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The Radiological and Functional Outcome for Trans-Symphyseal Cross-Screws in Superior Symphyseal Plate Fixation

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Abstract

Tile-type B1 “open book” external rotation injuries require stable fixation to restore function and prevent long-term complications. Superior symphyseal plate fixation is a commonly used technique, but concerns remain regarding its biomechanical stability. Open trans-symphyseal cross-screws have been proposed as an alternative or adjunct to improve fixation strength. This study evaluates the radiological and functional outcomes of open trans-symphyseal cross-screws in superior symphyseal plate fixation for pelvic ring injuries. A prospective analysis was conducted on 15 cases who underwent superior symphyseal plate fixation with additional trans-symphyseal cross-screws at Beni-Suef University Hospital between September 2021 and June 2023. Radiological outcomes were assessed using postoperative X-rays and CT scans to evaluate reduction quality, screw positioning, and potential complications like implant nonunion or failure. We measured the functional outcomes at 6–20 months postoperatively using the Majeed Pelvic Score, the Lowa Pelvic Score, and the Matta and Torentta criteria. A total of 15 patients were included. Radiological assessment showed satisfactory reduction in 52.5% of cases, with minimal loss of fixation over time. Functional assessment revealed a significant improvement in Majeed Pelvic Scores, with 60% achieving excellent or good outcomes at 12 months. Matt's and Torentto's scores indicated improved function according to the radiological outcomes at the last follow-up. Trans-symphyseal cross-screws provide a biomechanically stable construct with favorable radiological and functional outcomes. This technique may enhance fixation strength and improve postoperative recovery in patients with symphyseal disruptions.

Keywords: symphyseal disruption, trans-symphyseal screws, superior symphyseal plate fixation

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1. Introduction

Pelvic ring fractures commonly result from high-energy blunt trauma, like road traffic accidents, and are often related to significant intrapelvic visceral and vascular injuries, leading to high mortality rates. Anterior–posterior compression forces can cause external rotation of one or both hemipelves, increasing pelvic volume and resulting in "open book" fractures, which account for approximately 15–20% of pelvic fractures. A characteristic feature of this injury is pubic symphysis diastasis, defined as a separation exceeding 1 cm. When the diastasis surpasses 2.5 cm, it typically indicates injury to the posterior pelvic ligaments, leading to pelvic instability. Surgical fixation is usually suggested when the diastasis is more than 25 mm to make the pelvis stable again and avoid long-term functional impairments [1]. The current standard of care for managing pubic symphysis diastasis includes open reduction and internal fixation with a symphyseal plate, often combined with fixation of the posterior pelvic ring injury. Despite its widespread use, symphyseal plating alone has shown high failure rates, ranging from 12% to 75%, with revision surgery required in 3% to 30% of cases. The primary cause of failure is the inability of the construct to withstand physiological forces, including traction, compression, and shear applied to both the inferior and superior portions of the symphysis throughout daily activities [2].

Also, the symphyseal joint heals mostly through fibrous union, which takes a long time to get strong enough to handle repeated loading. Similarly, sacroiliac joint disruptions require prolonged rigid stabilization to facilitate

appropriate healing [3]. To address these challenges, various fixation techniques have been proposed, involving dual plating, particularly external fixators, designed plates, cross and parallel cannulated screws, and supracetabular internal fixation using spinal pedicle screws. Each technique offers specific advantages but also has inherent limitations [4]. Among these, trans-symphyseal cross-screw fixation has been suggested as a biomechanically advantageous technique, providing enhanced stability by counteracting both superior and inferior symphyseal stresses [5]. In this prospective research, we aim to evaluate the functional and radiological outcomes of superior symphyseal plate fixation augmented with open trans-symphyseal cross-screws in the management of pubic symphysis diastasis in Tile-type B1 pelvic injuries. We hypothesize that this method offers excellent stabilization and low failure rates while ensuring adequate support for fibrous healing.

2. Patients and Methods

2.1. Patients

2.1.1. Study Design and Settings

Prospective cohort research has been performed at Beni-Suef University Hospital between September 2021 and June 2023, with last follow-up in June 2023. The study aimed to assess functional and radiological outcomes of patients with symphysis pubis diastasis managed by open reduction and internal fixation using trans-symphyseal crossing screws. The follow-up period ranged from 6 to 20 months.

