Intertrochanteric femoral fractures are common in the elderly. These fractures provide a remarkable problem for all orthopedic surgeons due to the high mortality and morbidity rates. There are many ways to classify these fractures. The Evans’s classification is the most well-known, which classifies fractures into stable and unstable based on their fracture pattern. Dynamic hip screws (DHS) have been shown to be a valid option for treating stable trochanteric femoral fractures. Trochanteric fractures with unstable fracture patterns are more likely to fail with standard therapy than stable fractures.

Several factors contribute to the inherent instability of these fractures, including subtrochanteric extension, postero-medial calcar fracture, and lateral femoral...
Lateral wall repair is a critical procedure to keep these fractures stable and improve function. A variety of devices have been developed to replace DHS in unstable fractures, including different designs of cephalomedullary nails, proximal femoral locked plates, fixed angle blade plates, and trochanteric stabilizing plates (TSP). According to the AO classification, the literature recommends the fixation of 31-A1 fractures with a DHS and all others with an intramedullary device. Previous studies have demonstrated that with intramedullary nail insertion, postoperative weight-bearing and mobility are achievable, particularly in elderly patients.

Stabilizing the greater trochanter and lateral wall with TSP is similar to using a DHS with a modular extension, resulting in a lower incidence of femoral medialization and a significant improvement in functional outcomes. In the present study, we aimed to compare DHS with TSP and short proximal femoral nails (PFNs) in unstable trochanteric fractures in terms of the functional and radiological outcomes.

PATIENTS AND METHODS

This single-center, randomized-controlled trial (RCT) was conducted at Cairo University Kasr Al-Ainy Faculty of Medicine, Department of Orthopaedic and Traumatology between June 2019 and March 2020. We included patients above the age of 60 years with isolated unstable trochanteric fractures (AO/OTA 31-A2). Polytrauma patients and those with pathological fractures or incomplete follow-up records were excluded. Eligible patients were randomized to undergo DHS and TSP or short PFN and followed for one year. Randomization was conducted through a sealed envelope system. A total of 137 patients with intertrochanteric fractures were admitted from the accident and emergency (A&E) department during the study period. Seventy-two patients met the inclusion criteria: 36 were recruited in the DHS+TSP group (Group A) and 36 in the PFN group (Group B). Four patients dropped out during follow-up (n=2 in each group) and were excluded. Finally, a total of 68 patients (32 males, 36 females; mean age: 69.7±8.2 years; range, 60 to 88 years) were included in the study.

Operative techniques

All patients were assessed clinically and radiologically. Third-generation cephalosporins were given 30 to 60 min before surgery. All procedures were performed under spinal anesthesia, except in two patients. The patients underwent closed reduction and were positioned on the fracture table by slight internal rotation and abduction of the affected limb. Special attention was given to the medial calcar fragment, as it should be anatomically reduced (indicating good reduction under the image intensifier).

In the DHS+TSP group, we utilized a lateral approach, in which the skin incision extended from the greater trochanter tip to 5 to 7 cm below. The vastus lateralis was elevated to insert two Hohmann retractors and, then, a guidewire was inserted and centered to measure the length of the screw. The DHS plate was inserted and fixed by only the second plate screw to the shaft. Subsequently, the TSP was introduced over the DHS place; screws were inserted through the plates to the shaft. An anti-rotational screw was inserted through the TSP plate, followed by 3.5 cancellous screws added from the TSP to the greater trochanter, if required.

For the PFN group, a 3 to 5-cm skin incision was done parallel to the longitudinal axis of the femur, proximal to the greater trochanter. The nail entry point was optimized over the inner one-third point of the greater trochanter. Following guide wire introduction and reaming of the proximal canal, a nail of appropriate diameter was inserted. A lag screw was inserted, and a compression device was used to close the fracture surfaces. An anti-rotational screw was, then, added proximally, together with distal screws inserted through the targeting device.

In both groups, the tip of the lag screw was advanced to less than 25 mm on both anteroposterior (AP) and lateral views. All implants (PFN [3rd generation], DHS and TSP) were provided by a local manufacturer.

Postoperative follow-up

Postoperative care included broad-spectrum antibiotics for five days, low-molecular-weight heparin for four weeks, intravenous (IV) analgesics, and a suction drain. All patients were followed for one year postoperatively. Follow-up X-rays are done at Weeks 2, 4, and 6 and at 3, 6, and 12 months thereafter. Partial weight bearing was allowed starting at Week 6.

