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RESEARCH ARTICLE

SINGLE VERSUS DOUBLE COLUMN FIXATION IN TRANSVERSE ACETABULAR FRACTURES: A RANDOMIZED CONTROLLED TRIAL

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ABSTRACT

Objective: Transverse acetabular fractures (TAFs) account for roughly 25–30% of acetabular injuries and may occur either with or without associated posterior wall (PW) involvement. Achieving anatomical reduction is essential for optimal outcomes, yet recent efforts aim to minimize surgical invasiveness. Emerging studies have suggested that posterior column fixation (PCF) via a single approach may be sufficient. This investigationaims to compare the radiological and clinical outcomes of single-column versus double-column fixation (DCF) in TAFs, with particular focus on residual displacement, maintenance of reduction, and complication rates. **Methods:** This prospective randomized controlled trial was conducted over a two-year period at Ainshams University Hospitals. Thirty adult cases presenting with transverse or transverse–posterior wall fractures (TPWF) were randomly stratifiedinto two groups: Group A (n=15) received single-column posterior plating, while Group B (n=15) underwent DCF through combined posterior and anterior approaches. Clinical outcomes were assessed at two years using the modified Merle d'Aubigné and Postel (MDP) score, and radiographic reduction was evaluated according to the Matta criteria. **Results:** At 2-year follow-up, no statistically significant differences were found between groups in clinical scores (p=0.699) or radiological reduction outcomes (p=0.710). Immediate postoperative imaging likewise showed no meaningful variation (p=0.516). By contrast, Group B required significantly longer operative time and sustained greater blood loss (both p<0.001). Complication rates remained similar (33.4% vs. 40%; p=0.705). **Conclusion:** Single- and double-column fixation yield comparable clinical and radiological outcomes in TAFs. Nevertheless, PCF alone offers the advantages of shorter operative time and reduced blood loss, making it a viable option when adequate indirect anterior column reduction can be obtained.

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INTRODUCTION

Acetabular fractures are typically the result of high-energy trauma and often pose significant challenges to orthopedic surgeons due to the complex three-dimensional anatomy of the pelvis and the deep location of the acetabulum. [1]Transverse acetabular fractures (TAFs) are a frequent elementary subtype, comprising nearly 25–30% of acetabular fractures. [2,3] Because they frequently extend into the weight-bearing dome, they disrupt normal hip biomechanics and demand accurate anatomical reduction to minimize the risk of post-traumatic arthritis. [2] The surgical management of transverse fractures remains a subject of ongoing debate, particularly regarding the necessity of fixing both anterior and posterior columns. Traditional double-column fixation (DCF), often performed via extensile or combined approaches, has been associated with increased blood loss, operative time, and a higher risk of complications such as heterotopic ossification and deep infection. [4,5] In response to these concerns, recent clinical and biomechanical investigations have explored the efficacy of single-column posterior fixation, performed through the Kocher–Langenbeck (KL) approach, as a potentially less invasive alternative. [6] While biomechanical studies have demonstrated superior stability with dual-column constructs, others have shown comparable fixation strength with posterior plating alone when indirect reduction of the anterior column is satisfactory. [7] Importantly, clinical outcomes depend not only on construct rigidity but also on achieving an accurate reduction of the acetabular dome. Matta et al. emphasized the prognostic significance of roof-arc angles as a measure of dome restoration, advocating for intraoperative verification through oblique radiographic views due to the acetabulum hemispherical nature. The weight-bearing section of the acetabulum cavity is satisfactorily restored when the intraoperative roof-arc angles are 45° or greater[8] Given the paucity of high-level clinical evidence and ongoing debate, this randomized controlled trial sought to compare single-column and DCF in TAFs with respect to clinical and radiological outcomes. Secondary objectives encompassed intraoperative blood loss, operative time, and complication rates.

