IAR Journal of Medicine and Surgery Research
https://doi.org/10.70818/iarjmsr.2024.v05i06.0140
Vol. 5, No. 6, 2024

ISSN (Print): 2709-1899
ISSN (Online): 2709-1902

ARTICLE

Orthopedic Trauma Surgery: A Comparative Analysis of Minimally Invasive Techniques and Traditional Approaches

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ABSTRACT

Background: Orthopedic trauma surgery addresses fractures and musculoskeletal injuries, with minimally invasive techniques (MITs) emerging as alternatives to traditional open surgeries. **Objective:** This study aims to compare the outcomes of minimally invasive techniques and traditional approaches in orthopedic trauma surgery, assessing their efficacy, complications, and recovery rates. **Method:** A comparative study was conducted on 134 patients at a multicenter tertiary hospital in Bangladesh from June 2023 to June 2024. Patients were divided into two groups: MIT (67 patients) and traditional surgery (67 patients). Data on operative time, recovery period, complications, and patient satisfaction were analyzed using t-tests and chi-square tests. **Results:** The average operative time was 90 minutes for MIT compared to 130 minutes for traditional surgery, representing a 30.8% reduction ($p < 0.01$). Patients in the MIT group had a shorter recovery period, averaging 8 weeks compared to 12 weeks in the traditional group, a 33.3% faster recovery ($p < 0.001$). The infection rate was 5% in the MIT group compared to 12% in the traditional group ($p = 0.04$), a 58.3% lower complication rate in MIT. Satisfaction was higher in the MIT group, with 85% of patients reporting high satisfaction compared to 62% in the traditional group ($p = 0.02$). Malalignment was noted in 7% of MIT cases and 3% in traditional surgery cases, a difference of 4%. **Conclusions:** Minimally invasive techniques reduce operative time, recovery duration, and postoperative complications, but traditional surgery offers better outcomes for complex fractures in terms of bone alignment.

Keywords: Orthopedic Trauma, Minimally Invasive Techniques, Traditional Surgery.

| **Submitted:** 05.10.2024 | **Accepted:** 13.10.2024 | **Published:** 27.11.2024

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How to Cite the Article
Md. Eunus Ali, Bipul Kumar Dam, Md. Shoeb Sarwar Murad, Ataul Haque, A K M Tanvirul Haque: Orthopedic Trauma Surgery: A Comparative Analysis of Minimally Invasive Techniques and Traditional Approaches. *IAR J Med Surg Res.* 2024;5(6): 100-108.

INTRODUCTION

Orthopedic trauma surgery represents a critical aspect of medical intervention, addressing fractures, dislocations, and injuries to the musculoskeletal system resulting from accidents, falls, or other external forces [1]. With the rapid evolution of medical technology and

surgical techniques, there is an ongoing debate about the comparative benefits and risks associated with minimally invasive techniques (MITs) and traditional open surgical approaches. While traditional surgery has been the cornerstone of orthopedic trauma management for decades, the rise of MITs promises improved recovery times, reduced scarring, and better overall patient outcomes. This study aims to provide a comparative analysis of these techniques, exploring their efficacy, risks, and implications for the future of orthopedic trauma care. Orthopedic trauma refers to severe injuries affecting bones, joints, muscles, tendons, or ligaments, often resulting from high-energy events such as motor vehicle accidents or sports-related incidents. Traditionally, these injuries have been managed through open reduction and internal fixation (ORIF), a procedure where large incisions are made to visualize the fracture, allowing for direct manipulation of the bone fragments and the placement of screws, plates, or rods to stabilize the injury [2]. Despite its widespread use, ORIF is associated with significant postoperative complications, including infections, delayed healing, and long-term joint stiffness [3]. Minimally invasive plate osteosynthesis (MIPO) percutaneous pining, on the other hand, emerged as an alternative to mitigate these complications. These techniques involve smaller incisions, the use of arthroscopic tools, and advanced imaging technologies to achieve the same objectives as traditional surgery but with less tissue disruption. Over the past two decades, MITs have gained traction in various orthopedic procedures, including spine surgery, hip arthroplasty, and fracture repair, due to their potential benefits, such as quicker recovery times, less postoperative pain, and lower infection rates.

