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Original Article

NEW GENERATION NAIL VS. PLATE IN THE TREATMENT OF UNSTABLE INTERTROCHANTERIC FEMORAL FRACTURE

PREGOS DE NOVA GERAÇÃO CONTRA A PLACA NO TRATAMENTO DE FRATURAS DE FÊMUR INTERTROCANTÉRICAS INSTÁVEIS

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ABSTRACT

Objective: To compare antirotator proximal femoral nail (A-PFN) with antirotator dynamic hip screw (A-DHS). Methods: Fourteen proximal femur models with type 31/A2 fracture, according to the AO Foundation/Orthopaedic Trauma Association (AO/OTA) classification, were separated into two groups. Group 1 bones (n = 7) were fixed with A-PFN and Group 2 (n = 7) with A-DHS. A 5 mm/min axial load was applied to femur heads using a testing device. Results: Two of the seven models in the A-PFN group fractured at the proximal, and the other five at distal locking screw level. All models in the A-DHS group fractured at the tightened distal screw region. The median fracture load for the A-PFN group was 132.1 N (97.1-173.69 N range), and for the A-DHS group it was 81.7 N (75.15-89.12 N range). Conclusion: A-PFN-treated unstable intertrochanteric fractured models resisted to higher levels of axial load than the A-DHS-treated group, with statistically significant difference. However, clinical studies are required to support these results. ***Level of Evidence V, Biomechanical study.***

Keywords: Femoral fracture. Fracture fixation. Intramedullary and plate.

RESUMO

Objetivo: O objetivo deste estudo foi comparar a haste do fêmur anti-rotador (A-PFN) com o parafuso dinâmico do quadril anti-rotador (A-DHS). Métodos: Este estudo envolveu dois grupos de quatorze modelos de fêmur proximal, tipo fratura 31/A2, de acordo com a classificação The AO Foundation/Orthopaedic Trauma Association (AO/OTA). Os ossos do grupo 1 (n = 7) foram fixados com A-PFN, enquanto o grupo 2 (n = 7) foi fixado com A-DHS. Um dispositivo de teste foi utilizado para aplicar força axial de 5 mm/min nas cabeças do fêmur. Resultados: Dos sete modelos do grupo A-PFN, dois foram rompidos na proximal e o restante no nível do parafuso de travamento distal. Todos os modelos no grupo A-DHS foram quebrados a partir da região do parafuso distal apertado. Os modelos ósseos no grupo A-PFN foram quebrados a uma força mediana de 132,1 N (variação de 97,1-173,69 N). No grupo A-DHS, a força de fratura dos modelos ósseos foi mediana de 81,7 N (variação de 75,15-89,12 N). Conclusão: Neste estudo, modelos ósseos fraturados intertrocantéricos instáveis tratados com A-PFN foram resistentes a um nível mais alto de forças de pressão axial, em contraste com o grupo tratado com A-DHS, e a diferença foi estatisticamente significativa. No entanto, há uma necessidade de estudos clínicos para apoiar esses resultados. ***Nível de Evidência V, Estudo biomecânico.***

Descritores: *Fratura femoral. Fixação de fratura. Intramedular e placa.*

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INTRODUCTION

Trochanteric fractures of the proximal femur are very common among older adults. Surgical treatment and fracture fixation are the preferred treatment for preventing life-threatening complications and assisting bone healing.[1] Although a range of implant designs have been proposed for managing these fractures,[1,2] selecting the ideal implant for treatment is still a controversial issue. This study compares two new designs of implant models that recently became widely used in the surgical treatment of intertrochanteric femoral fractures: A-PFN and A-DHS.

All authors declare no potential conflict of interest related to this article.

The study was conducted at the Istanbul Medeniyet University.

