ARAŞTIRMA MAKALESİ/ ORIGINAL ARTICLE

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Geriatrik Pertrokanterik Femur Kırıklarında Farklı Fiksasyon Metodları Sonrası Gelişen Yetmezlik Nedenlerinin Değerlendirilmesi

Evaluation of The Causes of Failure in Elderly Patients after Different Fixation Methods in Pertrochanteric Femur Fractures

Hasan Ulaş Oğur[1], Ümit Tuhanioğlu[1], Fırat Seyfettinoğlu[1], Emre Fidan[1], Hakan Uslu[1], Ulaş Serarslan[2]

1Adana Şehir Eğitim Ve Araştırma Hastanesi, Ortopedi Ve Travmatoloji Kliniği,Adana,Türkiye
2Kocaeli Derince Eğitim Ve Araştırma Hastanesi, Ortopedi Ve Travmatoloji Kliniği,Kocaeli,Türkiye

ÖZ

GİRİŞ ve AMAÇ: *Yaşlı kemiğin farklı biyomekaniği dolayısıyla trokanterik bölge kırıklarında farklı fiksasyon yöntemlerinin etkinliği ve yetersizliklerini ortaya koymak amaçlanmıştır. Farklı kırık tiplerinde yetmezlik sebepleri öncelik sırasına göre değerlendirilmiştir.*

YÖNTEM ve GEREÇLER: *Bu çalışmaya Nisan 2011-Ekim 2016 yılları arasında ameliyat edilen ve takibi sağlanabilen 65 yaş ve üstü 186 geriatrik hasta (115 kadın,71erkek) dahil edildi. Hastaların ortalama takip süresi 16 ay idi. Kırıklar AO/OTA sınıflamasına göre sınıflandırıldı. 98 hastaya PFN, 14 hastaya proksimal kilitli femur plağı(PF-LCP),74 hastaya DHS uygulandı. Fiksasyon sonrası yetmezlik nedenleri değerlendirildi. Klinik sonuçlar Salvati ve Wilson's kalça skoruna göre, radyolojik sonuçlar Baumgaertner redüksiyon ölçütlerine göre değerlendirildi.*

BULGULAR: *Yetmezlik görülen 16 hastanın 9' u Proksimal femur çivisi (PFN) 5'i DHS, 2'si proksimal femur plağı yapılan hasta idi. 12 hasta AO sınıflamasına göre instabil kabul edilen kırıklardı.4'ü stabil olup 2'si DHS yapılan 2'si PFN yapılan hastalar idi.*

TARTIŞMA ve SONUÇ: *Kırık sınıflaması kırığı stabil veya instabil olarak tanımlar; bu uygun implant seçimi için çok önemlidir. Stabil kabul edilen ince lateral korteksi olan 31 A2.1 tipi kırıklar ve osteoporotik kırıklara şüphe ile yaklaşılması ve instabil olarak değerlendirilebileceği düşünülmektedir.Medial kalkar ve posteromedial korteks devamlılığının sağlanması, başarısızlığın önlenmesinde en önemli kriterlerden biridir. Postoromedial devamlılığı tespit etmek için bilgisayarlı tomografi kullanılabilir.*

Anahtar Kelimeler: *pertrokanterik kırık, yaşlı, fiksasyon*

ABSTRACT

INTRODUCTION: *To investigate the efficiency and failure of different fixation methods in trochanteric region fractures owing to different biomechanics of older bone. The causes of failure in different fracture types were evaluated in accordance with their priority.*

METHODS: *The study included 186 elderly patients aged ≥65 years, who underwent surgery and were followed up between April 2011 and October 2016. The mean follow-up period was 16 months. Fractures were classified in accordance with AO-Müller/Orthopaedic Trauma Association (AO/OTA) classification. Proximal Femoral Nail (PFN) was applied to 98 patients, Proximal Femur Locking Compression Plate (PF-LCP) to 14 patients, and Dynamic Hip Screw (DHS) to 74 patients. The causes of failure after fixation were evaluated. The clinical results were evaluated in accordance with the Salvati and Wilson hip score, and Baumgaertner's reduction standards were used in the evaluation of radiological results.*

RESULTS: *Nine failures were detected in PFN, 5 in DHS, and 2 were detected in PF-LCP. Twelve patients were regarded to have unstable fractures in accordance with the AO classification (31A2.2-3 and 31A3). Four were stable fractures(31A2.1) of which; 2 had DHS, and 2 had PFN.*

DISCUSSION and CONCLUSION: *Fracture classification defines the fracture as stable or unstable, which is very important for the selection of the appropriate implant. It is thought that some 31 A2.1 type fractures and osteoporotic fractures with a thin lateral cortex which are accepted as stable should be approached with suspicion and could be evaluated as unstable. Provision of medial calcar and posteromedial cortex continuity is one of the most important criteria for the prevention of failure. Computerized tomography can be used to detect posteromedial continuity.*

