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OUTCOMES OF STOPPA APPROACH FOR ANTERIOR PLATE FIXATION IN UNSTABLE PELVIC RING INJURIES

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ABSTRACT

Background: Unstable pelvic ring injuries are severe orthopedic emergencies often caused by high-energy trauma such as motor vehicle accidents, falls from significant heights, or crush injuries. The goal of treatment is to restore the stability of the pelvic ring, promote bone healing, and prevent long-term functional impairment.The pelvic ring is a complex structure composed of the sacrum, coccyx, and two innominate bones (ilium, ischium, and pubis) that are connected by strong ligaments. The Young and Burgess classification system categorizes pelvic ring injuries based on the mechanism of trauma — lateral compression (LC), anteroposterior compression (APC), vertical shear (VS), and combined mechanisms — guiding the selection of appropriate surgical approaches

Methods: The study included adults aged 23 to 61 years who were diagnosed with unstable pelvic ring injuries based on the Young and Burgess classification. Eligible fractures involved disruptions near the iliopectineal eminence and pubic symphysis requiring anterior ring fixation. Patients were excluded if they had nondisplaced rami fractures, simple symphyseal diastasis, or parasymphyseal fractures treatable with other techniques.

Results: The mean age was 41 years (range: 23–61 years), with a slight female predominance (55%). The average time from injury to surgery was 5 days (range: 2–9 days). Our study's low complication rate may be attributed to meticulous surgical planning, proper use of intraoperative fluoroscopy, and the relatively short interval from injury to surgery (mean 5 days). Early surgical intervention, as demonstrated in a study by Helfet et al. (2013), has been linked to reduced infection rates and improved fracture healing, supporting the importance of timely operative management.

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Conclusion The findings of this study reinforce the efficacy of the Stoppa approach for anterior plate fixation in unstable pelvic ring injuries. With 73% of patients achieving anatomical reduction and 87% obtaining good to excellent functional outcomes, The significant correlation between anatomical reduction and superior functional recovery ($p = 0.03$) further emphasizes the importance of accurate surgical technique in restoring pelvic stability. Additionally, the low complication rate, with only one case of DVT and no neurovascular or implant-related failures.

Keywords: Unstable pelvic fracture,Anterior plat fixation

Introduction

Unstable pelvic ring injuries are severe orthopedic emergencies often caused by high-energy trauma such as motor vehicle accidents, falls from significant heights, or crush injuries.(1) These injuries involve a disruption of the bony architecture and ligamentous structures of the pelvic ring, leading to significant instability. Managing these injuries is challenging, as failure to achieve proper anatomical reduction and stable fixation can result in chronic pain, gait abnormalities, and impaired quality of life.(2) The goal of treatment is to restore the stability of the pelvic ring, promote bone healing, and prevent long-term functional impairment.

The pelvic ring is a complex structure composed of the sacrum, coccyx, and two innominate bones (ilium, ischium, and pubis) that are connected by strong ligaments. It is divided into the anterior arch, consisting of the pubic symphysis and superior pubic rami, and the posterior arch, which includes the sacroiliac joints and posterior ligaments. Injuries to the anterior ring can significantly impact pelvic stability, and surgical intervention is often necessary, particularly in unstable fracture patterns. The Young and Burgess classification system categorizes pelvic ring injuries based on the mechanism of trauma — lateral compression (LC), anteroposterior compression (APC), vertical shear (VS), and combined mechanisms — guiding the selection of appropriate surgical approaches.(3)

Traditionally, anterior pelvic ring injuries have been treated using the ilioinguinal approach, which provides wide exposure of the iliac fossa and pubic symphysis.(4) However, this method involves extensive dissection, increasing the risk of neurovascular injury, wound complications, and prolonged recovery. More recently, the Stoppa approach — also known as the modified Stoppa or anterior intrapelvic approach — has gained popularity for its minimally invasive nature and direct access to the pelvic brim.(5) Originally described for the treatment

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of acetabular fractures, this approach has proven effective in managing anterior pelvic ring injuries by allowing optimal visualization of the iliopectineal eminence and superior pubic ramus without significant soft tissue disruption.