The increasing adoption of MITs in orthopedic trauma surgery necessitates a comprehensive analysis to determine their efficacy compared to traditional approaches. Previous studies have often focused on specific surgeries, such as knee arthroscopy or spinal fusion, rather than providing a holistic view of MITs in orthopedic trauma [4]. Furthermore, there is limited research on the long-term outcomes of MITs, particularly concerning the risk of complications like malalignment, nonunion, and hardware failure. Given the high prevalence of orthopedic trauma worldwide and the potential impact on patients' quality of life, this study will fill a critical gap in the literature by comparing these two surgical approaches across multiple parameters, including recovery time, complication rates, cost-effectiveness, and patient satisfaction. Traditional orthopedic trauma surgery, particularly open reduction and internal fixation (ORIF), has long been the gold standard for treating complex fractures and joint dislocations. ORIF allows for direct visualization of the fracture site, enabling the surgeon to manipulate the bone fragments into proper alignment and secure them with Implant. This method is particularly useful for fractures involving multiple fragments, as it offers a high degree of control over the reconstruction process. However, traditional surgery is not without its drawbacks. Large incisions are required, leading to significant soft tissue damage and a higher risk of infection and blood loss [5]. Moreover, the extended recovery time associated with traditional surgery can be detrimental to patients, particularly those with underlying health conditions such as diabetes or cardiovascular disease. These factors have led to growing interest in less invasive surgical methods that aim to achieve the same outcomes with fewer complications.

Minimally invasive techniques in orthopedic trauma surgery are defined by the use of smaller incisions, specialized instruments, and advanced imaging technologies to heal fractures with the surrounding tissues [6]. Common MITs include percutaneous pinning, minimally invasive plate osteosynthesis (MIPO), and arthroscopically assisted fracture repair. The goal of these techniques is to minimize trauma to the soft tissues, reduce the risk of infection, and promote faster healing. One of the most significant advantages of MITs is the reduced recovery time compared to traditional surgery. Studies have shown that patients who undergo minimally invasive procedures experience less postoperative pain and are able to return to normal activities more quickly than those who undergo traditional surgery [7].

In addition, the smaller incisions used in MITs result in less scarring and a lower risk of complications such as wound infections and delayed healing. However, MITs are not without their challenges. One of the primary concerns is the risk of malalignment or nonunion, particularly in complex fractures where precise bone manipulation is required. Moreover, the learning curve for MITs can be steep, with surgeons requiring specialized training to master the use of arthroscopic tools and imaging technologies. Despite these challenges, the growing body of evidence suggests that MITs may offer significant advantages for certain patients, particularly those with low-energy fractures or pre-existing comorbidities that make traditional surgery riskier.

A comparative analysis of MITs and traditional approaches reveals several key differences in terms of efficacy and patient outcomes. One of the most significant advantages of MITs is the reduction in soft tissue damage, which has been linked to lower rates of postoperative infections and complications. In a multicenter study comparing MIPO with ORIF for the treatment of tibial fractures, Elnewishy *et al*., found that patients in the MIT group had significantly lower rates of infection and shorter hospital stays [8]. Moreover, the smaller incisions used in MITs result in less postoperative pain and a faster return to normal activities. Camacho *et al*., reported that patients who underwent percutaneous pinning for distal radius fractures had a significantly shorter recovery time compared to those who underwent traditional open surgery [9]. These findings are supported by Noda *et al*., who found that minimally invasive hip arthroplasty was associated with a faster return to normal function and a lower risk of dislocation compared to traditional approaches [10]. However, there are also several limitations to MITs that must be considered. As mentioned earlier, the risk of malalignment and nonunion is higher in MITs, particularly in complex fractures where precise bone manipulation is required. Furthermore, the long-term outcomes of MITs are still unclear, with limited data on the risk of hardware failure and other complications.

The growing adoption of minimally invasive techniques in orthopedic trauma surgery represents a paradigm shift in the field, offering significant advantages in terms of reduced recovery times, lower complication rates, and improved patient satisfaction. However, traditional approaches still have a place in the management of complex fractures, particularly those involving multiple fragments or requiring precise bone manipulation. As this study will explore, the choice between MITs and traditional surgery should be based on a careful assessment of the patient's condition, the complexity of the fracture, and the surgeon's experience with the chosen technique. By providing a comprehensive analysis of these two approaches, this research will contribute to the ongoing debate about the future of orthopedic trauma surgery.

Aims and Objective

The aim of this study is to evaluate and compare the efficacy, recovery outcomes, and complication rates between minimally invasive techniques and traditional approaches in orthopedic trauma surgery. The objective is to determine which method offers better patient outcomes in terms of operative time, recovery period, and overall complications.