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MATERIALS AND METHODS

Twenty synthetic third-generation femur models (Synbone AG indust. Switzeland®, model 2420) initially composed our sample. However, due to the breakage of three models from each group during the study, evaluations were completed with fourteen . Each bone model had 135 mm collum-diaphyseal angle, 15 mm anteversion angle, 337 mm length, 48 mm femoral head diameter, and 10 mm diaphysis diameter. A type 31/A2 fracture was created in each model, according to AO/OTA classification (Figures 1 and 2), and the fourteen synthetic models were separated into two groups of seven. Fractures were fixed with antirotator proximal femoral nail (A-PFN) in Group 1, and with antirotator dynamic hip screw (A-DHS) in Group 2.

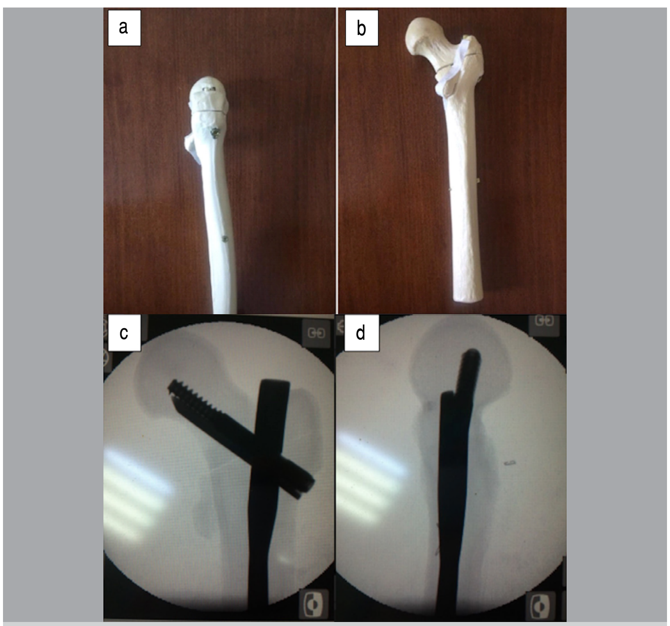

Figure 1. A and B: fracture model fixed with antirotator proximal femoral nail; C and D: fixation under image intensifier.

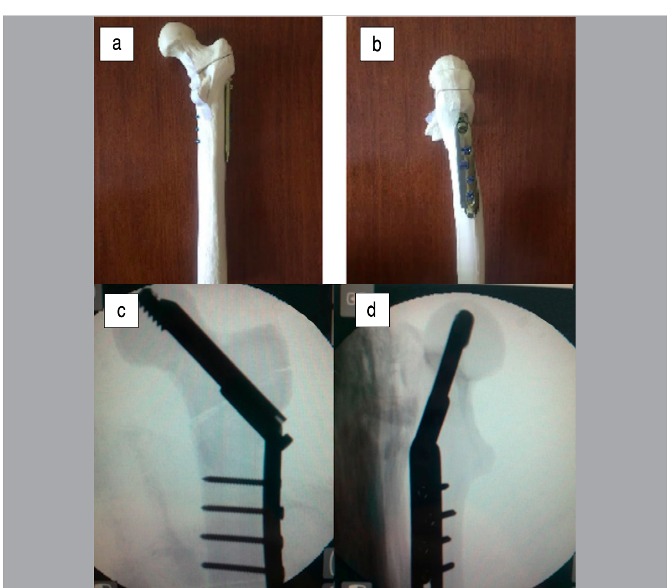

Figure 2. A and B: fracture model fixed with antirotator dynamic hip screw; B and C: fixation under image intensifier.

Characteristics of Implants

A-PFN (TST Industries Istanbul – Turkey®) is available in two lengths: 160 and 220 mm. Proximal nail diameter is 15 mm, and it has a 6^{o} valgus angle (mediolateral curvature) in the nail upper third. This nail presents four options of diameter – 9, 10, 11, and 12, – a lag screw compressing fracture fragments, and a wedge block improving rotational stability for femoral fractures. The lag screw has a 10 mm-width thread and a 125^{o} angle, compatible with the collum-diaphyseal angle. The wedge block lies on the groove, located at the inferior region of the lag screw. The nail distal features two locking holes, suitable for either dynamic or static fixations.