2.1.2. Study Population

- ***Inclusion Criteria***

1) Patients with post-traumatic symphysis pubis disruption requiring anterior osteosynthesis, including anteroposterior compression (APC), lateral compression, or vertical shear injuries combined with APC.2) Patients who are hemodynamically stable according to the Advanced Trauma Life Support (ATLS) protocol and had a hemoglobin level of 8 grams or more before surgery. 3) Skeletally mature patients. 4) Patients with closed pelvic fractures.

- ***Exclusion Criteria***

1) Patients with pelvic fractures not associated with symphyseal disruption. 2) Skeletally immature patients. 3) Patients with known or potential local infection**s**. 4) Non-traumatic symphysis pubis diastasis. 5) Severely contaminated open fractures with inadequate wound debridement**.** 6) Patients with old fractures.

2.2. Ethical Considerations

The Departmental Ethics and Research Committee has approved this research, and the guardians of the cases have provided written informed consent.

2.3. Methods

2.3.1. Preoperative Assessment

Upon admission, each patient underwent a comprehensive evaluation, including: 1) Detailed medical history and physical examination. 2) Assessment of hemodynamic stability following the ATLS protocol. 3) Laboratory investigations, including complete blood count to ensure hemoglobin levels ≥ 8 g/dL. 4) Imaging studies: Anteroposterior pelvic radiographs to assess the extent of symphyseal diastasis, computed tomography (CT) scans of the pelvis to evaluate associated posterior pelvic injuries, and plan surgical intervention.

2.3.2. Surgical Technique

Surgical procedures have been performed under general anesthesia with the patient in the supine position. Approach: A Pfannenstiel incision was made to expose the pubic symphysis. Reduction: After the exposure, many approaches were used to reduce it. The simplest way was to use massive, pointed reduction clamps on both sides of the symphysis. Pelvic-reduction or Farabeuf clamps were attached to the pubis with 4.5 millimeters screws inserted into the pubic body in an anterior-to-posterior manner. Fixation: Plate Fixation: We contoured and applied 3.5 millimeters or 4.5 millimeters reconstruction plate to the superior aspect of the pubic symphysis (Figure 1). The plate was secured utilizing bicortical screws. After fixing the plate, we inserted two trans-symphyseal crossing screws. An angle of 25 to 35 degrees was made with entry point at the pubic tubercle, going from top to bottom and side to side and medial to lateral. Screws traversed symphysis to engage contralateral pubic bone, providing additional stability to construct. Screw diameter and length were determined based on preoperative planning and intraoperative measurements to ensure optimal purchase without breaching cortex excessively.

2.3.3. Post-operative Outcome Measures

Patients were scheduled for follow-up visits at two weeks postoperatively, then every four weeks, followed by assessments every three months, and subsequently every six months, up to a maximum follow-up period of 20 months. During each visit, clinical and radiological evaluations were performed to assess the functional outcome (Figure 2). Key criteria included wound condition, anterior pelvic pain, dyspareunia and sexual dysfunction, gait abnormalities, sitting ability, and walking distance. Clinical assessment was conducted at six months postoperatively using the Majeed scoring system [6]. At the final follow-up, which ranged from 6 to 20 months, a comprehensive evaluation was performed using both the Matta and Tornetta scoring systems and the Iowa pelvic score to obtain quantitative data for analyzing outcomes [7-8].

2.3.4. Statistical Analysis

Data collected was coded, entered, and analyzed utilizing Microsoft Excel program software. Data analysis has been done by the Statistical Package for the Social Sciences (SPSS) version 26. Numerical data were represented as mean (± SD), whereas categorical data was expressed as proportions. The level of significance using p-value as outcomes was statistically significant if the p-value was below 0.05.

3. Results and discussions

3.1. Results

3.1.1. Demographic data

A prospective study conducted between September 2021 and June 2023 (the date of the last follow-up), involving 15 patients diagnosed with symphysis pubis diastasis. The cohort consisted of 13 men and 2 women, with a mean age of 35.93 ± 9.50 years, ranging from 19 to 52 years. Associated injuries were observed in 10 patients (66.7%). Utilizing the Young and Burgess Classification system [9], fractures were

put into groups. Eight patients (53.3%) had APC type II, five patients (33.3%) had APC type III, and two patients (13.3%) had a combination of APC and vertical shear (Table 1).