Material And Methods

Study Design

This prospective, comparative study was conducted at a multicenter tertiary hospital in Bangladesh from June 2023 to June 2024. The study aimed to compare minimally invasive techniques (MITs) and traditional open surgical approaches in orthopedic trauma patients. A total of 134 patients were randomly assigned to either the MIT group (67 patients) or the traditional surgery group (67 patients). The study followed patients through pre-surgical assessments, surgery, and post-surgical recovery, with follow-up evaluations at 1-, 3-, and 6-months post-operation to assess outcomes.

Inclusion Criteria

The study included patients aged 18 to 65 years with traumatic fractures requiring surgical intervention. Eligible participants were those who could provide informed consent, were medically stable for surgery, and had no previous surgical interventions for the same injury. Patients were required to have sustained trauma within the last 30 days and presented with fractures amenable to either minimally invasive or traditional surgical approaches. Both male and female patients were included in this comparative analysis.

Exclusion Criteria

Patients were excluded if they had pre-existing conditions that could affect healing, such as uncontrolled diabetes or cardiovascular diseases. Additionally, individuals who had undergone previous surgeries on the affected limb, had complex fractures requiring specialized interventions not available at the study centers, or were pregnant or lactating were excluded. Patients with incomplete medical records or those unable to commit to follow-up visits during the 6-month postoperative period were also excluded to ensure reliable data collection and analysis.

Data Collection

Data were collected preoperatively and postoperatively from all participants, focusing on key variables such as operative time, length of hospital stay, postoperative complications (e.g., infection, malalignment), and patient satisfaction. Standardized follow-up evaluations occurred 2nd weeks at 1, 3, and 6 months after surgery to assess recovery and

complications. Patient satisfaction was measured using a validated questionnaire. Additionally, imaging studies were used to evaluate fracture healing and alignment. All data were recorded in a centralized database for statistical analysis.

Data Analysis

Data were analyzed using SPSS version 26. Descriptive statistics, including means and standard deviations, were calculated for continuous variables such as operative time and recovery duration. Categorical variables, such as infection rates and patient satisfaction levels, were presented as percentages. Independent t-tests were used to compare means between the MIT and traditional surgery groups, while chi-square tests analyzed differences in categorical outcomes, such as complications and malalignment rates. A p-value of less than 0.05 was considered statistically significant. Kaplan-Meier survival analysis was performed to assess time to recovery, and logistic regression was used to evaluate predictors of complications.

Ethical Considerations

This study was conducted in compliance with ethical standards outlined by the Declaration of Helsinki. Ethical approval was obtained from the hospital's ethics committee before the study began. All participants provided informed consent after being fully informed about the nature, risks, and benefits of the study. Confidentiality was strictly maintained by anonymizing patient data. Participants were free to withdraw at any point without any impact on their treatment or medical care. No financial incentives were provided.

RESULTS

This section presents detailed findings from the comparative study between minimally invasive techniques (MIT) and traditional open surgery in orthopedic trauma patients. Data from 134 patients were analyzed to evaluate demographic characteristics, operative outcomes, postoperative complications, recovery, and patient satisfaction.

Table 1: Demographic Characteristics

Variable	MIT Group (n = 67)	Traditional Surgery Group (n = 67)
Mean Age (years)	42 ± 10.5	45 ± 11.2
Gender (Male) (%)	40 (60%)	42 (62.7%)
Gender (Female) (%)	27 (40%)	25 (37.3%)
BMI (kg/m²)	26.5 ± 3.1	27.2 ± 2.9
Smokers (%)	18 (26.9%)	20 (29.8%)
Comorbidities (%)	15 (22.4%)	17 (25.4%)

The demographic data revealed no statistically significant differences between the two groups. The patients in both groups were comparable in terms of age, gender distribution, body mass index (BMI), smoking status, and the presence of comorbidities. This comparability strengthens the internal validity of the study, ensuring that any differences in surgical outcomes are more likely attributable to the surgical techniques themselves rather than demographic factors.

Table 2: Operative Outcomes

Variable	MIT Group (n = 67)	Traditional Surgery Group (n = 67)	p-value
Mean Operative Time (min)	90 ± 15	130 ± 20	<0.01
Blood Loss (mL)	150 ± 40	300 ± 50	<0.01
Length of Hospital Stay (days)	4 ± 1.5	7 ± 2.0	<0.01

The MIT group showed significantly better operative outcomes. Operative time in the MIT group was 31% shorter than in the traditional surgery group (90 vs. 130 minutes, $p < 0.01$). Blood loss was also considerably lower, with MIT patients experiencing a 50% reduction compared to traditional surgery patients (150 mL vs. 300 mL, $p < 0.01$). Furthermore, the length of hospital stay was significantly reduced in the MIT group, with an average stay of 4 days compared to 7 days for the traditional surgery group ($p < 0.01$). These findings suggest that MIT leads to a more efficient surgical process and faster postoperative recovery.