MATERIALS AND METHODS

This prospective randomized controlled trial was carried out at the Level I trauma center of Ain Shams University Hospitals from January 2022 to January 2023. Ethical approval was secured from the institutional review board (Approval No. FMASU R04\2024), and written informed consent was obtained from all participants prior to inclusion. The study enrolled 30 consecutive adult cases with TAFs, with or without associated PW involvement. Cases were randomized into two equal groups (n=15 each) using a computer-generated sequence with allocation concealment via sealed opaque envelopes. Group A underwent posterior column fixation (PCF) only (single-column group), while Group B received both anterior and PCF (double-column group). All cases were followed for 2 years. The KL posterior approach was employed for fixation in Group A. This allowed direct access to the posterior column and wall, with indirect assessment of anterior column reduction performed via digital palpation through the greater sciatic notch. The posterior column was plated using a 3.5-mm reconstruction plate, with screws angled anteriorly to secure the anterior column.

In Group B, both columns were stabilized using a combination of the KL approach for the posterior column and the modified Stoppa approach (MSA) for the anterior column. Fixation was achieved using standard 3.5 mm plates and screws for both components.

Inclusion criteria

- Age ≥18 years.
- Transverse or transverse-PW acetabular fractures.
- Operative treatment within 21 days of injury.

Exclusion criteria

- Pathological fractures.
- Open fractures (Gustilo-Anderson grade II or III).
- Associated visceral or urogenital injuries.
- Age >60 years.
- Delayed presentation >21 days post-injury.
- Loss to follow-up during the 2 years period.

Surgical Technique

Case Positioning: Case positioning varied according to treatment group. In Group A (single-column fixation), surgery was conducted with the case prone. In Group B (DCF), posterior fixation was performed in the prone position, after which cases were repositioned supine to permit anterior access.

Posterior Column Fixation (Group A and B): Using KL approach, all cases underwent exposure ofthe posterior column and PW if present. Reduction was carried out under fluoroscopy and assessed by anteroposterior and Judet oblique views. Accurate reduction of the posterior column was ensured by confirming the alignment and continuity of the ilioischial line through palpation at the greater sciatic notch, which also permitted indirect assessment of the anterior column. PCF was achieved using standard 3.5 mm reconstruction plating. Screws were directed strategically to enhance cross-column purchase and biomechanical stability. In only one case within Group A who had a combined TPWF, an additional buttress plate was applied to stabilize the PW fragment.

Anterior Column Fixation (Group B only): Once posterior fixation had been performed, Group B cases were repositioned supine, and the anterior column was exposed via the MSA.At this stage, no further reduction of the anterior column was necessary, as both columns had already been adequately aligned during the initial KL approach. The anterior fixation was therefore intended solely to augment the existing stability rather than to correct or manipulate the reduction. Anterior stabilization was achieved using a contoured, low-profile plate, with the choice of implant, ncluding quadrilateral surface-specific plates tailored to the fracture pattern. Screw trajectories were planned to maximize bicortical purchase and enhance overall construct stability. We acknowledge that this sequential approach inherently limits the ability to mobilize the anterior column after definitive posterior fixation, which may compromise reduction accuracy in certain cases. This, however, underscores a known shortcoming of staged fixation approaches in the surgical management of TAFs.

Postoperative management: Radiological assessment after surgery employed the Matta acetabular criteria, with reductions classified as anatomical (0–1 mm), imperfect (2–3 mm), or poor (>3 mm displacement). Three separate radiographic techniques were used for evaluation:

- **Maximum fracture displacement** was measured in millimeters (step-off, gap, or joint line incongruity) across standard anteroposterior and Judet oblique radiographs. [10]
- **Roof arc angle analysis** was conducted using Matta's method, which assesses the anterior,medial, and posterior roof arc angles (Figure 1)[9].