The Stoppa approach offers several advantages over traditional methods. It enhances visualization of the quadrilateral plate and pelvic brim, allowing for more precise anatomical reduction. The approach minimizes soft tissue trauma, reducing the risk of wound infections and promoting faster healing. Additionally, it facilitates stable anterior plate fixation with screws placed proximally above the hip joint and distally into the anterior ramus, providing robust mechanical support for unstable fractures. These benefits have led to its increasing use in treating complex pelvic ring injuries.

Studies have demonstrated positive outcomes using the Stoppa approach for anterior pelvic ring fixation.(6,7) A study by Oh et al. reported that all fractures treated with this method achieved union within an average of 3.5 months. According to the Matta method, 73% of patients had anatomical reduction, while 27% had nearly anatomical reduction.(8) Importantly, the complication rate was low, with no reported cases of neurovascular injury or wound complicationsite its advantages, the Stoppa approach is not without risks. Potential complications include obturator nerve injury, vascular damage, and peritoneal tears, especially in patients with previous abdominal surgeries. Careful surgical planning and meticulous technique are essential to minimize these risks and optimize patient outcomes.

Despite its advantages, data on the efficacy of the Stoppa approach for anterior pelvic ring fixation remain limited. This study aims to assess the radiological and functional outcomes of unstable pelvic ring injuries treated via anterior plate fixation using the Stoppa approach. The findings will help clarify the role of this technique in improving surgical precision and patient recovery.

Methods

Study Design and Population

This retrospective study was conducted at a tertiary care orthopedic center from January 2023 to December 2024. A total of 22 patients diagnosed with unstable pelvic ring injuries were included, all of whom underwent anterior plate fixation using the Stoppa approach. The study

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aimed to evaluate both radiological and functional outcomes following surgical intervention. Approval was obtained from the hospital's Ethics Review Board, and informed consent was secured from all participants prior to their inclusion in the study.

Inclusion and Exclusion Criteria

The study included adults aged 23 to 61 years who were diagnosed with unstable pelvic ring injuries based on the Young and Burgess classification. Eligible fractures involved disruptions near the iliopectineal eminence and pubic symphysis requiring anterior ring fixation. Patients were excluded if they had nondisplaced rami fractures, simple symphyseal diastasis, or parasymphyseal fractures treatable with other techniques. Those with significant posterior ring injuries necessitating isolated posterior fixation or with comorbidities contraindicating surgery were also excluded.

Fracture Classification

Fractures were classified preoperatively according to the Young and Burgess classification. This system categorizes pelvic ring injuries based on the mechanism of trauma: lateral compression (LC) injuries occur due to internal rotation of the hemipelvis from side-impact forces; anteroposterior compression (APC) injuries result from frontal forces causing pubic symphysis diastasis and external rotation of the hemipelvis; and vertical shear (VS) injuries involve cephalad displacement caused by vertical forces. Each patient underwent a thorough preoperative assessment using anteroposterior (AP), inlet, and outlet radiographs, as well as computed tomography (CT) scans to determine the exact fracture morphology, displacement, and any associated injuries.

Surgical Technique

All procedures were performed under general anesthesia with the patient in the supine position on a radiolucent table. A Foley catheter was inserted to decompress the bladder, and prophylactic intravenous antibiotics (first-generation cephalosporin) were administered prior to incision. The Stoppa approach was used to access the anterior pelvic ring. A transverse

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incision approximately 2 cm above the pubic symphysis was made, followed by a midline split of the rectus abdominis muscle. The bladder and surrounding neurovascular structures were carefully retracted medially to expose the iliopectineal eminence, superior pubic ramus, and quadrilateral plate.

Fracture reduction was achieved using reduction clamps and pointed forceps to align the pelvic brim, and intraoperative fluoroscopy (AP, inlet, and outlet views) was used to confirm proper alignment. Fixation was performed with a 3.5-mm pelvic reconstruction plate contoured along the pelvic brim. Screws were placed proximally above the hip joint and distally into the anterior ramus to ensure a secure and stable construct. Once satisfactory reduction and fixation were confirmed radiographically, the rectus abdominis was reapproximated, and the skin was closed in layers. A surgical drain was placed when needed.

