ORIGINAL ARTICLE

Comparison of functional outcomes in patients fixed with dynamic hip screw and proximal femur nail-anti-rotation in A1 and A2 type intertrochanteric femur fractures

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ABSTRACT

BACKGROUND: We aimed to compare clinical and functional outcomes between patients treated with Dynamic hip screw (DHS) and Proximal Femoral Nail-Antirotation (PFN-A) implants.

METHODS: This study included 122 patients (66 men [54.1%] and 56 women [45.9%]) who underwent surgery with DHS and PFN-A for an intertrochanteric femur fracture and had at least 12 months follow-up. Reduction assessment, femoral neck-shaft angle and tip-apex distance measurements were performed in early postoperative radiographs. On control visits in months 1, 3, 6 and 12, range of motion, thigh or hip pain, and Trendelenburg positivity were assessed in clinical examination and reduction assessment, femoral neck-shaft angle and tip-apex distance measurements were performed on radiographs after the union. Patients were assessed using Hip Harris Score after the union.

RESULTS: Regardless of implant type used, mean tip-apex distance measured at the immediate postoperative period was 27.6 in patients with implant failure, whereas 21.6 in patients without, indicating a significant difference. Again, mean femoral neck-shaft angle measured at the immediate postoperative period was 123 degree in patients with implant failure, whereas 130 degree in those without, indicating a significant difference. It was found that the femoral neck-shaft angle was <128 degree in all patients with implant failure whereas it was >128 degree in 94% of patients without implant failure at immediate postoperative period.

CONCLUSION: The findings regarding femur neck-shaft angle at the immediate postoperative period was <128 degree in all patients with implant failure and that it was ≥128 degree in 94% of patients without implant failure emphasize the importance of anatomic restoration in femur neck-shaft angle during surgery. The finding that mean tip-apex distance was 27.6 mm in patients with implant failure and 21.6 mm in patients without implant failure indicates that the technique is as important as implant type selected for treatment success of the implantation.

Keywords: Dynamic hip screw; femoral neck-shaft angle; intertrochanteric femur fractures; proximal femoral nail anti-rotation; tip-apex distance.

INTRODUCTION

In the treatment of intertrochanteric femur fractures, which often occur in elder individuals, the aim is to return to daily activities as before the fracture and to prevent complications that arise from immobilization by ensuring mobilization as soon as possible.[1] There is a consensus that the primary aim is to ensure early mobilization by providing stable fixation.[2]

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However, there is an ongoing debate on the selection of the implant type to be used for fixation.

Dynamic hip screw (DHS) is considered as the gold standard in the treatment of stable intertrochanteric femur fractures.[3,4] The rate of implant problems is 1% in stable intertrochanteric femur fractures, whereas the rate reaches up to 20% in unstable intertrochanteric femur fractures treated by DHS.[5,6] Despite the success of lag plate-screw implants, failure in unstable fractures has led to an increased interest in proximal femur nails (PFN).[7] Theoretically, PFNs have many biomechanical advantages when compared to lag screws. Despite their advantages, their rate of complications is higher than lag screws.[8] There are new-generation nails designed to reduce complication rates. As a result, PFNs are increasingly used in the treatment of both stable and unstable intertrochanteric femur fractures. In a study conducted by Anglen and Weinstein, it was found that the rate of PFN use reached from 3% in 1999 to 67% in 2006.[9] However, many studies showed that there was no significant difference between DHS and PFN-antirotation (PFN-A) used in the treatment of low-energy (A1 and A2) intertrochanteric fractures concerning radiological and clinical parameters, operation time, scopy time, mean blood loss, length of hospital stay and functional outcomes.[4,10–12] In several series, excellent outcomes were achieved with DHS used for fixation in intertrochanteric fracture.[13,14]

In this study, we aimed to compare clinical and functional outcomes between patients treated with DHS and PFN-A implants. This study was approved by the Institutional Ethics Committee numbered 04/01-23.02.1015. All patients gave written informed consent before their participation.