3.1.2. Operative data

Of the 15 patients, 9 (60%) underwent surgery under general anesthesia, while 6 patients (40%) were operated on under spinal epidural anesthesia. The mean duration of surgery was 68.0 ± 28.90 minutes, with a range of 40 to 130 minutes. The mean exposure time to X-rays for the placement of the symphyseal plate and crossing screws was 16.60 ± 5.34 seconds, with a range of 8 to 27 seconds. Mean intraoperative blood loss in current study was 305.0± 121.1 cc.

3.1.3. Postoperative data

The mean postoperative hemoglobin concentration was 9.03 ± 0.74 g/dl. In the current study, there were 2 patients (13.3) who presented with postoperative hemoglobin concentration less than 8 (g/dl) and had received blood transfusions. The mean hospital stay following operation was 3.73 ± 1.98 days (range 2-9 days). The mean postoperative blood loss in the current study was 210.0 ± 82.81 cc. The mean monitoring duration was 11.67 ± 4.30 months (range 6 to 20 months), and the average clinical healing time was 10.27 ± 2.69 weeks. All patients achieved fracture union, including those with re-displacement of the symphyseal diastasis. In the current study, the mean pubic space on the immediate postoperative follow-up radiograph was 4.27 ± 2.22 mm (range 2-9 mm), while the mean pubic space on the final follow-up radiograph was 7.40 ± 5.77 mm (range 3-24 mm), with a significant difference between the two measurements (P-value = 0.0086).

3.1.4. Functional outcomes

Majeed scores were evaluated at six months and at the last follow-up, with a mean score of 92.0 ± 6.28 (range 80-100) at the final follow-up. Radiological outcomes were assessed using the Matta and Tornetta grading system, which revealed that 12 patients (80%) had excellent outcomes, 2 patients (13.3%) had good outcomes, and 1 patient (6.7%) was classified as fair at the last follow-up (Table 2 & 3).

3.1.5. Complications

Wound infection occurred in two patients (13.3%). Anatomical reduction was the goal for all cases, although two patients had immediate postoperative non-anatomical reduction. A significant re-displacement of the symphyseal diastasis was observed in one patient. One patient experienced late screw backout or unscrewing of locking screws, but this did not affect the reduction of the public space or clinical outcomes. Heterotopic ossification (HO) developed in three patients, either at the obturator ring or around the public space, but was asymptomatic. Screw loosening was noted in four patients, which remained asymptomatic. The intraoperative drill breakage occurred in two patients, but this did not impact the radiological or clinical outcomes.

3.2. Discussion

The present study evaluates the radiological and functional outcomes of open trans-symphyseal cross-screws in conjunction with superior symphyseal plate fixation for the management of symphysis pubis diastasis. The results show that this surgical approach has good clinical and radiological outcomes, including a high rate of fracture union, good functional recovery, and few complications after surgery.Pubic symphysis diastasis is a hallmark feature of open-book pelvic fractures, characterized by a pubic symphyseal gap exceeding 1 cm. A widening greater than 25 mm necessitates surgical intervention to restore pelvic stability and prevent long-term functional impairment [1]. The current standard of care for managing pubic symphysis diastasis involves open reduction and internal fixation with a symphyseal plate, often supplemented by fixation of the posterior pelvic ring injury. Despite its widespread use, symphyseal plating alone has been associated with high failure rates, ranging from 12% to 75%, necessitating revision surgery in 3% to 30% of cases. Consequently, several biomechanical studies have explored the efficacy of stabilizing both the inferior and superior regions of the symphysis using various implants, leading to improved stability and reduced failure rates [2].

In 2012, cadaveric specimens underwent the first successful biomechanical study that introduced trans-symphyseal cross-screws for Tile-type B1 injuries. The study demonstrated that these screws, which traverse the symphysis on both sides, effectively stabilize the symphyseal plane at both inferior and superior locations [10]. Subsequently, in 2015, Gonzálvez et al. found that cross-screws provided superior stabilization compared to the conventional six-hole non-locked plate in Tile-type B1 injuries [11]. Additionally, Beder et al. demonstrated that a single-cross plate fixation device was a safe, effective, and straightforward method for managing post-traumatic symphyseal diastasis based on radiological and functional outcomes [5].Our study further substantiates the effectiveness of trans-symphyseal screws. Throughout the follow-up period, all patients achieved fracture union. Even in cases of symphyseal diastasis redisplacement, successful bony healing was observed, underscoring stability of this fixation technique. Radiological outcomes, assessed using the Matta and Tornetta grading system, indicated that 80% of patients had excellent results, with only one patient classified as fair. These results are in line with what other research has found about fixing the symphyseal plate, which shows that cross-screw augmentation works to keep the joint in place and help it heal.