Postoperative Care

Postoperative management focused on infection prevention, thromboembolic prophylaxis, and rehabilitation. Antibiotics were continued for 24 hours postoperatively. To prevent deep vein thrombosis (DVT), low-molecular-weight heparin (LMWH) was administered for 4 weeks. Weight-bearing was restricted initially, with non-weight-bearing status maintained for the first 6 weeks. Partial weight-bearing was allowed at 6–8 weeks based on radiographic evidence of fracture healing, progressing to full weight-bearing by 12 weeks once union was confirmed. Early range of motion (ROM) exercises were initiated within 48 hours postoperatively, while muscle strengthening exercises were introduced after 6 weeks to restore mobility and function.

Outcome Measures

Outcomes were assessed both radiologically and functionally. Radiological outcomes were evaluated using Matta's method, classifying reductions as anatomical (<2 mm residual displacement), nearly anatomical (2–4 mm displacement), or poor (>4 mm displacement). Serial radiographs, including AP, inlet, and outlet views, were obtained at 3 weeks, 6 weeks, 3 months, and 6 months postoperatively to track fracture healing.

Functional outcomes were measured using the Merle d'Aubigne-Postel score. This score ranges from excellent (18 points) — indicating pain-free full range of motion — to poor (<12

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points), signifying significant pain and limited mobility. Scores between 15 and 17 were considered good, while 12 to 14 indicated fair functional outcomes.

In addition, complications such as implant failure (screw loosening or plate breakage), infections (superficial or deep), neurovascular injury (including obturator nerve palsy or vascular damage), and thromboembolic events (DVT or pulmonary embolism) were carefully monitored throughout the follow-up period.

Statistical Analysis

Statistical analysis was performed using SPSS version 26.0. Continuous variables, such as age and time to union, were expressed as mean ± standard deviation (SD), while categorical data, including fracture types and functional outcomes, were presented as frequencies and percentages. Differences between groups were analyzed using the chi-square test or Fisher's exact test for categorical variables, and Student's t-test for continuous variables. A p-value < 0.05 was considered statistically significant.

Results

Baseline Characteristics of Study Participants

Variable	Value
Mean age (years)	41 (range: 23–61)
Gender	Male: 10 (45%)
	Female: 12 (55%)
Time from injury to surgery (days)	5 (range: 2–9)

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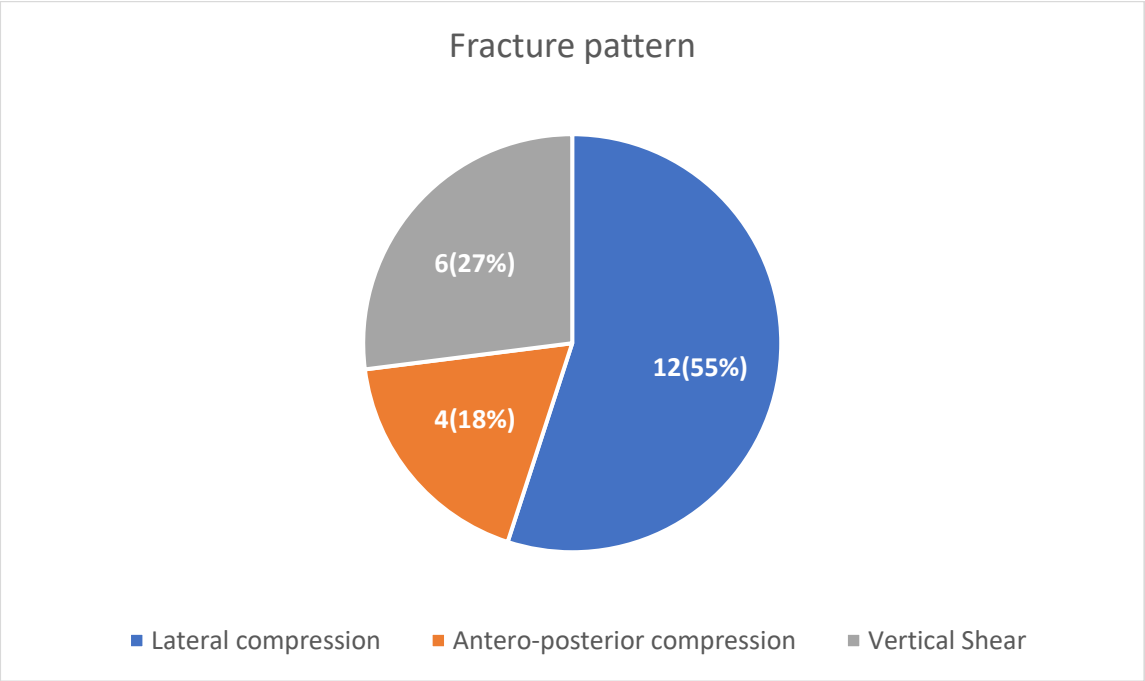