The hip function was assessed using the Harris Hip Score (HHS) starting from the six-month visit. In addition, we graded patients regarding their postoperative walking capabilities whether independent, assisted with one crutch, or two crutches, and compared it to their pre-fracture capabilities. Besides, we compared patients regarding their activity whether restricted to home or society.

The outcome measures including operating room time, the amount of blood loss and need for...
intraoperative transfusion, return to activity, time to union, postoperative complications, failure rate, and mortality rate were analyzed.

**Statistical analysis**

Using a clinical sample size calculator for RCT non-inferiority studies, with an alpha error of 0.05, power of the study of 0.8, 95% confidence interval (CI), enrolment ratio=1, and expected anticipated postoperative complication rate of about 10%; the minimal sample size calculated to detect the difference is 34 patients (17 in each group).

Statistical analysis was performed using the IBM SPSS version 25.0 software (IBM Corp., Armonk, NY, USA). Descriptive data were expressed in mean ± standard deviation (SD), median (interquartile range [IQR]) or number and frequency, where applicable. The hypothesis of a significant difference between both techniques in terms of postoperative radiological and functional was tested using the t-test or chi-square test. A \( p \) value of <0.05 was considered statistically significant.

**RESULTS**

Both patient groups had comparable demographics with most of the patients having low-energy trauma in the form of minor falls (Table I).

| TABLE I |
|---|
| Preoperative patients’ characteristics |
| | DHS+TSP (n=34) | PFN (n=34) |
| | n | % | Mean±SD | n | % | Mean±SD | \( p \) |
| Age (year) | 68.7±8.7 | 70.8±7.7 | 0.292 |
| Right side | 12 | 35 | 20 | 59 | 0.053 |
| Mode of trauma | | | | | | | |
| Low energy trauma | 29 | 85 | 30 | 88 | 0.381 |
| High energy trauma | 5 | 15 | 4 | 12 | 0.453 |
| Walking ability (pre-fracture) | | | | | | | |
| Independent | 14 | 41 | 14 | 41 | 0.776 |
| One crutch | 20 | 59 | 20 | 59 | 0.998 |
| Level of activity (pre-fracture) | | | | | | | |
| Home | 12 | 35 | 18 | 53 | 0.143 |
| Society | 22 | 65 | 16 | 47 | 0.659 |
| ASA score | | | | | | | |
| ASA 1 | 12 | 35 | 16 | 47 | 0.659 |
| ASA 2 | 18 | 53 | 14 | 41 | 0.353 |
| ASA 3 | 4 | 12 | 4 | 12 | 0.659 |

| TABLE II |
|---|
| Intraoperative data |
| | DHS+TSP (n=34) | PFN (n=34) |
| | n | % | Mean±SD | n | % | Mean±SD | \( p \) |
| Operative time (min) | 105±10 | 94±8 | 0.001* |
| Blood loss (mL) | 438±152 | 509±313 | 0.409 |
| Intraoperative lateral cortex fracture | 0 | 0 | 4 | 11.8 | 0.114 |
| Reduction | | | | | | | |
| Closed | 32 | 94.1 | 26 | 76.5 | 0.040* |
| Open | 2 | 5.9 | 8 | 23.5 | |

DHS: Dynamic hip screw; TSP: Trochanteric stabilizing plate, PFN: Proximal femoral nail; SD: Standard deviation; * Statistically significant.
Although more patients required open reduction for their fracture in the PFN group, the operating room time was significantly shorter than in the DHS+TSP group ($p=0.001$). However, the amount of blood loss and need for intraoperative transfusion were similar (Table II).

Union was assessed both clinically (absence of pain) and radiologically (bridging callus on X-rays). Time to union was significantly shorter and the patients’ return to their pre-fracture level of activity was faster in the PFN group (Figures 1 and 2). On the other hand, the final patient function as assessed by HHS, ambulation, and walking aid dependence showed no difference between the groups (Table III).

From another perspective, we noted a direct impact of the mode of trauma on HHS both at 6 and 12 months (Table IV).