Functionally, the Majeed score at final monitoring demonstrated a mean value of 92.0 ± 6.28, indicating well to excellent functional recovery. These results align with existing literature, which associates rigid anterior pelvic ring fixation with improved functional outcomes. The additional use of cross-screws may enhance rotational and vertical stability, potentially contributing to improved postoperative scores observed in our study. Despite the overall success of this approach, certain complications noted. Wound infection occurred in 13.3% of patients, a rate comparable to previous reports on anterior pelvic ring fixation. Screw loosening was observed in four patients; however, it remained asymptomatic and did not affect clinical or radiological outcomes. Heterotopic ossification (HO) developed in three patients but was asymptomatic and did not impact function. One patient experienced late screw back out, but this did not result in loss of reduction or functional impairment. Additionally, intraoperative drill breakage occurred in 2 patients, highlighting a potential technical challenge associated with procedure, though it did not affect final outcomes.

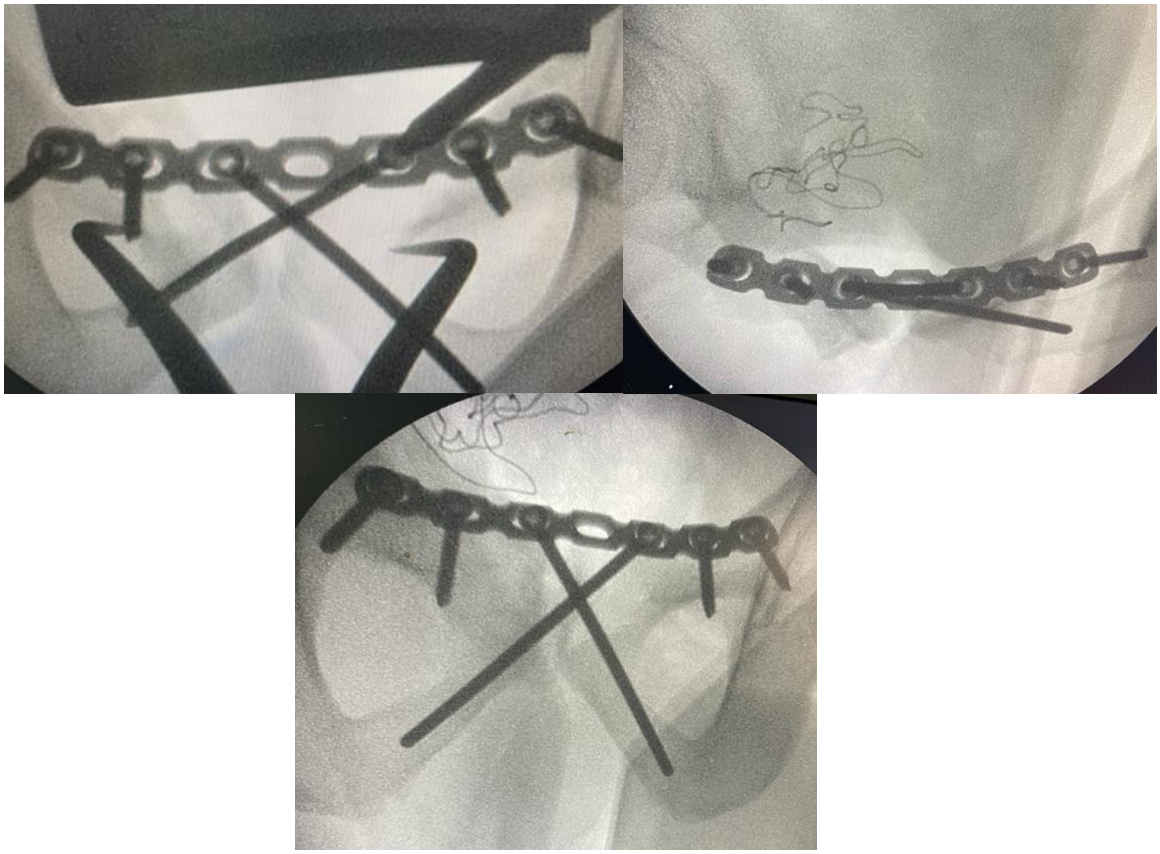

Figure 1: Intraoperative fluoroscopic images showing confirmation for reduction and fixation of symphysis pubis diastasis with 7 holes 3.5 reconstruction plate with crossing screws, by AP, inlet and outlet views