MATERIALS AND METHODS

This study included 122 patients (66 men [54.1%] and 56 women [45.9%]) who underwent surgery with DHS and PFN-A for an intertrochanteric femur fracture and had at least 12 months follow-up. Patients who had undergone surgery with a proximal femoral plate and bipolar hip arthroplasty for intertrochanteric fracture of the femur and patients who did not voluntarily participate in follow-ups and did not willingly participate in this study were excluded. As the use of DHS in the treatment of A3 type femur intertrochanteric fractures resulted in high complication rates, A3 type fractures were excluded from this study. This study was conducted in the outpatient setting at a tertiary-level care center in three surgeons' practice (Figs. 1, 2).

Bilateral anteroposterior and lateral hip radiographs, anteroposterior femur radiographs including the hip on the involved side, and hip radiographs in internal rotation were taken at presentation for all patients. Fractures were classified according to the Müller AO classification system.

Patients were operated on by three surgeons who had 10 years of experience as a specialist in orthopaedics and traumatology. Implant selection was made according to our clinical protocol, which considered fracture and patients' characteristics. No randomization was used for implant selection. All patients were treated on the elective basis as soon as conditions are satisfied. Radiolucent standard operating table was used according to surgeons' preference. All patients were positioned supine with a bump under the ipsilateral buttock when the standard table was used. Perfect anteroposterior and lateral images were obtained before patient preparation. Standard operative techniques were utilized according to implant chosen. The postoperative regime was the same for all patients, which includes immediate weight-bearing according to patients' tolerance.

Reduction assessment, femoral neck-shaft angle and tip-apex distance measurements were performed in early postoperative radiographs. On control visits in months 1, 3, 6 and 12, range of motion, thigh or hip pain and Trendelenburg positivity

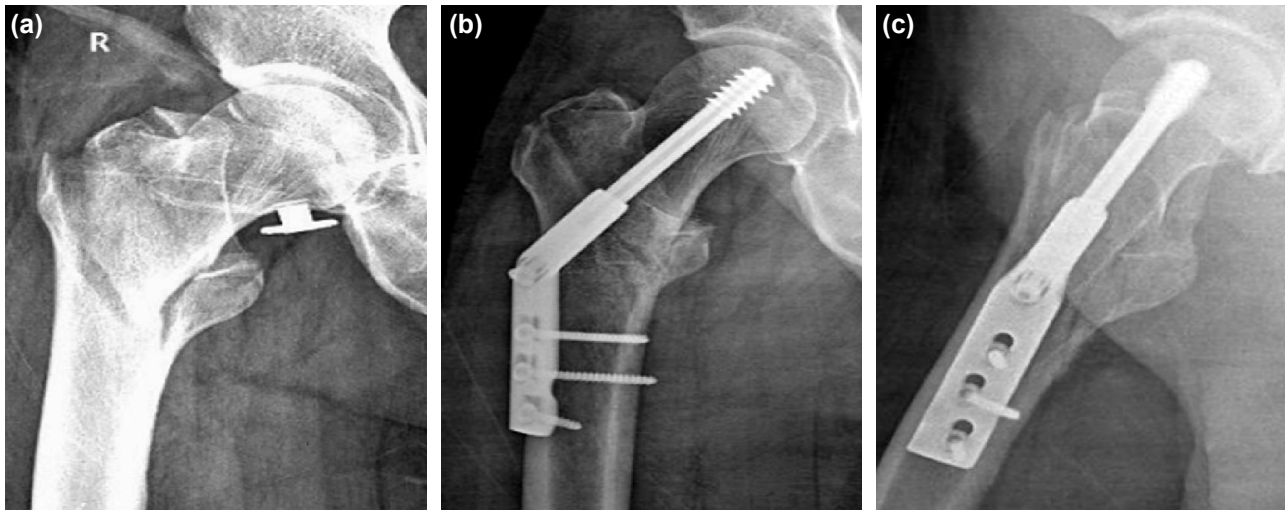

Figure 1. (a) Anteroposterior radiograph of a 56 years old man with an A1 type intertrochanteric femur fracture. **(b)** Postoperative anteroposterior radiograph of the fracture treated with DHS. **(c)** Postoperative lateral radiograph of the fracture treated with DHS.