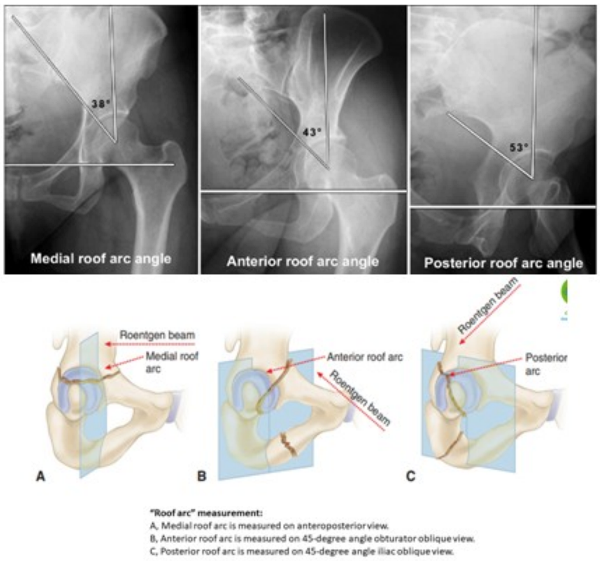

Fig.1. Roof arc measurement and beam direction

- Roof arc measurements were rounded to the nearest 5°, with a difference ≤2.5° considered clinically insignificant. The angles were measured according to the method described by Matta[1] to assess whether the weight-bearing portion of the acetabular dome was adequately restored following fracture reduction. On anteroposterior (AP), iliac oblique, and obturator oblique radiographs, a vertical line was drawn through the center of the femoral head. A second line was then drawn from the femoral head center to the most superior intact portion of the anterior, posterior, or medial acetabular roof, respectively. The angle formed between these two lines in each view represents the anterior, posterior, and medial roof arc angles. A roof arc angle of 45° or greater in all three views was considered satisfactory, indicating that the fracture reduction had effectively restored the weight-bearing dome.[10]

- **Femoral head offset** was measured to evaluate the restoration of the anatomical center of the hip joint (Figure 2)[11]. Comparisons were made to the contralateral, uninjured hip to detect any significant deviation. This method required consistent imaging technique and observer reliability to ensure accurate comparisons. [11]

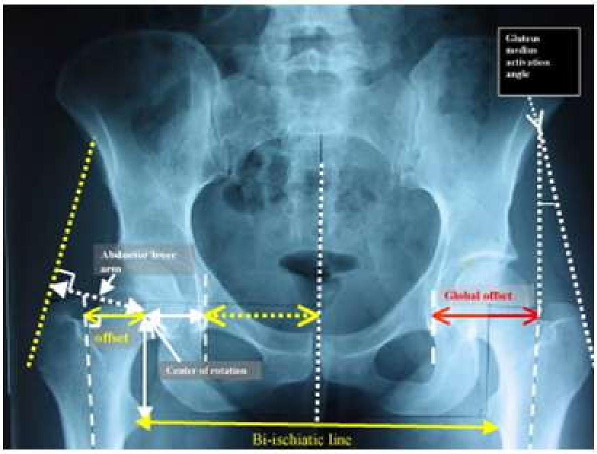

Fig.2. Femoral head offset measurement

Early postoperative physiotherapy included isometric strengthening of the quadriceps and hip abductors. Passive hip motion exercises were started on postoperative days 2–3, individualized to fracture stability and cases comfort.

Follow-up: At two weeks postoperatively, cases attended the outpatient clinic for suture removal and assessment of wound healing. Partial weight-bearing was gradually introduced between weeks 8 and 12 once radiographic union was evident. The follow-up protocol included clinical and radiological evaluations at 6 weeks, 12 weeks, 6 months, and 2 years.

At each follow-up, anteroposterior and Judet oblique pelvic radiographs were obtained with identical positioning, projection, and magnification to the immediate postoperative images to maintain consistency. Clinical evaluation was performed using the modified MDP scoring system (Figure 3). [12]

Score	Pain	Ambulation	ROM (%)
6	No pain	Normal	95–100
5	Slight or intermittent	No cane, but slight limp	80–94
4	Pain after ambulation, but disappears	Long distances with cane or crutch	60–79
3	Moderately severe, permits ambulation	Limited, even with support	40–59
2	Severe with ambulation	Very limited	
1	Severe, prevents ambulation	Bedridden	0–39

Clinical grades: Excellent 18, Good 15–17, Fair 12–14, Poor 3–11 (Matta et al. 1986). The total numeric score was used in the present study

Fig. (3). Modified Merle d'Aubigne and Postel (MDP) score

Radiographic evaluation included the same parameters recorded postoperatively: maximum displacement, roof arc angles, and femoral head offset. These were compared at 6- and 48-month intervals to determine secondary displacement, loss of reduction, or development of post-traumatic arthritis using Matta's grading for arthritic changes. [13] Cases records were also reviewed from admission through the final follow-up for any postoperative complications, including neurovascular injuries, deep vein thrombosis, and wound-related issues such as superficial or deep infections.