A-DHS (TST Indust. Istanbul – Turkey®) consists of four parts: the plate, lag screw, compression screw, and antirotation wedge. The lag screw not only enables a controlled dynamic sliding of the femoral head, but also improves anti-rotational stability together with the wedge block. The wedge block lies in the groove located at the inferior region of the screw. Plate is 8 mm thick and 19 mm wide, and holes are 16 mm distant. The lag screw on the plate is positioned 135^{o} to the femoral head and its length may range from 60 mm to 120 mm, whereas the plate ranges from 73 mm to 207 mm.

Group 1 bone models were fixed with 220 mm A-PFN. After drilling the due point of the major trochanter tip, proximal femoral nail was applied with the help of the guide. A Kirschner wire guided lag screw placement, and femoral head was drilled inside out to verify centralization. After correction, the lag screw of correct size was applied, followed by anti-rotation wedge and distal locking screw (Figure 1).

Group 2 models were fixed with A-DHS. First, a Kirschner wire with a 135^{o} angled guide was used for placing the lag screw. Once centralization was corrected and K-wire inserted, the lag screw was placed with the dynamic plate seated on it. Then antirotator wedge block was applied, followed by five cortical screws, inserted bicortically (Figure 2).

All models were tested under compressive axial load using the Shimadzu Autograph AGS. For applying physiological load, models were placed into the device with a 15^{o} valgus angle (Figure 3). An axial load was applied to femoral heads at a constant speed of 5 mm/min, according to the femoral mechanical axis, until implant or model failure. After all bone models were evaluated, data from the testing device were recorded and failure type was observed.

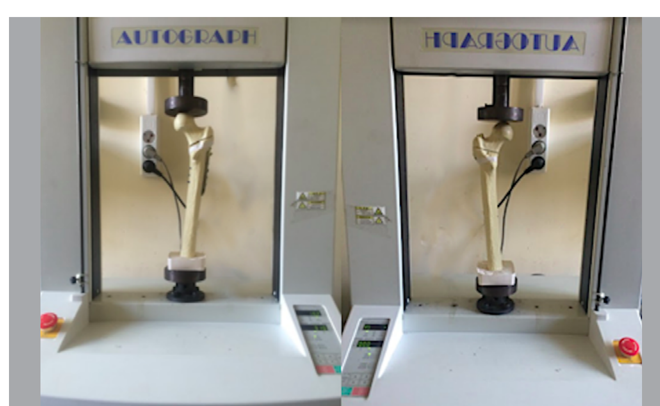

Figure 3. Placement of the fracture model into the Shimadzu Autograph AGS compression device.

Obtained data were statistically analyzed using SPSS Statistics V.22.0 software. Results are presented in mean ± standard deviation, median, minimum and maximum values, absolute numbers, and percentages. Variables distribution was analyzed using the Kolmogorov-Smirnov test. The Mann-Whitney U test was used to compare quantitative data. A p value < 0.05 was considered statistically significant.

RESULTS

After axial loading, two of the seven bone models fixed with A-PFN fractured from the proximal part and five from distal locking screw. In models fractured proximally, we observed a new fracture line from the nail entry point to the fracture line (Figure 4a and 4b). Among models fractured distally, three fractured with a butterfly fragment and two with a new oblique fracture line (Figure 4c and 4d). Table 1 shows the loads causing the new fracture line.

Figure 4. Fracture patterns in the antirotator proximal femoral nail group after testing. A: new fracture line from the entry point, anterior view; B: new fracture line from the entry point, axial view; C: butterfly fragment and new oblique fracture line, anterior view; D: butterfly fragment and new oblique fracture line, lateral view.

Table 1. Loads causing new fracture line in Group 1.

No.	Group	Failure time (sec)	Load (N)
1	1	170.30	1736.9
2	1	191.80	1549.5
3	1	196.00	971.0
4	1	196.30	1557.6
5	1	201.90	1599.3
6	1	216.10	1670.0
7	1	232.20	1643.5

As for models fixed with A-DHS, all seven presented a nearly transverse new fracture line from the distal locking screw (Figure 5). Table 2 shows the load causing the new fracture line.