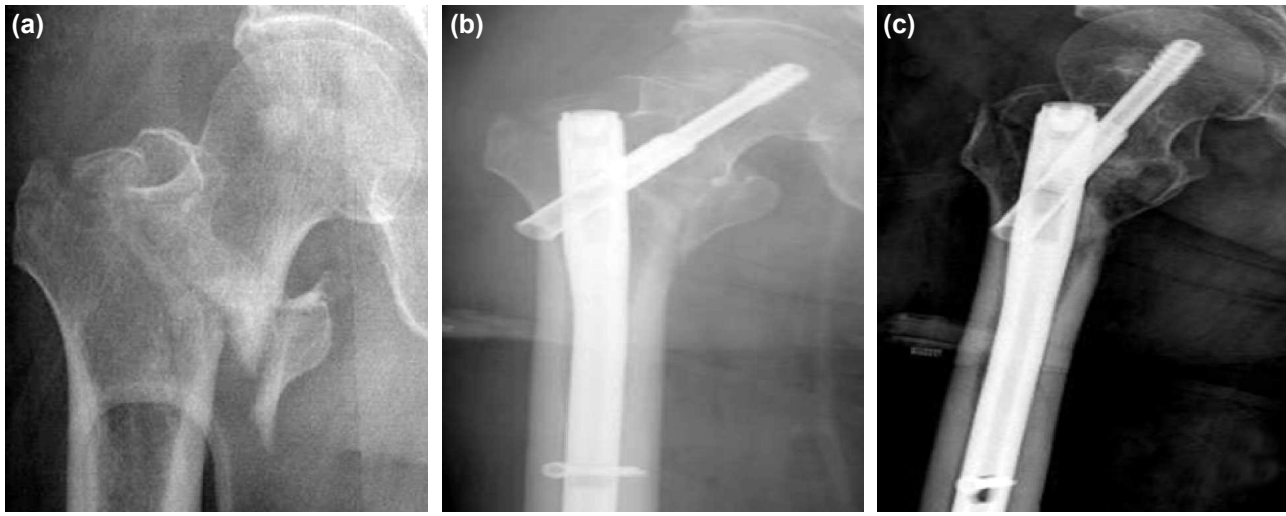

Figure 2. (a) Anteroposterior radiograph of an 83 years old man with an A2 type intertrochanteric femur fracture. **(b)** Postoperative anteroposterior radiograph of the fracture treated with PFN-A. **(c)** Postoperative lateral radiograph of the fracture treated with PFN-A.

were assessed in clinical examination and reduction assessment, femoral neck-shaft angle and tip-apex distance measurements were performed on radiographs after the union. Patients were assessed using Hip Harris Score after the union.

Statistical analyses were carried out using the SPSS version 17.0 software package. Descriptive statistics (mean, standard deviation) were used to analyze the data. Quantitative data with normal distribution were compared using Student's t-test, and those with skewed distribution were compared using the Mann-Whitney U test. To assess relationships, Pearson's correlation analysis was used for parametric variables and Spearman's correlation analysis was used for non-parametric variables.

RESULTS

When the mechanism of injury was considered, it was found that fractures developed as a result of fall at home in 109 (89.3%), fall at outdoors in eight (6.6%), in-vehicle traffic accident in three (2.5%) and out-of-vehicle traffic accident in two patients (1.6%). No significant difference was detected concerning implant type according to the mechanism of injury (p=0.370).

Patient characteristics in the DHS and PFN-A groups are shown in Table 1. Patient characteristics in the both A1 groups are shown in Table 2. Patient characteristics in the both A2 groups are shown in Table 3.

Table 1. Patients characteristics in both groups

Variable	DHS (n=66)	PFNA (n=56)	p
Age (years)	77.1 (35–92)	78.9 (50–105)	0.370
Sex (male/female)	39/27	27/29	0.230
AO, n (%)			0.001
A1	48 (72.7)	16 (28.6)	
A2	18 (27.3)	40 (71.4)	
Side (right/left)	39/27	27/29	0.986
Singh Index	2.81	2.78	0.755
Implant failure (n=13) (10.7%), n (%)	2 (3.0)	11 (19.6)	0.003
Mean TAD immediate postoperative	21.3	23.5	0.009
Mean TAD after the union	20.4	18.9	0.281
Mean NSA immediate postoperative	132.2	126.2	0.001
Mean NSA after the union	130	124	0.001
Harris	80.5	66.5	0.001
Trendelenburg, n (%)	4 (6.1)	25 (44.6)	0.001

DHS: Dynamic hip screw; PFNA: Proximal femoral nail-antirotation; TAD: Tip apex distance; NSA: Neck shaft angle.