The rate of postoperative complications was comparable between the two patient groups. Five cases (7.3%) had a mechanical failure of the fixation construct and needed later revisions with total hip replacement. Moreover, four (11.8%) patients in the DHS+TSP group had deep wound infections. Infection was controlled with surgical debridement and IV antibiotic therapy. Similarly, two (5.8%) patients in the PFN group had deep wound infections, but unfortunately, these patients died before any intervention could be done.

### TABLE III
Postoperative data

|                      | DHS+TSP (n=34) | PFN (n=34) |
|----------------------|---------------|------------|
|                      | n    | %    | Mean±SD     | n    | %    | Mean±SD | p    |
| Time to union (weeks)| 10.1±1.9 | 12.6  | 10.8±1.8    | 0.008* |
| Return to pre-fracture activity (weeks) | 10.8 | 0.005* |
| Complications        |      |      | 3 | 2 | 0.114 |
| Mechanical failure   |      |      | 4 | 2 | 0.099 |
| Infection            |      |      | 0.145 |
| HHS                  |      | 6 months | 67.7±8.5 | 68.3±9.07 | 0.8 |
|                      |      | 12 months | 77.9±8.4 | 80.4±8.7 | 0.26 |
| Walking ability (postoperative) |      | Independent | 6 | 10 | 0.284 |
|                      |      | One crutch | 14 | 6 |  |
|                      |      | Two crutches | 14 | 6 |  |
|                      |      | One-year mortality | 6 | 10 |  |

DHS: Dynamic hip screw; TSP: Trochanteric stabilizing plate; PFN: Proximal femoral nail; SD: Standard deviation; HHS: Harris Hip Score; * Statistically significant.
The one-year mortality rate was 23.5% for the whole patient cohort, indicating no statistically significant difference between the study groups (p=0.284).

DISCUSSION

Intertrochanteric fractures of the femur are quite prevalent in the elderly. Returning the patient to his/her pre-fracture level of activity is the ultimate goal of intertrochanteric fracture surgery. In this study, the mean operative time in the PFN group was significantly shorter than in the DHS+TSP group. Time until union was also significantly shorter, as well as return to the pre-fracture level of activity faster in the PFN group. The HHS at 6 and 12 months were similarly higher in the PFN group than the DHS+TSP group; however, it did not reach statistical significance. The complication and one-year mortality rates were also comparable between the two groups.

Patients in the Madsen et al.’s[19] study were treated with PFN and DHS. Surgical therapy for unstable trochanteric fractures had a significant failure rate, as this study indicated. The TSP, on the other hand, prevented severe femoral shaft fractures associated with the PFN design and decreased the concern of femoral shaft medialization and excessive fracture impaction found with traditional sliding hip screw systems. Another RCT was conducted by Klinger et al.[20] in 173 patients with trochanteric fractures: 51 were treated by DHS+TSP and 122 were treated by PFN. There was no significant difference between both groups in terms of functional scores. Revisions were needed in 16% of the PFN group and 21% in the DHS+TSP group. The authors recommended the use of PFN in unstable trochanteric fractures. Similarly, a prospective study conducted by Shetty et al.[17] in 32 patients with unstable trochanteric fractures who were treated with DHS and TSP showed that HHS after six months was excellent in nine patients, good in 10, fair in nine, and poor in four patients. No postoperative complications such as infection, scar dehiscence, implant failure, re-fracture, malunion, non-union, or requirement of re-surgery were noted in this series. Likewise, in another study, 20 patients with unstable trochanteric fractures and lateral wall fractures were treated with PFN.[21] The patients started partial weight-bearing one week after surgery. Zhang et al.[22] reported that using intramedullary fixation to treat unstable intertrochanteric femoral fractures was encouraging. The duration of the operation was relatively short, and the volume of blood loss during the operation was relatively small. They also found the patients restored ability to perform their activities as much as possible, while promoting fracture healing became the key for treating hip fractures. The authors believed that intramedullary fixation provided this possibility.

In the current study, the mean operational time in the DHS+TSP group was 105±10 min compared to 94±8 min in the PFN group. Although it was statistically significant, there was only an 11-min difference. Despite more patients requiring open reduction for their fracture in the PFN group, additional TSP, larger trochanter fixation by 3.5-mm cancellous screws, and restoration of posteromedial corner all contributed to longer operating duration in the DHS+TSP group. A similar operative time was found in the study by Shetty et al.,[17] but Klinger et al.[20] and Madsen et al.[19] reported a shorter operative time.