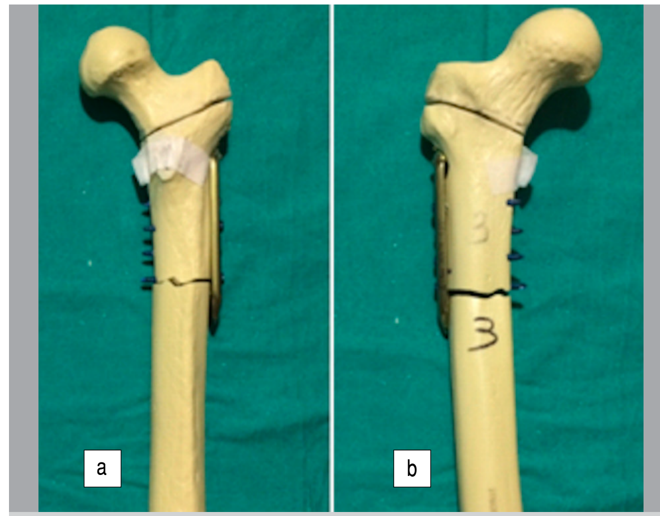

Figure 5. Fracture patterns in the antirotator dynamic hip screw group after testing. A: transverse fracture, anterior view; B: transverse fracture, posterior view.

Table 2. Loads causing new fracture line in Group 2.

No.	Group	Failure time (sec)	Load (N)
1	2	93.85	796.5
2	2	109.25	859.25
3	2	90.25	891.2
4	2	87.50	841.5
5	2	87.00	751.5
6	2	80.85	753.2
7	2	53.05	826.6

In the A-PFN group, models fractured under a minimum load of 971 N and maximum 1736.9 N, according to test results, resulting in a median fracture load of 1599 N (Figure 6). As for the A-DHS group, minimum fracture load was 751.5 N and maximum 891.2 N, resulting in a median value of 817 N (Figure 7).

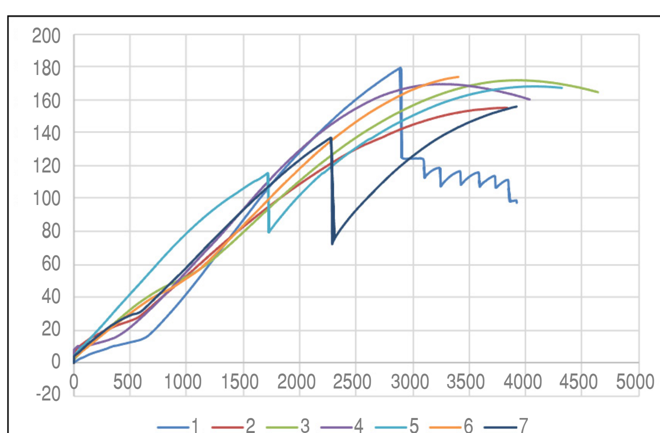

Figure 6. Antirotator proximal femoral nail group load (N) × 10/time.

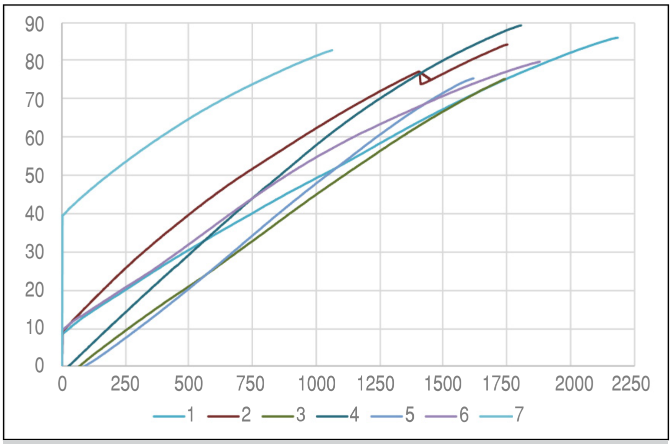

Figure 7. Antirotator dynamic hip screw group load (N) × 10/time.