Statistical analyses: Data were collected, coded, and analyzed using RStudio (version 2.3.2). Categorical variables were expressed as frequencies and percentages. Quantitative data were presented as mean ± SD with range if normally distributed, or median with IQR if non-normally distributed. Distribution normality was tested using the Shapiro test. Group comparisons used chi-square or Fisher's exact tests for categorical variables, and independent t-test or Mann–Whitney U test for continuous variables, depending on distribution.A 95% CI was adopted, with statistical significance set at $p<0.05$.

RESULTS

A total of 30 cases were enrolled and randomized equally into two groups: Group A, managed with single-column posterior fixation, and Group B, managed with Double Column Fixation

Demographic Characteristics: *Demographic characteristics of both groups are presented in Table 1. The mean age was 38.2 ± 9.2 years (range 21–50) in Group A and 33.7 ± 7.5 years (range 20–47) in Group B, with no substantialvariation (p=0.100). Males represented 73.3% of Group A and 86.7% of Group B, while females accounted for 26.7% and 13.3%, respectively, with no significant difference in sex distribution.*

Clinical Outcomes. Clinical evaluation at 2 years postoperatively using the MDP score showed similar distributions across both groups (Table 2). In Group A, 40% achieved good outcomes, 26.7% excellent, 26.7% fair, and 6.7% poor. In Group B, 53.3% achieved good, 26.7% excellent, and 20% fair outcomes. No substantial variation in clinical outcomes was detected between both groups (p = 0.699).

Radiological Outcomes: Radiological assessment based on the Matta scoring system at final follow-up revealed no substantial variation between groups (p=0.710) (Table 2). In Group A, 53.3% had good reduction, 26.7% excellent, and 20% fair. In Group B, 40% had excellent reduction, 40% good, and 20% fair.

Immediately postoperatively, anatomical reduction was achieved in 66.7% of Group A and 80.0% of Group B, with imperfect reductions in 26.7% and 20.0%, respectively. Poor reduction occurred in only one case in Group A. These differences were not statistically significant (p=0.516) (Table 3).

Postoperative Complications: Overall complication rates were comparable between groups (p=0.705) (Table 4). In Group A, complications included post-traumatic arthritis (6.7%), implant failure (6.7%), and sciatic nerve injury (13.3%). Group B showed post-traumatic arthritis (13.3%), implant failure (6.7%), and superficial infection (13.3%). The majority of cases in both groups had no complications (66.6% in Group A vs. 60.6% in Group B).