Keywords: *pertrochanteric fracture, elderly, fixation*

İletişim / Correspondence:
Dr. Ümit Tuhanioğlu
Adana Şehir Eğitim Ve Araştırma Hastanesi, Ortopedi Ve Travmatoloji Kliniği, Adana, Türkiye
E-mail:ümittuhanioglu@hotmail.com
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INTRODUCTION

Pertrochanteric fractures may occur with low-energy trauma in patients of advanced age with osteoporosis and this fracture are problematic fractures that have increased in numbers in recent years. Failures have frequently been detected after fixation in such fractures, and patients have difficulty in regaining previous functional capacity (1). Accompanying diseases, the degree of osteoporosis, fracture type, patient orientation, implant choice, reduction quality and social environmental support are factors that may affect functional outcomes (2-6). Fracture classification as stable or unstable during surgical planning is important for the selection of the correct implant, and treatment. The concept of stability is also associated with reduction quality after fracture fixation (7). Although a consensus has been established in the treatment of stable fractures in recent years, unstable fractures do not always have a successful definition and treatment. Although the use of proximal femoral nailing (PFN) and proximal femoral locking compression plates (PF-LCP) are new and commonly-used approaches in unstable fractures, dynamic hip screws (DHS) have mostly been used in stable fractures (8-12). In the present study, it was aimed to accurately describe the fracture classifications and evaluate the clinico-radiological outcomes of 3 different fixation methods used in pertrochanteric fractures, and to discuss the causes of failure.

METHODS

A retrospective study was conducted of 234 elderly patients aged 65 years and above (range, 65-101 years) who presented at our clinic with pertrochanteric fractures and underwent surgery between April 2011 and October 2016. The study included 186 patients (115 females, 71 males), with regular follow-up (Table 1). Spinal anesthesia was administered to 138 patients, and general anesthesia to 48 patients. The patients underwent surgery 1-6 days (mean: 2.5 days) after hospitalisation. Surgery was performed in the supine position to those who received DHS and PF-LCP (n=88) and in the lateral decubitus position to patients who underwent PFN (n=98). No traction tables were used in any of the operations.

All patients were evaluated using preoperative and postoperative anteroposterior (AP) and lateral radiographs. Computed tomography (CT) was also used to evaluate patients with comminuted fractures, and those with cortical discontinuity or suspicion of cortical discontinuity (31A2) in the posteromedial region. In accordance with the AO-Müller/Orthopaedic Trauma Association (AO/OTA) classification, 31 A1. and 31 A2.1 were included in the stable group, and 31 A2. 2-3, and 31 A3. were included in the unstable group. All patients undergoing PFN (n = 98) were in the 31A2(n=70) - 31A3(n=28) classification, while 44 of the DHS patients were 31A2 (n=32, 31A2.1) and 30 were 31A1 fractures. All patients who underwent PF-LCP were 31A3 type unstable fractures. The tip-apex distance was evaluated as ≤25 mm or >25 mm, and the collodiaphyseal angle was evaluated in 2 different categories as <130˚ and ≥130˚. The location of the helical screw in the femoral head was evaluated in patients who underwent PFN and DHS, using the method described by Cleveland and Bosworth (7) (figüre 1). Postoperative fracture reduction was ranked in accordance with the reduction scales (Table 2) described by Baumgaertner et al (8). Proximal femoral plate (PF-LCP) (Pronorm) was applied generally in patients with comminuted pertrochanteric fracture and subtrochanteric extension (n=14) generally using a minimally invasive technique to enable flexible fixation. Fixation was performed using PFN (involving lag screw and antirotation wedges,Tantum Germany) in 98 patients. Fixation was performed using DHS (Pronorm Turkey) in 74 patients.

Reduction was performed using auxiliary reduction tools through a mini-incision in patients where fracture reduction could not be obtained using a closed method. The Salvati and Wilson hip scoring system (SWS) was used in the clinical evaluation with the assessment of unassisted and pain-free walking capacity.

