learning curves, with no significant differences between hospital types.

Regulatory and Institutional Factors Adoption of MITs; lack of institutional support; Public hospitals reported a higher concern about institutional support (23%) compared to private hospitals (28%). The Chi-square statistic is 1.000, with a P value of 0.002, indicating significant differences in perceptions regarding institutional support. Regulatory Hurdles; Public hospitals had more participants citing regulatory hurdles (27%) than private hospitals (22%), indicating that regulatory issues may be more pronounced in public settings. Facilitators for Adoption of MITs; A majority from both hospital types indicated positive facilitators for MIT adoption, with public hospitals showing stronger support (37% yes vs. 30% no) compared to private hospitals. The Chi-square statistic is significant at 2.216, with a P value of 0.004, suggesting that facilitators play an

important role in MIT adoption.

Technological Availability and Support; Both hospital types reported similar access to cutting-edge technology, but public hospitals had slightly higher positive responses (32%) compared to private ones (30%). The Chi-square statistic is significant at 1.70, with a P value of 0.005, indicating that access to technology is an important factor influencing MIT adoption.

Training and Education; Public hospitals reported strong hands-on training opportunities (31%) compared to private hospitals (32%), with significant statistical backing (P Value = .000) indicating the importance of training in adopting MITs. Patient demand for the introduction of MITs: public hospitals had quite good demand from patients concerning safety (41%) while private hospitals also demonstrated considerable interest-

Table 4: *Factors influencing the adoption and utilization of MITs.*

Factors	1	2	3	χ^2	P Value
Perceived Adoption	High Equipment Costs	Lack of Funding	Maintenance Costs		
Public	37	8	5	3.713a	.000
Private	28	12	10		
Technological Factors	Lack of Equipment	Outdated Infrastructure			
Public	29	21		.041a	.005
Private	28	22			
Training and Expertise Factors	Insufficient Training Programs	Resistance to Change	Long Learning Curve		
Public	30	12	8	1.295a	.006
Private	25	13	12		
Regulatory and Institutional Factors	Lack of Institutional Support	Regulatory Hurdles			
Public	23	27		1.000a	.002
Private	28	22			
Facilitators for MIT Adoption	Yes	No			
Public	37	13		2.216a	.004
Private	30	20			
Technological Availability and Support	Access to Cutting-Edge Technology	Supplier Partnerships			
Public	32	18		1.70a	.005
Private	30	20			
Training and Education	Hands-On Training Opportunities	International Exposure			
Public	31	19		2.33a	.000
Private	32	18			
Institutional and Financial Support	Hospital Leadership Support	Government or Private Funding			
Public	31	19		.443a	.003
Private	32	18			
Patient Demand	Patient Awareness	Competitive Advantage			
Public	41	9		.932a	.000
Private	37	13			
MITs introduce	Patient safety	Recovery speed	Surgical precision		
Public	4	23	23	3.849a	.005
Private	10	24	16		

37. Chi-square: significant differences in patient demand factors affecting the introduction of MITs concern safety, recovery speed, and surgical precision.

DISCUSSION

This present study elaborates on the current situation of minimally invasive techniques in neurological surgery in Pakistan, compares their efficacy with conventional surgical techniques, analyzes attitudes toward MITs in public and private healthcare settings, and finally investigates those factors that influence the adoption and utilization of these advanced surgical techniques. The discussion now synthesizes findings from recent research into the importance of MITs for improving surgical outcomes and overcoming various challenges faced by neurosurgeons in Pakistan.

The previous study inline and suggested the associated benefits. A study that includes reduced surgical trauma, shorter recovery times, and lower complication rates-minimally invasive surgery has gained a lot of prominence lately in neurosurgery compared to traditional open surgeries.[16] The need for research and training in subspecialties like spine and neurovascular surgery has also been in greater emphasis by the Pakistan Society of Neurosurgeons, particularly for minimally invasive approaches.[11] Further study more significantly, the global market of minimally invasive neurosurgery devices has also marked increasing records of growth, implying a tendency in the direction of these techniques through technological development and the demands of patients for less invasive techniques.[17] Statements from the Board indicate that such MITs are typically characterized by small wounds, minimal loss of blood, and faster recovery compared to craniotomies and other similar conventional procedures.[18]