Table 2. Patients characteristics in both A1 groups

Variable	DHS (n=66)	PFNA (n=16)	p
Implant failure (n=2) (3.1%)	0	2 (12.5%)	0.013
Mean TAD immediate postoperative	20.9	22.1	0.377
Mean TAD after the union	20.5	19.5	0.281
Mean NCA immediate postoperative	132.5	127.7	0.001
Mean NSA after the union	130.8	126	0.001
Harris	84	72.5	0.004
Trendelenburg	2 (4.2%)	5 (31.3%)	0.003

DHS: Dynamic hip screw; PFNA: Proximal femoral nail-antirotation; TAD: Tip apex distance; NSA: Neck shaft angle.

Table 3. Patients characteristics in both A2 groups

Variable	DHS (n=18)	PFNA (n=40)	p
Implant failure (n=11) (19%)	2 (11.1%)	9 (22.5%)	0.306
Mean TAD immediate postoperative	22.1	24	0.138
Mean TAD after the union	20.1	18.7	0.566
Mean NCA immediate postoperative	131.3	125.7	0.001
Mean NSA after the union	127.7	123.2	0.016
Harris	71.1	64.2	0.270
Trendelenburg	2 (11.1%)	20 (50%)	0.005

DHS: Dynamic hip screw; PFNA: Proximal femoral nail-antirotation; TAD: Tip apex distance; NSA: Neck shaft angle.

When early mobilization was assessed, 66 patients (100%) treated with DHS were mobilized at the first postoperative day by weight-bearing as tolerated, while 51 (91.1%) treated with PFN-A were mobilized at the first postoperative day by weight-bearing as tolerated. Four patients (7.1%) were mobilized by partial weight-bearing, and no weight-bearing was allowed in one patient (1.8%). A significant difference was detected between the groups concerning the postoperative first day early mobilization (p=0.046).

When complications were considered, complications were observed in eight patients who underwent DHS (12.1%) and in 12 (21.4%) who underwent PFN-A, indicating a significant difference (p=0.065).

In DHS patients, complications included a loosening of compression screw in six patients and implant failure in two patients. In PFN-A patients, complications included intraoperative fracture in one patient and implant failure in 11.

Regardless of the implant type, mean tip-apex distance measured at the immediate postoperative period was 27.6 in patients with implant failure and 21.6 in patients without, indicating a significant difference (p=0.001). Again, mean femoral neck-shaft angle measured at the immediate postoperative period was 123 degrees in patients with implant failure and 130 degrees in those without, indicating a significant difference (p=0.001). It was found that the femoral neck-shaft angle was <128 degrees in all patients with implant failure and >128 degrees in 94% of patients without implant failure at the immediate postoperative period.

DISCUSSION

DHS is the choice of the implant in stable fractures, while the intramedullary nail is preferred in instable fractures due to its effectiveness. However, there is no consensus on the choice of the implant in unstable fractures.[15] We should note that given that DHS systems are inadequate for instable fractures, there is a growing interest in intramedullary nails. While DHS is the choice of the implant in stable fractures, the preference of surgeons has shifted to PFN-A due to its potential biomechanical advantages in theory.[15] In a multicenter meta-analysis, including 3279 patients, it was concluded that intramedullary nails had no superiority over the dynamic hip screw in both stable and instable trochanteric fractures.[16] In many studies, dynamic hip screws have been considered as the gold standard in the treatment of stable intertrochanteric femur fractures.[8,15,17] When our cases were assessed according to the Müller AO classification, it was seen that we mainly used DHS in A1 fractures and PFN-A in A2 fractures.

At the immediate postoperative period, a significant difference was detected between patients with and without implant failure regarding femoral neck-shaft angle, which is used to investigate whether the reduction is achieved in varus-valgus position in clinical practice. The finding that the femur neck-shaft angle at the immediate postoperative period was <128 degrees in all patients with implant failure, and that it was ≥128 degrees in 94% of those without implant failure emphasizes the importance of anatomic restoration in femur neck-shaft angle during surgery. These data are inconsistent with the study of Davis et al.,[18] who reported that the femur-shaft angle did not affect the loosening rate. Şahin et al.[19] found the mean femur-shaft angle as 136.7 degrees in patients treated for instable intertrochanteric femur fracture, and authors observed that femur-shaft angle decreased from 125 degrees to 118 in a case with the loosening of the helical screw. In a study by Ertürer et al.,[20] the mean femur-shaft angle was found to be 125.5 degrees in patients treated with profine nail for the intertrochanteric femur fracture. The femur-shaft angle is approximately 125 degrees in individuals aged >75 years.[21] Based on our data, we think that femur-shaft angle <128 degrees is not acceptable at the immediate postoperative period as it increases complications.