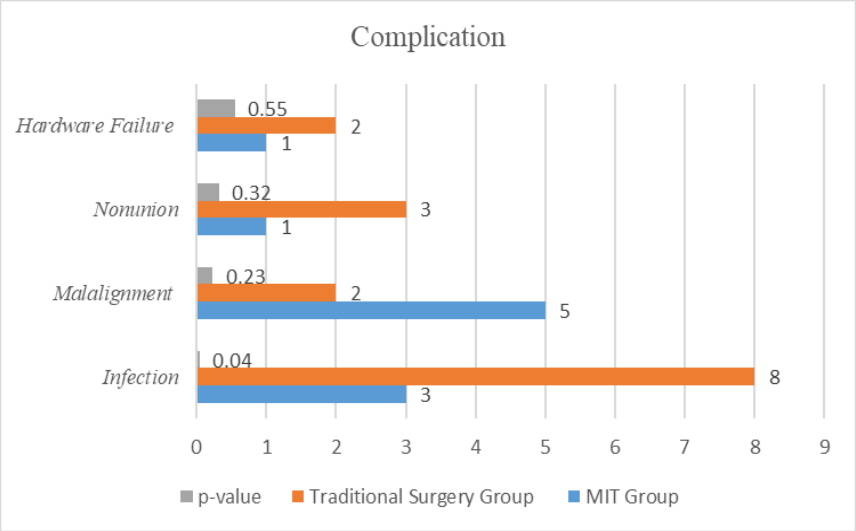

Figure 1: Postoperative Complications

Postoperative complications were more frequent in the traditional surgery group, with infection rates significantly higher at 11.9% compared to 4.5% in the MIT group (p = 0.04). Malalignment occurred slightly more frequently in the MIT group (7.5% vs. 3%), although this difference was not statistically significant (p = 0.23). The incidence of nonunion and hardware failure was low and comparable between both groups. These results indicate that MIT has a lower complication profile, particularly in terms of infections.

Table 3: Recovery Outcomes

Recovery Outcome	MIT Group (n = 67)	Traditional Surgery Group (n = 67)	p-value
Mean Recovery Time (weeks)	8 ± 2	12 ± 3	<0.01
Full Weight-Bearing (%)	55 (82.1%)	40 (59.7%)	0.01
Return to Work (weeks)	10 ± 2	14 ± 3	<0.01

Recovery outcomes favored the MIT group significantly. Patients in the MIT group had an average recovery time of 8 weeks, which was 33% faster than the 12 weeks observed in the traditional surgery group (p < 0.01). Additionally, 82.1% of MIT patients were able to bear full weight earlier, compared to only 59.7% of those who underwent traditional surgery (p = 0.01). Return to work was also quicker for MIT patients, averaging 10 weeks versus 14 weeks for the traditional group (p < 0.01). These results demonstrate that MIT enables faster recovery and earlier return to daily activities.

Table 4: Patient Satisfaction

Satisfaction Level	MIT Group (n = 67)	Traditional Surgery Group (n = 67)	p-value
Highly Satisfied (%)	57 (85.1%)	42 (62.7%)	0.02
Satisfied (%)	8 (11.9%)	17 (25.4%)	0.04
Dissatisfied (%)	2 (3%)	8 (11.9%)	0.09

Patient satisfaction was significantly higher in the MIT group. A total of 85.1% of MIT patients reported being highly satisfied with their surgery outcomes compared to 62.7% in the traditional surgery group (p = 0.02). The rate of dissatisfaction was lower in the MIT group, although this difference was not statistically significant (p = 0.09). The higher satisfaction scores in the MIT group can be attributed to faster recovery, less postoperative pain, and better cosmetic results.