DISCUSSION

Trochanteric femur fractures are one of the most common fractures among older adults.[2] In young patients, they occur after high-energy trauma, but in older patients they may occur even after a low-energy trauma due to osteoporosis.[3] Hip fractures are a leading cause of morbidity and mortality among older patients.[1]

Biomechanical studies have shown that intramedullary devices are more stable than others (plate, dynamic hip screw ([DHS]) due to their shorter lever arm. However, differences in intramedullary implants design, incorrect surgical procedure, and non-anatomic reduction may lead to considerably high failure rates.[2] Despite the technical advances in implants for trochanteric fractures fixation, morbidity and mortality rates are still high in older patients after hip fracture. Several studies are under progress worldwide to determine the most appropriate treatment.[2,4]

Intramedullary implants may be more suitable for older patients because its fixation technique is less invasive than that of extra-medullary implants. Closed reduction facilitates fracture healing by protecting hematoma containing osteogenic cells and preventing excessive soft tissue dissection. This would possibly decrease infection rates, postoperative complications, and blood loss.[5]

Many studies compare extramedullary and intramedullary implants. Two prospective randomized trials comparing patients with intertrochanteric femoral fractures treated with gamma nail and dynamic hip screw (DHS) found no statistically significant difference between mortality rates. However, the rate of iatrogenic femoral shaft fracture was higher in gamma nail-treated patients, due to its design, than in those treated with DHS. Consequently, DHS was recommended for treating intertrochanteric femoral fractures.[6,7] Although five of the seven models fixed with A-PFN in our study fractured at the distal lock screw level, bone models pertaining to this group can overall withstand higher loads than the A-DHS group.

Mechanical problems such as cut-out, varus deformity, Z-effect, and reverse Z-effect have been reported in patients treated with proximal femoral nail (PFN).[3,5] Third -generation nails were developed to reduce these complications.[8] A study showed that a single screw inserted in a central location could prevent lag screw early cut-out.[9] Subsequently, a study performing a biomechanical comparison reported that A-PFN reduced lag screw cut-out issues.[10] In our study, both A-PFN and A-DHS have a single lag screw, the additional wedge with rail system ensures anti-rotation, and the system entails three different compression parts.

Proximal femoral nail antirotation (PFNA), a third generation nail, contains a helical head that increases trabecular bone volumetric compression in osteoporotic fractures, decreasing cut-out rate.[11] Many studies reported that PFNA is a good alternative for osteoporotic bones.[2,4,11-17] However, PFNA has some disadvantages in relation to telescopic nails, as lag screw lateral migration and inadequate compression.[18,19]

According to the literature, new lag screw system with A-PFN nail and A-DHS plate were designed to mitigate such problems – their main goal is to increase rotational stability with three different compression sites. Increasing lag screw diameter provides not only resistance to cut-out, but also extra compression force by threads on the lag screw. A wedge, located at the inferior region of the screw, compresses trabecular bone and, consequently, increases resistance to rotational forces. The locking mechanism also increases resistance against lateral migration.

We found no lag screw cut-out and lateral migration for the A-PFN nor for the A-DHS group – which may occur in DHS plate new generation and femoral nails third generation. A-PFN-fixed bone models showed no femoral shaft fracture and distal screw failure. The synthetic bone models used in this study were also used in the aforementioned biomechanical studies. However, studies conducted with more samples of cadaver bones may help reaching more definitive results. We also have not applied all forces acting on the hip in daily life, posing another limitation for this study. We encourage the development of further multicentric, randomized controlled clinical trials to support these findings and contribute to the literature.

CONCLUSION

The results showed that the A-PFN group could withstand significantly higher loads than the A-DHS group, due to the shorter lever arm and the ability to transfer forces applied into the models. We found no lag screw cut-out or lateral migration in either group. This biomechanical study findings may guide new clinical trials approaching the fixation of unstable intertrochanteric femoral fractures using A-PFN and A-DHS.

AUTHORS' CONTRIBUTIONS: BO: correspondence author, data collection, study standardization, and biomechanical work; SE: biomechanical work and data collection; TTO: biomechanical work; KO: consultant.

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