Lag screws are used for fixation in DHS and PFN-A fixation systems for intertrochanteric femur fractures, which is sent to the femur head via femur neck over the implant system. The tip-apex distance is the best marker for implant survival and outcome, which was first defined by Baumgaertner et al.[5,22] Tip-apex distance is directly correlated to implant failure. Baumgaertner et al.[5,22] suggested that implant failure is less likely when the tip-apex distance is below 25 mm and that it is the most important parameter, although not the only one, to predict treatment success. In our study, regardless of implant type, a significant difference was detected between patients with and without implant failure in terms of immediate postoperative tip-apex distance. In consistent with the literature, the finding that mean tip-apex distance was 27.6 mm in patients with implant failure and 21.6 mm in those without indicates that the technique is as important as implant type for the success of implantation.

In A2 fractures, no significant difference was found in tip-apex distance measured at the immediate postoperative period and after the union between DHS and PFN-A groups. However, the presence of a significant difference in femur-shaft angel favoring DHS at immediate postoperative period and after the union and better clinical outcomes in DHS patients indicates that the DHS system can maintain long-term stability even in displaced fractures.

When clinical outcomes and complications were assessed in our study, complication rates for A1 and A2 fractures were lower in the DHS group when compared to the PFN-A group, and complications were considered as minor in the DHS group. When the groups were compared regarding Hip Harris Score, it was found that Hip Harris Score was higher in A2 fractures undergoing DHS. We think that the difference occurred as PFN-A was mainly preferred in A2 fractures, in which stable reduction can be challenging. In many studies comparing DHS and gamma nail, it was shown that there was no significant difference in terms of complications and clinical and functional outcomes.[23–27] However, Xu et al.[28] reported that PFN-A was associated with lower complication rates than DHS. Again, Kristek et al.[29] reported lower complications in patients undergoing PFN-A. Thus, these advantages in the selection of the implant system can explain the tendency to choose intramedullary nails. In the literature, there are studies reporting that walking ability at the postoperative period was recovered more rapidly with intramedullary nails when compared to DHS and that intramedullary nails provided better restoration of hip anatomy. In our study, the finding of less Trendelenburg and significantly higher Hip Harris Score in DHS patients is inconsistent with the literature. In many studies, it was reported that walking ability was recovered more rapidly in PFN-A patients than DHS patients.[29,30] Another difference in our study was the finding that DHS patients could be mobilized earlier with weight-bearing as tolerated. We think that the differences in recovery of walking ability, presence of Trendelenburg and tolerance to weight-bearing can be attributed to injury in the hip abductor mechanism for optimal positioning of the intramedullary nail.

In conclusion, based on our findings, we think that fracture type and stability, and regardless of the system used, tip-apex distance are the most important factors in the selection of the implant system for fixation. We believe that DHS when implemented by a proper technique, will provide better results in A1 and A2 fractures (if a stable reduction is possible) regarding union, functional outcomes and complication rates. However, further studies with larger samples are needed to use these findings as a guide in clinical practice.

Conclusion

We think that both DHS and PFN-A implant systems can be selected in A1 intertrochanteric femur fractures and that both systems can ensure union without implant failure in such fractures. However, DHS should be the first choice in A1 fractures as the femur-shaft angle is better after DHS treatment, resulting in more convenience functional activity.

Both DHS and PFN-A can be selected in A2 intertrochanteric femur fractures; however, DHS can be preferred in A2 fractures, where stable reduction can be achieved since PFN-A is associated with higher rates of Trendelenburg presence, complication and implant failure, and Hip Harris Score is lower after union. PFN-A should be the choice of the implant in A2 intertrochanteric femur fractures, but DHS can provide successful clinical outcomes in selected patients if a proper

reduction is provided and implantation techniques are followed meticulously.