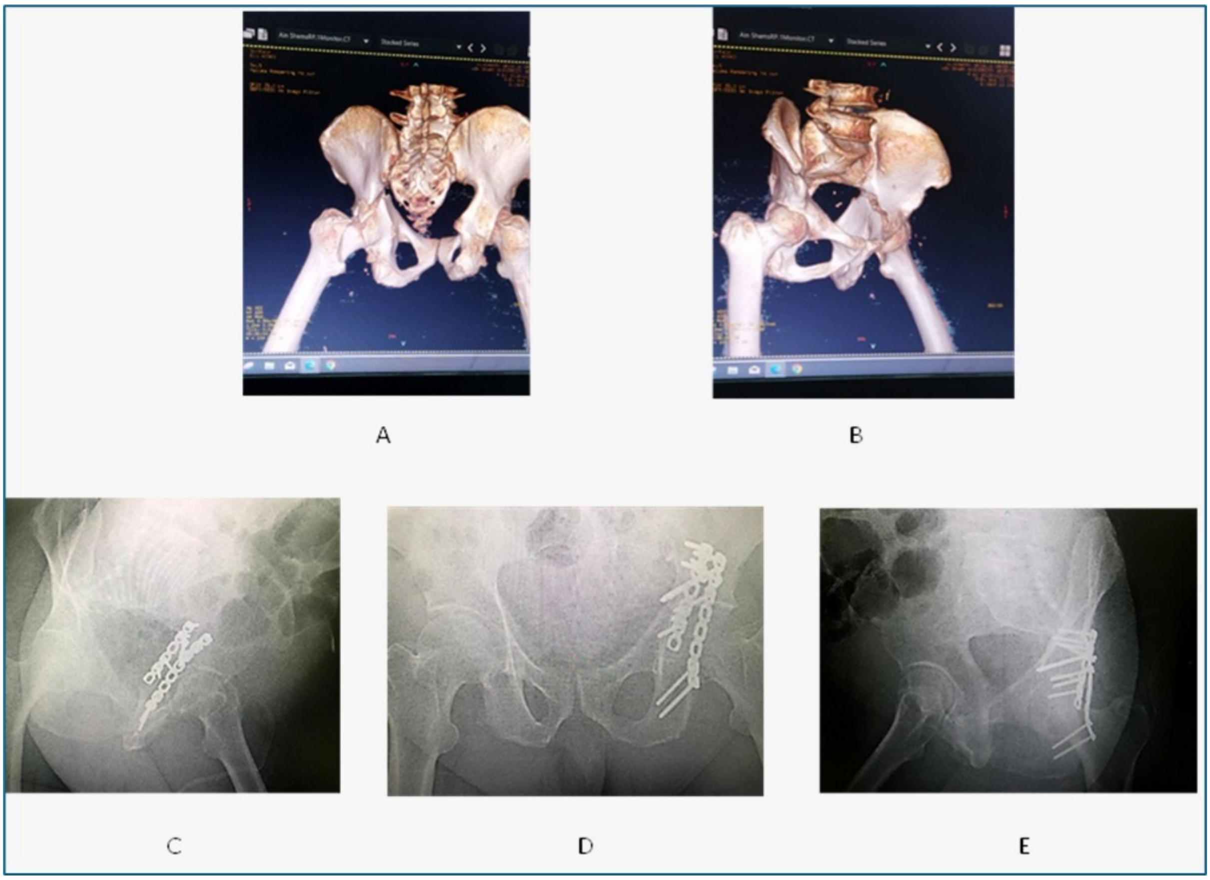

Fig. (4): 55 years old male patient, RTA, (A,B) preoperative CT scan showing transverse fracture acetabulum, (C,D,E) postoperative radiographs showing single column fixation through Kocher langenebeck approach