Furthermore, anesthetist-assessed intraoperative blood loss was 438 mL in the DHS+TSP compared to 509 mL in the PFN group. Although the difference was statistically significant, there was only an 11-min difference. Despite more patients requiring open reduction for their fracture in the PFN group, additional TSP, larger trochanter fixation by 3.5-mm cancellous screws, and restoration of posteromedial corner all contributed to longer operating duration in the DHS+TSP group. A similar operative time was found in the study by Shetty et al.,[17] but Klinger et al.[20] and Madsen et al.[19] reported a shorter operative time.

In the present study, the mean time until union in the DHS group was 10.1 weeks, while in the PFN group, it was 8.8 weeks. The nails are biomechanically

| Low energy | High energy |
|------------|-------------|
| Mean±SD | Mean±SD | Range | Range | Range | Range |
| HHS at 6 months (post) | 68.5±9 | 50-81 | 64.3±4.4 | 60-71 | 0.047* |
| HHS at 1 year (post) | 80.1±8.6 | 62-93 | 72±4 | 68-78 | 0.011* |

SD: Standard deviation; HHS: Harris Hip Score; * Statistically significant.
more stable than DHS and TSP and preserve the fracture hematoma. Their follow-up X-rays usually revealed earlier callus. The findings from Klinger et al. were similar to ours, 11 weeks for PFN and 12.5 weeks for DHS and TSP; however, it did not reach statistical significance. The time to union in the studies by Han et al. and Zhang et al. was 18.8 and 16 weeks, respectively.

Similarly, the mean time for the return to the pre-fracture level of activity was significantly shorter in the PFN compared to the DHS+TSP group. This could be explained by the union of the fracture which was faster with that group. After six months, the HHS outcomes of Han et al. and Zhang et al. were equivalent to our PFN group. In Shetty et al.'s study, the results were inferior to our DHS and TSP group, while Madsen et al. reported better functional outcomes with the DHS and TSP group.

Mortality rate is high for such frail patients and seems not to be affected by the type of fracture treatment. The one-year mortality rate in our DHS and PFN groups was 17.6% and 29.4%, respectively. As the patients were selected in a random fashion, there was no significant difference in the mortality rates between the two groups. Similarly, there was no significant difference in the mortality rates between the two groups in the Klinger et al. study.

The results of the present study benefits from the prospective nature of data collection, as well as the RCT design. Nevertheless, we acknowledge that this study has several limitations including the small number of cases included compared to previous studies and the relatively short follow-up period. Further randomized studies with larger sample sizes and longer follow-up periods are, thus, needed.

In conclusion, the use of PFN in unstable trochanteric fractures is associated with a shorter time until union and a faster return to the pre-fracture level of activity than the DHS+TSP. However, postoperative hip function, walking independence, as well as complication and one-year mortality rates seem to be comparable. Based on these findings we suggest that PFN should be the first choice implant for the unstable (AO/OTA 31-A2) intertrochanteric fractures.

**Ethics Committee Approval:** The study protocol was approved by the Faculty of Medicine, Cairo University, Egypt Ethics Committee (date: 12.10.2019, no: 20191811). The study was conducted in accordance with the principles of the Declaration of Helsinki.

**Patient Consent for Publication:** A written informed consent was obtained from each patient.

**Data Sharing Statement:** The data that support the findings of this study are available from the corresponding author upon reasonable request.

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**REFERENCES**

1. Dhanwal DK, Dennison EM, Harvey NC, Cooper C. Epidemiology of hip fracture: Worldwide geographic variation. Indian J Orthop 2011;45:15-22.

2. Lee J, Shin KY, Nam HW, Oh M, Shim GS. Mortality rates of hip fracture patients with non-operative treatment. Jt Dis Relat Surg 2022;33:17-23.

3. Tawari AA, Kempegowda H, Suk M, Horwitz DS. What makes an intertrochanteric fracture unstable in 2015? Does the lateral wall play a role in the decision matrix? J Orthop Trauma 2015;29 Suppl 4:S4-9.

4. Andersen E, Jørgensen LG, Hededef LT. Evans' classification of trochanteric fractures: An assessment of the interobserver and intraobserver reliability. Injury 1990;21:377-8.