We think that femur neck-shaft angle <128 degrees should not be accepted during surgery since it is associated with increased complication rates.

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Authorship Contributions: Concept: H.F.S., B.D., M.Ç.; Design: H.F.S., B.D., M.Ç.; Supervision: H.F.S., B.D., M.Ç.; Fundings: H.F.S., B.D., M.Ç.; Materials: H.F.S., B.D., M.Ç., B.O., S.D.; Data: H.F.S., B.D., M.Ç., İ.D.C., B.O., S.D.; Analysis: H.F.S., B.D., M.Ç., S.D.; Literature search: H.F.S., B.D., M.Ç., İ.D.C., B.O., S.D.; Writing: H.F.S., M.Ç., B.D., S.D.; Critical revision: H.F.S., B.D., S.D.

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ORİJİNAL ÇALIŞMA - *ÖZET*

A1 ve A2 tipi femur intertrokanterik kırıklarında kayan kalça vidası ve proksimal femur çivisi-antirotasyon ile tespit sonrası hastaların fonksiyonel sonuçlarının karşılaştırılması

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AMAÇ: Dinamik hip screw (DHS) ve proksimal femoral çivi-antirotasyonu (PFN-A) implantları ile tedavi edilen hastaların klinik ve fonksiyonel sonuçlarını karşılaştırmayı amaçladık.

GEREÇ VE YÖNTEM: Çalışmaya Kırıkkale Üniversitesi Tıp Fakültesi Ortopedi ve Travmatoloji Anabilim Dalı'nda femur intertrokanterik kırığı nedeniyle DHS ve PFN-A kullanılarak ameliyat edilen, en az 12 ay takibi olan 66'sı erkek, 56'sı kadın olan toplam 122 hasta alındı. Hastaların erken postoperatif grafilerinde kırığın redüksiyonu değerlendirilmesi, boyun cisim açısı ve tip apeks mesafesi ölçümleri yapıldı. Postoperatif 1. ay, 3. ay, 6. ay, 12. ay yapılan takiplerinde kalça eklem hareket açıklığı, uyluk-kalça ağrısı, Trendelenburg pozitifliği bakıldı ve takiplerdeki ve kaynama sonrası çekilen grafilerinde redüksiyon, fiksasyon kaybı, boyun cisim açısı ve tip apeks mesafesi ölçümleri yapıldı. Hastalar kaynama sonrası dönemde Kalça Harris Skoru ile değerlendirildi.

BULGULAR: Kullanılan implanttan bağımsız olarak implant yetmezliği görülen grupta erken postoperatif ölçülen tip apeks mesafesi ortalaması 27.6 iken implant yetmezliği görülmeyen grupta 21,6 idi ve istatistiksel olarak anlamlı bir fark saptandı. Kullanılan implanttan bağımsız olarak implant yetersizliği görülen grupta erken postoperatif ölçülen boyun cisim açısı ortalaması 123 iken implant yetersizliği görülmeyen grupta 130 idi ve istatistiksel olarak anlamlı bir fark saptandı. İmplant yetersizliği görülen hastaların tümünde erken postoperatif ölçülen boyun cisim açısının 128 derecenin altında olduğu saptandı. İmplant yetersizliği görülmeyen hastaların %94'ünün erken postoperatif ölçülen boyun cisim açısının 128 derecenin üstünde olduğu saptandı.

TARTIŞMA: İmplant yetersizliği olan hastaların tümünde erken postoperatif boyun cisim açısının 128° altında olması ve implant yetersizliği görülmeyen hastaların %94'ünde erken postoperatif boyun cisim açısının 128° ve üzerinde olması cerrahi sırasında bu açının anatomik şekilde restore edilmesinin önemini ortaya çıkarmaktadır. İmplant yetersizliği görülen grupta TAD'nin ortalama 27.5 mm ve implant yetersizliği görülmeyen grupta ortalama 21.7 olması, bu sistemlerin implantasyonunda tedavi başarısı açısından tekniğin en az seçilen implant türü kadar önemli olduğunu göstermektedir.

Anahtar sözcükler: Dinamik kalça vidası; femur boyun cisim açısı; femur intertrokanterik kırık; proksimal femoral çivi antirotasyon; tip apeks mesafesi.

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