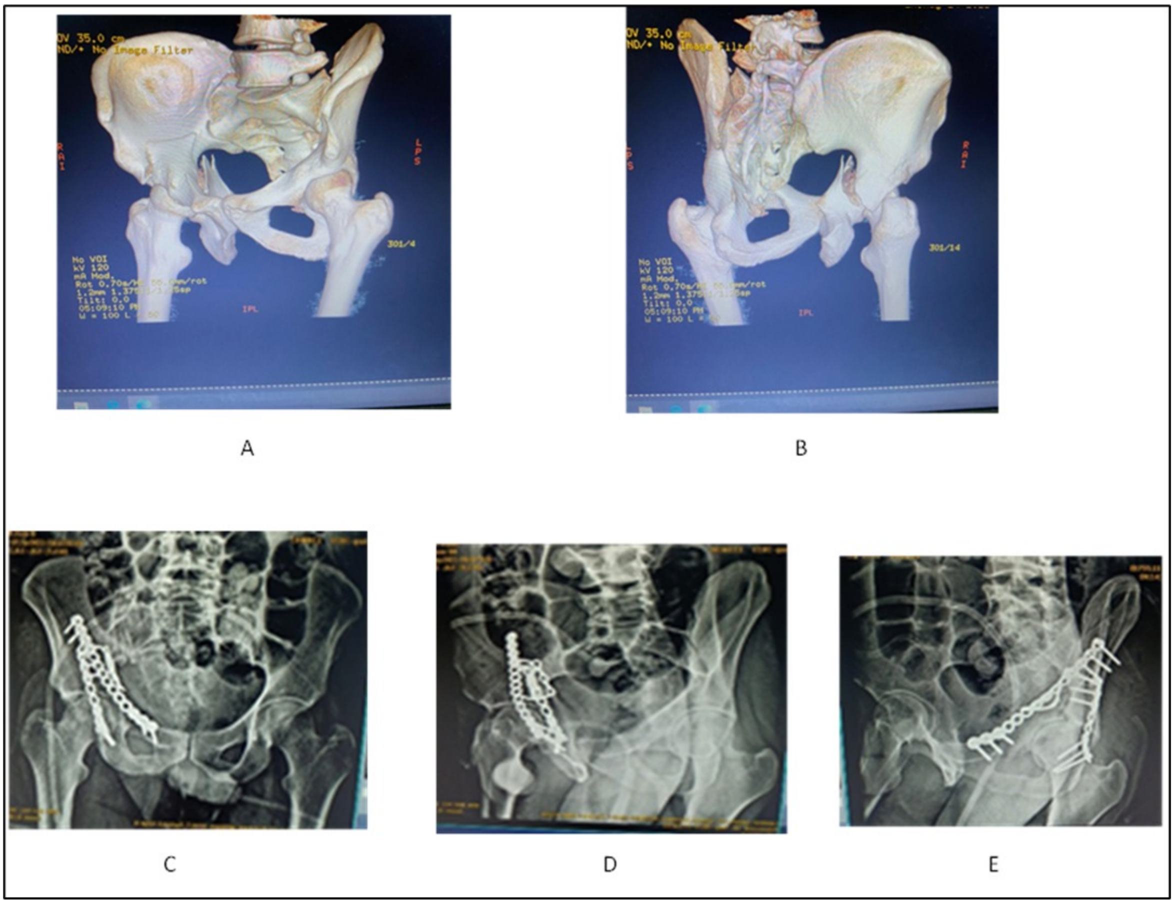

Fig. 5. 35 years old male patient, RTA, (A,B) preoperative CT scan showing transverse fracture acetabulum. (C,D,E) postoperative radiographs showing double column fixation through modified stoppa approach and Kocher langenebeck approach

Table 1. Comparison between the two studied groups according to Demographic characters (Age and Sex)

		Group A	Group B	Test value	P-value	Sig.
		No. = 15	No. = 15			
Age	Mean ± SD	38.20 ± 9.24	33.47 ± 8.11	1.492•	0.147	NS
	Range	21 – 50	16 – 47			
Sex	Female	4 (26.7%)	2 (13.3%)	0.833*	0.361	NS
	Male	11 (73.3%)	13 (86.7%)			

P-value >0.05: Non significant(NS); P-value <0.05: Significant(S); P-value< 0.01: highly significant(HS) ; *: Chi-square test, •: Independent t-test

Table 2. Comparison between Group A and Group B regarding Clinical Outcomes (modified Merle d Aubignepostel score)and Radiological Outcome at last follow up (Matta radiological acetabular scoring system)

		Group A		Group B		Test value*	P-value	Sig.
		No.	%	No.	%			
Clinical Outcomes	Excellent	4	26.7%	4	26.7%	1.429	0.699	NS
	Good	6	40.0%	8	53.3%			
	Fair	4	26.7%	3	20.0%			
	Poor	1	6.7%	0	0.0%			
Radiological outcome at last follow up	Excellent	4	26.7%	6	40.0%	0.686	0.710	NS
	Good	8	53.3%	6	40.0%			
	Fair	3	20.0%	3	20.0%			

P-value >0.05: Non significant(NS); P-value <0.05: Significant(S); P-value< 0.01: highly significant(HS)
*: Chi-square test, •: Independent t-test

Table 3. Comparison between Group A and Group B regarding immediate postoperative assessment of reduction