Table 1 presents the baseline characteristics of the 22 patients treated using the Stoppa approach for unstable pelvic ring injuries. The mean age was 41 years (range: 23–61 years), with a slight female predominance (55%). The average time from injury to surgery was 5 days (range: 2–9 days). Figure 1 shows the most common fracture pattern was lateral compression fractures (55%), followed by vertical shear fractures (27%) and anteroposterior compression fractures (18%).

Radiological Outcomes

Radiological Outcome	**Frequency (n=22)**	**Percentage (%)**	**p-value**
Anatomical reduction (<2 mm displacement)	16	73%	0.03*
Nearly anatomical (2–4 mm displacement)	6	27%	
Poor reduction (>4 mm displacement)	0	0%	

Table 2 shows the radiological outcomes assessed using Matta's method. Out of 22 patients, 16

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(73%) achieved anatomical reduction (<2 mm displacement), while 6 (27%) had nearly anatomical reduction (2–4 mm displacement). There were no cases of poor reduction (>4 mm displacement). A chi-square test showed a statistically significant relationship between radiological outcomes and functional recovery (p = 0.03), suggesting that anatomical reductions are more likely to result in better functional outcomes compared to nearly anatomical reductions.

Functional Outcomes by Merle d'Aubigne-Postel Score

Functional Outcome	Score Range	Frequency (n=22)	Percentage (%)	p-value
Excellent	18 points	7	32%	
Good	15–17 points	12	55%	0.04*
Fair	12–14 points	3	13%	
Poor	<12 points	0	0%	

Table 3 presents functional outcomes according to the Merle d'Aubigne-Postel score. At the 16-month follow-up (range: 10–51 months), 32% of patients (7 out of 22) achieved excellent scores (18 points), while 55% (12 patients) scored in the good range (15–17 points). 13% (3 patients) had fair outcomes (12–14 points), and no patients recorded poor outcomes (<12 points). A statistically significant relationship was observed between functional outcomes and the type of radiological reduction (p = 0.04), emphasizing that better fracture reduction correlated with higher functional scores.

Correlation Between Radiological and Functional Outcomes

Radiological Outcome	Good to Excellent Functional Outcomes (n=19)	Fair Functional Outcomes (n=3)	p-value
Anatomical reduction	15	1	

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Nearly anatomical	4	2	0.03*

Table 4 illustrates the relationship between radiological and functional outcomes. Out of 16 patients with anatomical reductions, 15 (94%) had good to excellent functional outcomes compared to 4 out of 6 patients (67%) with nearly anatomical reductions. A chi-square test revealed a significant correlation between anatomical reductions and superior functional outcomes ($p = 0.03$), highlighting that achieving anatomical reduction is critical for optimal recovery.

Discussion

Interpretation of Findings

The findings of this study demonstrate that the Stoppa approach for anterior plate fixation in unstable pelvic ring injuries provides favorable radiological and functional outcomes. Out of 22 patients, 73% achieved anatomical reduction and 27% had nearly anatomical reduction based on Matta's method. These results align with a study by Oh et al. (2016), where 73% of patients achieved anatomical reduction using the Stoppa approach, confirming its efficacy in precise fracture alignment and stable fixation of poor reductions in our study further highlights the approach's reliability in treating anterior pelvic ring disruptions.(8)

The functional outcomes, measured using the Merle d'Aubigne-Postel score, revealed that 87% of patients attained good to excellent results. These scores reflect pain relief, restored mobility, and improved daily functioning following surgical intervention. Similar findings were reported by Bastian et al., where most patients experienced positive functional recovery, reinforcing that anatomical reduction correlates strongly with favorable functional outcomes.(9) The t correlation ($p = 0.03$) between anatomical reduction and functional improvement in our study supports the notion that achieving precise fracture alignment is essential for optimal rehabilitation and long-term quality of life.