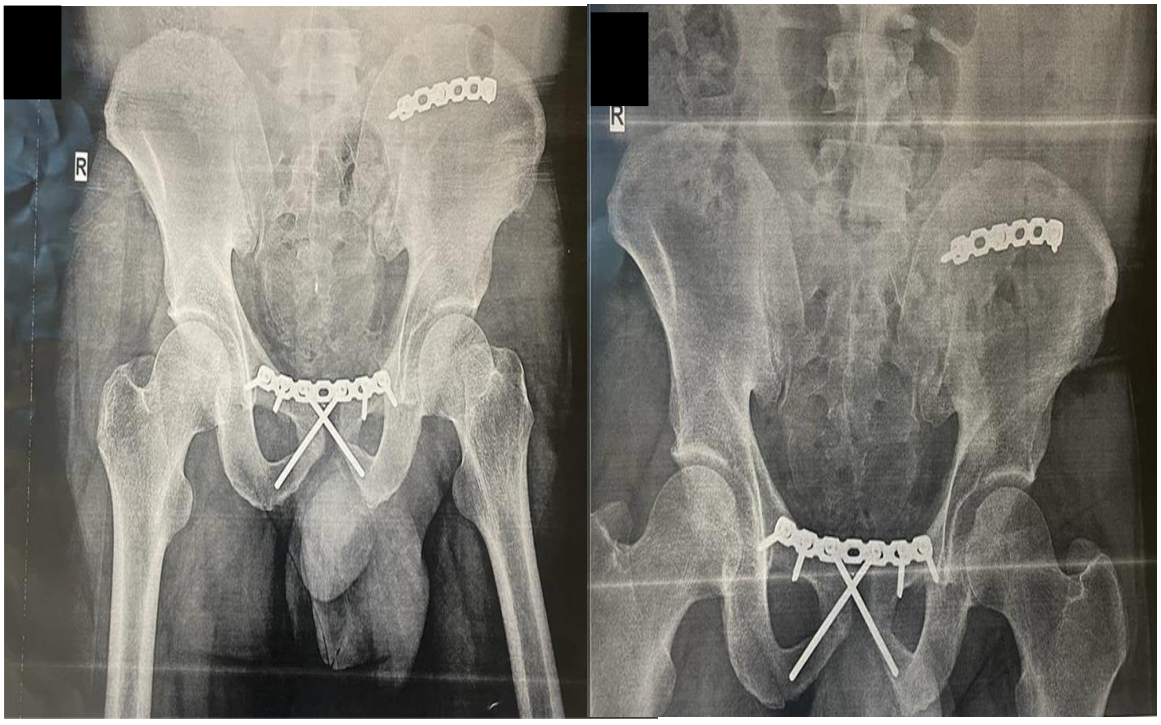

Figure 2: Showing six months postoperative x-rays A: AP, B: outlet view.

Table 1: Distribution of the demographic and clinical characteristics in both groups (n =20)

Variable	(n=15)
Gender	
Males -	13 (86.7%)
Females -	2 (13.3%)
Age (years)	35.93 ± 9.50 (range: 19–52)
Associated Injuries	10 (66.7%)
Fracture Classification (Young & Burgess)	
- APC Type II	8 (53.3%)
- APC Type III	5 (33.3%)
- Combined (APC + Vertical Shear)	2 (13.3%)
Type of Anesthesia	
- General Anesthesia	9 (60%)
- Spinal Epidural Anesthesia	6 (40%)
Mode of injury	
- Road traffic accident	5 (33.3%)
- Falling from height	6 (40%)
- Motor car accident	2 (13.3%)
- Motor bicycle accident	2 (13.3%)

Quantitative data are expressed in mean±SD, range. Qualitative data are presented as number (percentage)

Table 2: Assessment of functional outcome in among the included patients using Majeed score.

FUNCTIONAL OUTCOMES	**Count**	**%**
Excellent	**12**	**80**
Good	**3**	**20**
Fair	**0**	**0**
Poor	0	0

Qualitative data are expressed in numbers and percentages.