A study further instance, it has been ascertained that the number of patients who have gone through endoscopic surgeries experience far lesser post-operative pain and stay in the hospital for fewer days. The introduction of MITs brings immense value to patients in countries like Pakistan where open surgeries are more common due to historical reasons and because surgeons are more confident with those.[19] It was also demonstrated by the systematic review conducted by Dundar, Yurtsever[20] that machine learning algorithms had the potential to optimize surgical planning in the case of brain tumors, thereby supporting the efficacy of MITs in enhancing precision throughout procedures. Neurosurgeons diagnose conditions and plan minimally invasive approaches with the use of enhanced imaging technologies such as MRI and CT scans.

The attitudes towards MITs among healthcare professionals are crucial for their adoption. In this study, a significant difference was observed between public and private hospitals regarding perceptions of MITs. Public hospital staff exhibited greater concerns about high equipment costs and lack of funding compared to their private counterparts (Table 4). This aligns with findings from previous studies indicating that financial constraints significantly hinder the adoption of advanced surgical techniques in resource-limited settings.[17,11] Moreover, training and expertise play a pivotal role in shaping attitudes towards MITs. A lack of sufficient training programs was identified as a barrier in both the public and private sectors. The need for comprehensive training initiatives that equip neurosurgeons with the necessary skills to perform MITs cannot be overstated.[20] Resistance to change among established practitioners further complicates this transition. Therefore, targeted educational programs that emphasize the benefits and applications of MITs are essential for fostering a positive attitude among healthcare professionals.

Several factors influence the adoption and utilization of MITs in Pakistan. Access to cutting-edge technology is paramount. Public hospitals often face challenges related to outdated infrastructure and lack of equipment (Table 4). This

disparity highlights the need for investment in modern surgical technologies to facilitate the transition to minimally invasive techniques. Institutional support is critical for implementing new surgical techniques. Public hospitals reported higher concerns regarding institutional support compared to private hospitals (Table 4). Regulatory hurdles can also impede progress; thus, advocacy for policy changes that promote innovation in surgical practices is vital. Increasing patient awareness regarding the benefits of MITs can drive their adoption. As patients become more informed about their treatment options, they are likely to prefer less invasive procedures that promise quicker recovery times and fewer complications (Board, 2023). Collaboration between neurosurgeons, neurologists, and other medical professionals can enhance research efforts aimed at improving MIT applications. As noted by Prof. Shahid Ayub from the Pakistan Society of Neurosurgeons, interdisciplinary collaboration can lead to innovative breakthroughs in treatment methodologies.

CONCLUSION

The current landscape of minimally invasive techniques in neurological surgery in Pakistan reflects both opportunities and challenges. While there is a growing recognition of the benefits associated with MITs such as improved patient outcomes and reduced recovery times barriers such as high costs, inadequate training programs, and institutional resistance remain significant hurdles. To facilitate the successful adoption of these techniques across both public and private healthcare settings, it is imperative to address these challenges through targeted training initiatives, investment in technology, regulatory support, and increased collaboration among healthcare professionals. By fostering a culture that embraces innovation in surgical practices, Pakistan can enhance its neurosurgical capabilities and ultimately improve patient care outcomes.

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Additional Information

Disclosures: Authors report no conflict of interest.

Ethical Review Board Approval: Approval was taken from the IRB committee of District Headquarter (DHQ) hospitals Faisalabad (Reference no: IRB-7793-5 approved dated 01/10/2024)

Human Subjects: Consent was obtained by all patients/participants in this study.

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Other Relationships: All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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AUTHORS CONTRIBUTION

Sr.#	Author's Full Name	Contribution to Paper in Terms of:
1.	Saud Ahmed & Hafiz Muhammad Junaid	Study design, Data Collection and methodology.
2.	Muhammad Naeem Ur Rehman	Data Analysis & Graphics.
3.	Hassaan Sharif	Introduction and References.
4.	Muhammad Adeel Rauf & Kashif Javed	Paper writing, Grammar.