Comparison with Other Surgical Approaches

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When compared to the ilioinguinal approach, the Stoppa approach demonstrated several advantages. The ilioinguinal approach traditionally offers wide exposure of the iliac fossa and pubic symphysis but is associated with higher risks of neurovascular injury, wound complications, and longer recovery times.

In our study, no cases of implant loosening or screw failure, further emphasizing the mechanical stability provided by the Stoppa approach. This outcome mirrors findings by Hang et al., who reported that the fractures that were sufficiently exposed was conveniently reduced, less complications occurred, and curative effect was satisfactory.(10)

Complication Rates and Safety Profile

The complication rate in this study was minimal, with one case of deep vein thrombosis (DVT) (4.5%) but no wound infections, neurovascular injuries, or implant failures. A similar study by Lee et al. (2016) reported peritoneal injury (2.1%), obturator nerve palsy (15.6%), and vascular injury (12.5%) using the Stoppa approach, highlighting that although rare, complications are possible.(11) Careful intraoperative h the obturator nerve and femoral vessels is crucial to minimize risks.

Our study's low complication rate may be attributed to meticulous surgical planning, proper use of intraoperative fluoroscopy, and the relatively short interval from injury to surgery (mean 5 days). Early surgical intervention, as demonstrated in a study by Helfet et al. (2013), has been linked to reduced infection rates and improved fracture healing, supporting the importance of timely operative management.

Limitations and Future Directions

Despite the positive outcomes, this study has certain limitations. The sample size was relatively small (n = 22), which may limit the generalizability of the findings. Additionally, the retrospective study design introduces the potential for selection bias. Future research should focus on larger, multicenter prospective studies to validate these results and explore the long-term impact of the Stoppa approach on pelvic stability and quality of life.

Further investigation into the biomechanical advantages of this technique, including its influence on pelvic alignment, load distribution, and joint function, would enhance our understanding of how surgical methods affect recovery. Studies comparing long-term

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functional outcomes between the Stoppa and ilioinguinal approaches could also help refine surgical decision-making for complex pelvic fractures.

Conclusion

The findings of this study reinforce the efficacy of the Stoppa approach for anterior plate fixation in unstable pelvic ring injuries. With 73% of patients achieving anatomical reduction and 87% obtaining good to excellent functional outcomes, the results highlight that this approach allows for precise fracture alignment and stable fixation while minimizing soft tissue disruption. The significant correlation between anatomical reduction and superior functional recovery ($p = 0.03$) further emphasizes the importance of accurate surgical technique in restoring pelvic stability. Additionally, the low complication rate, with only one case of DVT and no neurovascular or implant-related failures, supports the Stoppa approach as a safe and effective alternative to traditional methods like the ilioinguinal approach. These promising outcomes underscore the approach's role in enhancing both radiological healing and long-term functional mobility for patients with complex pelvic fractures.

Recommendations

Based on this study's outcomes, it is recommended that the Stoppa approach be considered a preferred surgical method for managing anterior pelvic ring injuries, particularly for cases requiring precise reduction of the iliopectineal eminence and superior pubic ramus. To further optimize outcomes, early surgical intervention within the first week post-injury is encouraged to reduce the risk of infection and facilitate better fracture healing. Additionally, the use of intraoperative fluoroscopy should be standard practice to ensure accurate screw placement and minimize the risk of implant failure. Future research should focus on multicenter, prospective studies with larger sample sizes to validate these findings and compare the Stoppa approach with traditional techniques like the ilioinguinal approach. Lastly, integrating comprehensive postoperative rehabilitation programs — including early range of motion exercises and progressive weight-bearing protocols — will be essential in maximizing functional recovery and improving long-term patient outcomes.

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