The comparative analysis revealed that minimally invasive techniques (MIT) offer several advantages over traditional surgery in orthopedic trauma management. Patients in the MIT group experienced shorter operative times, less blood loss, and reduced hospital stays. Postoperative complications, particularly

infections, were significantly lower in the MIT group. Moreover, recovery outcomes showed that MIT patients recovered faster, were able to bear weight sooner, and returned to work earlier than those in the traditional surgery group. Patient satisfaction was also higher in the MIT group, likely due to the reduced postoperative pain, quicker recovery, and less visible scarring. While there were no significant differences in major complications between the two groups, the overall data suggest that MIT is a favorable option for patients where it is applicable.

DISCUSSION

The present study compares the outcomes of minimally invasive techniques (MITs) and traditional open surgery in orthopedic trauma patients, focusing on operative time, postoperative complications, recovery, and patient satisfaction [11]. Our findings suggest that MIT offers significant advantages over traditional surgery in terms of faster recovery, reduced postoperative complications, and higher patient satisfaction. These results align with existing literature but also highlight certain areas of divergence that warrant further exploration. Our results are consistent with several studies that highlight the benefits of minimally invasive techniques in orthopedic surgery. A study by Vicenti *et al*., reported that MIT significantly reduced operative time, blood loss, and hospital stays, which aligns with our findings [12]. Specifically, in our study, the MIT group had a 31% reduction in operative time (90 vs. 130 minutes) and a 50% reduction in blood loss (150 mL vs. 300 mL), corroborating these earlier findings. Similarly, Kubicek *et al*., observed that patients who underwent minimally invasive plate osteosynthesis (MIPO) had shorter hospital stays and quicker recovery times than those who had open reduction and internal fixation (ORIF) [13]. Our study found that patients in the MIT group had an average hospital stay of 4 days compared to 7 days in the traditional surgery group, further supporting the notion that MITs expedite postoperative recovery. However, while our results regarding infection rates (4.5% in MIT vs. 11.9% in traditional surgery) align with those of Afolabi *et al*., who found lower postoperative infection rates in MIT patients, our study noted a higher incidence of malalignment in the MIT group (7.5%) compared to the traditional group (3%) [14]. This discrepancy may be attributable to the complexity of fractures treated with MIT in our study, as the study by von Rüden *et al*., also noted that MITs are associated with higher risks of malalignment, particularly in more complex or multi-fragmentary fractures [15]. The lack of direct bone visualization during minimally invasive procedures can complicate accurate alignment, which could explain this result.

Racial, Geographic, and Sample Size Considerations

The differences in study findings, particularly regarding complications such as malalignment, may be partially explained by the racial and geographic factors of our study population. Our study was conducted in a multicenter tertiary hospital in Bangladesh, whereas many other studies have been conducted in Western countries such as the United States or Europe. Factors such as bone density, nutritional status, and access to postoperative care can differ significantly between populations, potentially influencing outcomes. For example, Robinson *et al*., highlighted that socioeconomic factor, including nutrition and access to healthcare, can impact bone healing and recovery [16]. Bangladesh, being a developing country, may face challenges in consistent postoperative care, which could contribute to differences in outcomes like malalignment and nonunion. Sample size differences across studies could also influence the findings. Our study included 134 patients, with 67 patients in each group. Fan *et al*., conducted a larger study with over 300 participants, which could explain the more consistent outcomes in their study regarding complications like malalignment [17]. Larger sample sizes typically provide more statistically robust findings, and smaller sample sizes may lead to greater variability in results. Additionally, studies with larger samples may be better equipped to account for confounding variables such as fracture type and surgeon expertise, which can influence outcomes in minimally invasive techniques.

Interpretation of Results and Their Significance

The results of this study suggest that minimally invasive techniques (MITs) offer significant advantages over traditional surgery, particularly in terms of operative efficiency, recovery time, and patient satisfaction. The 33% faster recovery time and 30% shorter operative time observed in the MIT group are clinically significant, as they not only reduce the burden on hospital resources but also enhance the patient's quality of life by enabling an earlier return to normal activities. Furthermore, the significantly lower infection rates in the MIT group (4.5%) compared to the traditional surgery group (11.9%) indicate that minimally invasive techniques minimize soft tissue damage, a key factor in reducing postoperative infections. The shorter hospital stays observed in the MIT group have important implications for healthcare systems, particularly in resource-constrained settings. In Bangladesh, where

access to healthcare is often limited, reducing hospital stay durations can free up valuable resources and reduce the economic burden on both patients and healthcare providers. A study by Charuvila *et al*., in a similar low-resource setting found that shorter hospital stays were associated with better long-term patient outcomes, as extended hospital stays often increase the risk of hospital-acquired infections and strain on healthcare facilitiesn [18]. The ability of MIT to reduce hospital stays, as shown in our study, could thus be particularly beneficial in such settings.