Intra operative assessment of reduction	Group A		Group B		Test value	P-value	Sig.
	No.	%	No.	%			
Anatomical	10	66.7%	12	80.0%	1.325	0.516	NS
Imperfect	4	26.7%	3	20.0%			
Poor	1	6.7%	0	0.0%			

P-value >0.05: Non significant(NS); P-value <0.05: Significant(S); P-value< 0.01: highly significant(HS)
*: Chi-square test, •: Independent t-test

Table 4. Comparison between Group A and Group B regarding Postoperative Complication

	Group A		Group B		Test value*	P-value	Sig.
	No.	%	No.	%			
Postoperative complication	**5**	**33.3%**	**6**	**40.0%**	**0.144**	**0.705**	**NS**
Implant Failure	1	6.7%	1	6.7%	0.000	1.000	NS
Infection	1	6.7%	2	13.3%	0.000	1.000	NS
Arthritis	1	6.7%	2	13.3%	0.186	0.666	NS
Sciatic nerve injury	2	13.3%	1	6.7%	0.186	0.666	NS

P-value >0.05: Non significant(NS); P-value <0.05: Significant(S); P-value< 0.01: highly significant(HS)
*: Chi-square test, •: Independent t-test

Table 5. Comparison between Group A and Group B regarding Operative time and Blood loss

		Group A	Group B	Test value•	P-value	Sig.
		No. = 15	No. = 15			
Operative time (hours)	Mean ± SD	1.47 ± 0.35	2.63 ± 0.30	-9.816	0.000	HS
	Range	1 – 2	2 – 3			
Blood loss (ml)	Mean ± SD	866.67 ± 351.87	2166.67 ± 308.61	-10.758	0.000	HS
	Range	500 – 1500	1500 – 2500			

P-value >0.05: Non significant(NS); P-value <0.05: Significant(S); P-value< 0.01: highly significant(HS)
*: Chi-square test, •: Independent t-test

Operative Time and Intraoperative Blood Loss: The operative time was substantially shorter in Group A, with a median duration of 1.47±0.35 hours relative to 2.63±0.30 hours (IQR: 2.5–3.0) in Group B (p < 0.001) (Table 6). Similarly, Group A demonstrated significantly less intraoperative blood loss, with a mean of 866.7 ± 351.6 mL versus 2166.7 ± 308.6 mL in Group B (p < 0.001) (Table 5).

DISCUSSION

Numerous prognostic factors have been correlated with suboptimal outcomes followingTAF fixation, including case age over 50, obesity, fracture comminution, articular impaction, significant initial displacement, femoral head dislocation, and surgeon experience. [14,15]Optimal surgical outcomes rely on precise anatomical reduction of the articular surface, which is critical for preserving hip function and minimizing post-traumatic degenerative changes. While multiple fixation strategies have been described in the literature, consensus regarding the optimal approach for transverse patterns is still lacking. [16,17]