Table 3: Assessment of radiological outcomes according to Matta and Tornetta grading system.

The radiological results	Count	%
Excellent	**12**	**80**
Good	**2**	**13.3**
Fair	**1**	**6.7**
Poor	0	0

Qualitative data are expressed in numbers and percentages.

Similarly, Beder et al. reported two cases of superficial infections that resolved with dressing and antibiotic therapy. Three cases exhibited significant increases in public space; one experienced immediate postoperative malreduction, and one had late implant backout, which did not affect reduction or pubic space and required removal surgery. Additionally, two patients experienced cross-screw breakage, five developed heterotopic ossification, six had screw loosening, and three encountered intraoperative drill breakage [5]. Another study by Uliana et al. compared t groups: thirteen patients in Group 1 underwent stabilization with a 4.5 mm locked reconstruction plate, while eighteen patients in Group 2 received 3.5 mm unlocked reconstruction plate. In Group 1, six patients (46.1%) had radiographic fixation failure with few clinical effects, 4 patients (30.8%) had screws come loose, and two patients (15.4%) had screws break. In Group 2, two patients (11.1%) exhibited both screw loosening and breakage. Notably, no surgical site infections occurred in either group, and no individuals required revision surgery or implant removal [12]. New evidence also suggests that percutaneous cannulated screw fixation may be a less invasive option that might be better for improving the efficiency of surgery and lowering the risk of complications.

In a 3-dimensional finite element model of Tile type B1, Yao et al. found that in comparison to single superior plate or single cannulated screw constructs, dual fusion of symphysis pubis diastasis with a superior and anterior plate (dual-plate) or crossed dual cannulated screws (cross-screw) provided superior posterior and anterior pelvic stability. Nevertheless, the clinical implications of their research remain undetermined. The highest measured movement of the symphysis pubis was 0.643 and 0.408 millimeters, correspondingly, indicating that the percutaneous technique and the plating method were equally efficient and adequate for fixation [13]. Different research by Salama et al. observed that the failure rate was higher in the group that used symphyseal plating than in the group that used percutaneous screw fixation. Compared to the symphyseal plating group, the symphyseal screw group experienced more radiation exposure but had a shorter operating time, a smaller incision, and less loss of blood through the surgery [14]. In their biomechanical investigation comparing plate osteosynthesis with percutaneous screw fixation for the management of pubic symphysis diastasis, O'Neill et al. found that symphyseal screws would be a good substitute for the traditionally described symphyseal plating [15].

Zheng et al. used finite element analysis to assess the biomechanical characteristics of seven fixation techniques for the management of symphysis pubis diastasis. They came to the conclusion that the optimum fixation technique for traumatic symphysis pubis diastasis is twin cannulated screw fixation, which provides the best results in terms of stability and biomechanical failure prevention. Compared to single plate fixation, the dual symphyseal plate and single plate with crossed symphyseal screws procedures were superior and more successful [16]. Furthermore, compared to traditional plate techniques, percutaneous cannulated screw fixation for traumatic symphysis pubis diastasis linked to shorter operating times, less loss of blood, and a reduced rate of infection without raising the risk of fixation failure following the operation and revision operation, according to a recent systematic review. It has also been demonstrated that percutaneous cannulated screw fixation is biomechanically adequate for stabilization. As a result, closed reduction should be considered as an effective and practical option for rebuilding symphysis pubis diastasis when it can be done well enough [17]. Comparative clinical trials should be focus of future research to find out long-term effectiveness and safety of different fixation techniques. This will help surgeons' better treat people who have been hurt by pelvic rings.

4. Strengths and Limitations of the present research

One **o**f the key strengths of this research is its prospective design, allowing for systematic assessment of clinical and radiological outcomes. However, we must acknowledge certain limitations. The relatively small sample size may limit the generalizability of the findings, and a longer follow-up period would be beneficial to evaluate long-term implant stability and functional outcomes. Additionally, the absence of a control group prevents direct comparison with other fixation techniques, such as stand-alone plating or percutaneous screw fixation.

5. Conclusions

In conclusion, the use of open trans-symphyseal cross-screws in conjunction with superior symphyseal plate fixation provides a stable and effective method for treating symphysis pubis diastasis. The approach results in high union rates, favorable functional recovery, and minimal complications.

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