5. Fu CW, Chen JY, Liu YC, Liao KW, Lu YC. Dynamic hip screw with trochanter-stabilizing plate compared with proximal femoral nail antirotation as a treatment for unstable AO/OTA 31-A2 and 31-A3 intertrochanteric fractures. Biomed Res Int 2020;2020:1896935.

6. Alessio-Mazzola M, Traverso G, Coccarello F, Sanguineti F, Formica M. Dynamic hip screw versus intramedullary nailing for the treatment of A1 intertrochanteric fractures: A retrospective, comparative study and cost analysis. Jt Dis Relat Surg 2022;33:314-22.

7. Selim AAHA, Beder FK, Algeaidy IT, Farhat AS, Diab NM, Barakat AS. Management of unstable pertrochanteric fractures, evaluation of forgotten treatment options. SICOT J 2020;6:21.

8. Abbas AM, Kazem GEDH, Abd El Alem AES, Shoulah SA. Different methods of treatment of trochanteric fractures in elderly. BMJ 2021;381-10.

9. Haroun ARS, Ramadan MO, Seleem OA, Amin OA. Outcomes of unstable trochanteric fractures treated with short proximal femoral nail. Med J Cairo Univ 2019;87:3417-25.

10. Garrison I, Domingue G, Honeycutt MW. Subtrochanteric femur fractures: Current review of management. EFORT Open Rev 2021;6:145-51.

11. Babhulkar S. Unstable trochanteric fractures: Issues and avoiding pitfalls. Injury 2017;48:803-18.

12. Gotfried Y. The lateral trochanteric wall: A key element in the reconstruction of unstable pertrochanteric hip fractures. Clin Orthop Relat Res 2004;425:82-6.
13. Wirtz C, Abbassi F, Evangelopoulos DS, Kohl S, Siebenrock KA, Krüger A. High failure rate of trochanteric fracture osteosynthesis with proximal femoral locking compression plate. Injury 2013;44:751-6.

14. Socci AR, Casemyr NE, Leslie MP, Baumgaertner MR. Implant options for the treatment of intertrochanteric fractures of the hip: Rationale, evidence, and recommendations. Bone Joint J 2017;99-B:128-33.

15. Ozkan K, Türkmen I, Sahin A, Yildiz Y, Erturk S, Soylemez MS. A biomechanical comparison of proximal femoral nails and locking proximal anatomic femoral plates in femoral fracture fixation: A study on synthetic bones. Indian J Orthop 2015;49:347-51.

16. Öner K, Durusoy S, Özer A. A new proximal femoral nail antirotation design: Is it effective in preventing varus collapse and cut-out? Jt Dis Relat Surg 2020;31:426-31.

17. Shetty A, Ballal A, Sadasivan AK, Hegde A. Dynamic hip screw with trochanteric stabling plate fixation of unstable inter-trochanteric fractures: A prospective study of functional and radiological outcomes. J Clin Diagn Res 2016;10:RC06-RC08.

18. World Medical Association. World Medical Association Declaration of Helsinki. Ethical principles for medical research involving human subjects. Bull World Health Organ 2001;79:373-4.

19. Madsen JE, Naess L, Aune AK, Alho A, Ekeland A, Strømsæe K. Dynamic hip screw with trochanteric stabilizing plate in the treatment of unstable proximal femoral fractures: A comparative study with the Gamma nail and compression hip screw. J Orthop Trauma 1998;12:241-8.

20. Klinger HM, Baums MH, Eckert M, Neugebauer R. A comparative study of unstable per- and intertrochanteric femoral fractures treated with dynamic hip screw (DHS) and trochanteric butt-press plate vs. proximal femoral nail (PFN). Zentralbl Chir 2005;130:301-6.

21. Han L, Liu JJ, Hu YG, Quan RF, Fang WL, Jin B, et al. Controlled study on Gamma nail and proximal femoral locking plate for unstable intertrochanteric femoral fractures with broken lateral wall. Sci Rep 2018;8:11114.

22. Zhang L, Shen J, Chen S, Wu Z, Huang Z, He S, et al. Treatment of unstable intertrochanteric femoral fractures with locking gamma nail (LGN): A retrospective cohort study. Int J Surg 2016;26:12-7.