A unique feature of transverse fractures is the structural integrity of the distal bone block, which spans both columns without fragmenting into separate ischial and pubic components, as seen in T-type fractures. This anatomical arrangement raises the question of whether fixation of both columns is truly necessary, as reduction of one column can indirectly achieve alignment of the other. [2] This prospective randomized trial compared posterior column plating (Group A, Fig. 4) with DCF (Group B, Fig. 5) for TAFs. At one-year follow-up, both groups achieved comparable radiological and functional outcomes, with no significant differences in reduction quality, alignment stability, or clinical scoring (P = 0.710; P = 0.699). The results reinforce previous evidence supporting PCF as an effective strategy in selected transverse patterns. Giordano et al.[7]studied 35 cases with combined transverse and PW fractures treated via the KL approach; 20 underwent single-column plating, while 15 received supplementary posterior-to-anterior lag screws. Their results demonstrated no significant differences in femoral head medialization or functional outcomes between the two subgroups, suggesting that anterior column fixation may be unnecessary when adequate indirect reduction is achieved. Additionally, the use of cortical lag screws carries added risks of articular penetration, neurovascular injury, and increased operative time [18]. Similarly, Fahmy et al.[19]compared posterior-only fixation with combined posterior plating and percutaneous anterior column screw insertion. No significant differences were observed in immediate post-operative reductions (P = 0.651) or clinical scores at final follow-up (P = 0.412). In our cohort, anatomic reduction was achieved in 66.7% of cases in Group A, closely matching the 73% rate reported in Fahmy's single-column group. Yang et al.[1] reported on 24 cases with TPWF treated exclusively with posterior fixation. They achieved anatomic reduction in 70.8% and documented good or excellent functional outcomes in 66.7% of cases. These outcomes suggest that, in properly selected cases, indirect anterior column reduction via a posterior approach may be sufficient. Biomechanical studies have yielded conflicting findings. Atchison et al.[20] found no substantialvariation in construct stability between posterior plating alone and posterior plating supplemented with anterior lag screws, irrespective of hip flexion angle. In contrast, Chang et al.[21] demonstrated that single-column plating provided greater yield and ultimate strength than DCF with lag screws in cadaveric pelvic models [20,21]. Conversely, Shazar et al[22].and Khajavi et al.[23]reported improved construct stiffness with DCF in synthetic models. Pei et al.[24]found that DCF offered biomechanical advantages in terms of lower stress concentrations and displacement. These findings suggest that while dual fixation may provide superior mechanical resistance in vitro, clinical outcomes may not differ significantly when posterior-only fixation achieves a stable reduction [22,23,24]. Our study also highlighted significant differences in surgical burden. Group A demonstrated a significantly shorter operative time (mean 1.47± 0.35 hours) and reduced intraoperative blood loss (mean 866.7 ± 351.6 mL) compared to Group B (mean 2166.7 ± 308.6 mL; P < 0.001). These results corroborate findings by Fahmy et al.[19]and Giordano et al[7].noted reduced operative morbidity when anterior fixation was omitted. Regarding complications, both groups exhibited similar rates, with no substantialvariation (P = 0.705). two cases in Group A experienced transient sciatic nerve palsy, and two cases in Group B developed deep infections requiring surgical debridement. These complication profiles are consistent with previous literature on the KL approach, as reported by Yang et al.and Gänsslen et al.[25] While Gänsslen observed satisfactory outcomes in over 75% of cases, he also noted a 32.1% incidence of post-traumatic osteoarthritis, emphasizing the importance of achieving near-perfect reduction.[25] Indeed, as Jang et al.[26]reported, residual step-offs greater than 1 mm and gaps exceeding 3 mm significantly accelerate the progression of osteoarthritis. This underscores the critical role of reduction quality over fixation strategy in long-term prognosis.[26]

In summary, our findings support the selective use of posterior-only fixation in TAFs, particularly when indirect anterior column reduction is confirmed intraoperatively. While biomechanical studies may favor dual fixation, clinical outcomes appear comparable when anatomical reduction is achieved. Furthermore, omitting anterior fixation reduces operative time, blood loss, and potential iatrogenic risks, without compromising stability or function.

LIMITATIONS

A relatively small cohort, short follow-up intervals, and the lack of digitalized reduction quality assessment represent the principal limitations of this study. Nevertheless, these factors are not expected to have influenced the reliability of the outcomes. Larger, long-term trials are recommended to confirm and expand upon these findings.

CONCLUSION

Both single- and double-column fixation yield similar clinical and radiological outcomes in TAFs. Nonetheless, single PCF was linked to decreased operative time and blood loss. Hence, when intraoperative assessment confirms adequate indirect anterior column reduction, single-column fixation may provide a simpler, less invasive option without compromising outcomes.

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Ethical statement: The ethics committee of AinshamsUniversity has approved the study. The Approval number for the ethical committee is FMASU R04\2024, and the approval date is 8\1\2024.

Authors' contribution: AM and ISM conceived the study, developed the protocol, performed data analysis, critically revised the manuscript, and approved the final version. ZH and MS contributed to data analysis and critical manuscript review. AN was responsible for data collection and drafting the manuscript. All authors reviewed and approved the final draft and accept responsibility for the content and similarity index.

Declaration of cases' consent to publish their data and images: All participants in the study provided informed consent.

Declaration of competing interest: None.

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