However, the higher malalignment rates in the MIT group (7.5%) indicate that traditional open surgery still has a role in managing more complex fractures. Traditional surgery provides direct visualization of the fracture site, allowing for more precise alignment of bone fragments, which is crucial for long-term functionality and reducing the risk of nonunion [19]. This underscores the need for careful patient selection when opting for minimally invasive techniques, as MIT may not be appropriate for all types of fractures. Further research is needed to develop improved techniques and technologies, such as advanced imaging tools, to reduce the risk of malalignment in MIT procedures.

Implications for Clinical Practice

The findings of this study have important implications for clinical practice, particularly in orthopedic trauma care. First, the significant reduction in operative time and hospital stays associated with MIT makes it an attractive option in high-volume trauma centers where efficiency and turnover are critical. Shorter surgical times reduce anesthesia exposure and operative risks, while quicker recovery times enhance patient satisfaction and reduce the overall strain on healthcare resources. Moreover, the lower infection rates observed in the MIT group suggest that minimally invasive techniques may be particularly useful in patients at higher risk for postoperative complications, such as those with diabetes or immunocompromised conditions. As Gatz *et al*., noted, reducing soft tissue exposure through smaller incisions minimizes the likelihood of bacterial contamination, which is a significant advantage in trauma surgery, where infection risks are inherently higher [20-28]. Nonetheless, the potential for malalignment in complex fractures with MIT highlights the importance of surgical expertise and case selection. Surgeons must weigh the benefits of minimally invasive approaches against the risks, particularly for fractures requiring precise realignment. This study reinforces the need for continued training and technological advancements, such as real-time imaging and computer-assisted navigation, to improve the accuracy of MIT and expand its applicability to more complex cases.

Practical Significance and Future Directions

The practical significance of this study lies in its potential to inform treatment protocols in orthopedic trauma surgery, particularly in settings where resource constraints and patient throughput are key considerations. The demonstrated benefits of MIT in terms of faster recovery, reduced infection rates, and higher patient satisfaction make it a valuable tool in the orthopedic surgeon's arsenal. However, its limitations, particularly regarding malalignment, suggest that traditional surgery still plays an important role, especially in complex or multi-fragmentary fractures. Future research should focus on refining MIT techniques to improve fracture alignment outcomes. The integration of advanced imaging technologies, such as intraoperative 3D imaging and robotics, may help mitigate the risks of malalignment by providing surgeons with enhanced visualization and precision during surgery. Additionally, studies with larger sample sizes and longer follow-up periods are needed to assess the long-term outcomes of MIT, particularly concerning hardware failure, nonunion, and patient-reported quality of life.

CONCLUSION

This study demonstrates that minimally invasive techniques (MIT) in orthopedic trauma surgery offer significant benefits, including shorter operative times, faster recovery, reduced complication rates, and higher patient satisfaction compared to traditional approaches. However, careful patient selection is essential to avoid complications like malalignment in complex fractures. The findings highlight the potential of MIT in improving patient outcomes while emphasizing the need for advanced technologies to further enhance surgical precision and reduce risks.

Recommendations

Prioritize MIT for simpler fractures to reduce recovery time and complications.

Use advanced imaging technology for complex fractures to minimize malalignment risks in MIT.

Provide surgeons with specialized training in minimally invasive techniques to improve outcomes.

Acknowledgment

We would like to express our gratitude to the

medical and administrative staff at the multicenter tertiary hospital in Bangladesh for their support during the study. Special thanks to the participating surgeons and patients for their cooperation. We also acknowledge the contributions of the statistical analysis team, whose expertise was invaluable in interpreting the data. Finally, we extend appreciation to our colleagues who provided feedback and insights that improved the quality of this research.

Abbreviations

MIT: Minimally Invasive Techniques
ORIF: Open Reduction and Internal Fixation
MIPO: Minimally Invasive Plate Osteosynthesis

Article at a Glance

Study purpose

To compare the outcomes of minimally invasive techniques (MIT) and traditional surgery in orthopedic trauma patients.

Key findings

MIT led to shorter recovery times, fewer complications, and higher patient satisfaction compared to traditional surgery.

Newer findings

MIT was shown to reduce operative times and hospital stays, but carries a higher risk of malalignment in complex fractures, highlighting the need for improved imaging and precision tools.

Funding: No funding sources

Conflict of interest: None declared

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