Table 1. Frequency-percentaged distribution of patients in accordance with sex and fracture classification

		Age		S/I						Sex					
		n	Mean	I		S		Total		Male		Female		Total	
				n	%	n	%	n	%	n	%	n	%	n	%
Surgery	DHS	74	83.8	11	14.9	63	85.1	74	100.0	27	36.5	47	63.5	74	100.0
	PFLCP	14	69.7	14	100.0	0	.0	14	100.0	7	50.0	7	50.0	14	100.0
	PFN	98	75.5	68	69.4	30	30.6	98	100.0	37	37.8	61	62.2	98	100.0
	TOTAL	186	78.4	93	50.0	93	50.0	186	100.0	71	38.2	115	61.8	186	100.0

S: stabil fracture, I: instabil fracture

Table 2. Baumgaertner's Reduction Scale

Sequencing

1. Anterior posterior plane

Normal collodiphyseal angle (>130°) or slight valgus sequencing

2. Angling less than 20° in lateral plane and deplacement less than 4 mm in any of the fragments

Result: Good: If met in both scales

Acceptable: If met in only one scale

Poor: If not met in either scale

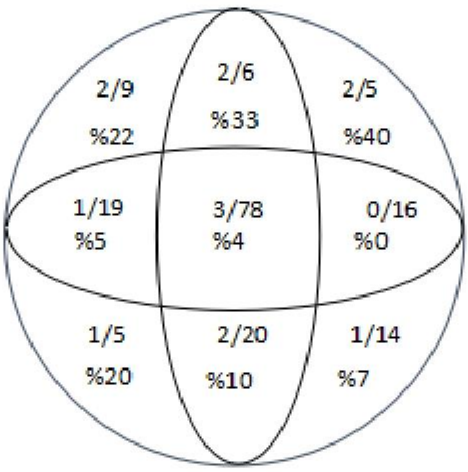

Figure 1. *Cleveland's definition of the location of helical screw in the head, number of patients/failure in each quadrant ratio*

Statistical Analysis

Data were analysed using the Statistical Program for the Social Sciences (SPSS) vn 20 software. The Shapiro-Wilk test was used in the evaluation of variables to normal distribution according to the number of units. The Mann-Whitney U and Kruskal-Wallis H tests were used to investigate differences between the groups. A value of p<0.05 was accepted as statistically significant.

RESULTS

The age range was 69-83 years in all 3 groups, and the mean follow-up period was 20 months (range, 6-48 months). The complication rate with CDA <130˚ in patients with unstable fractures, with acceptabl and good reduction who underwent PFN was more than 2-fold higher than in patients with a CDA >130˚ (p<0.0234). There were no failures in the lag screw central and inferior central quadrant (Cleveland 5, 8) with good reduction in the patients treated with DHS and PFN(31A2), but high-grade failure was observed in patients with poor and acceptable reduction in placement of the lag screw in the superior quadrant (p<0.05).

Secondary varus deformity was detected in 6 of 9 patients who received PFN and had symptoms of failure. Cut-out was detected in 6 of 9 patients. Posteromedial cortex continuity could not be adequately achieved, and posteromedial displaced portions over 2 cm could not be reduced in 4 of 6 patients (Figure 2,3,4). No failure was observed in the 31A1 patients treated with DHS (n=30). Lateral cortex fractures were detected in the lag screw entry points in 2 of 5 patients who underwent DHS (31A2 fracture) and had symptoms of failure (Figure 5,6,7). Cut-out was detected in 3 of 5 patients who developed failure after treatment with DHS (n=44, 31A2 type fracture),and posteromedial contact and impaction could not be adequately achieved in 2 of those patients (Table 3). According to the Baumgaertner scale, in patients with failure, acceptable reduction was obtained in 8 patients and poor reduction in 5 patients. Poor reduction is an important criterion for failure development (5/12) (p<0.001), while acceptable (8/56) and good reduction(3/118) does not mean failure will not occur. A comparison of the Baumgaertner reduction scales and the Salvati-Wilson clinical scores (SWS) demonstrated that the clinical score was statistically significantly higher in the group with better reduction in patients with PFN and DHS(($p<0.05$) (Table 4).

Figure 2. *83 Y, 31.A2.1 trochanteric fracture, Early post-operative, PFN fixation*

Figure 3. *Early post- operative lateral radiography*

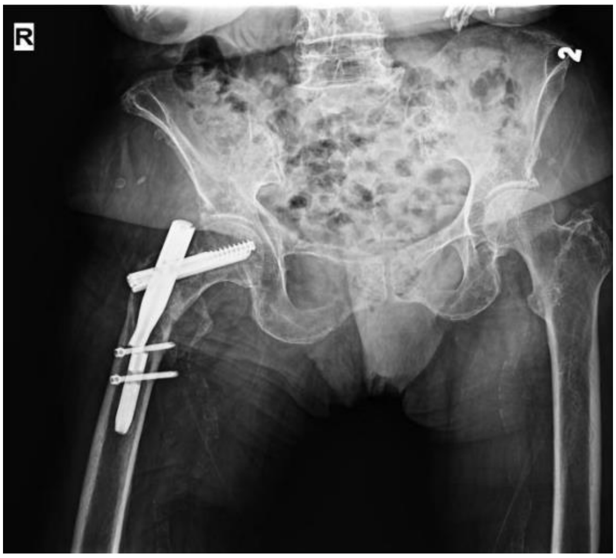

Figure 4. *Post- operative month 4. nail was broken*

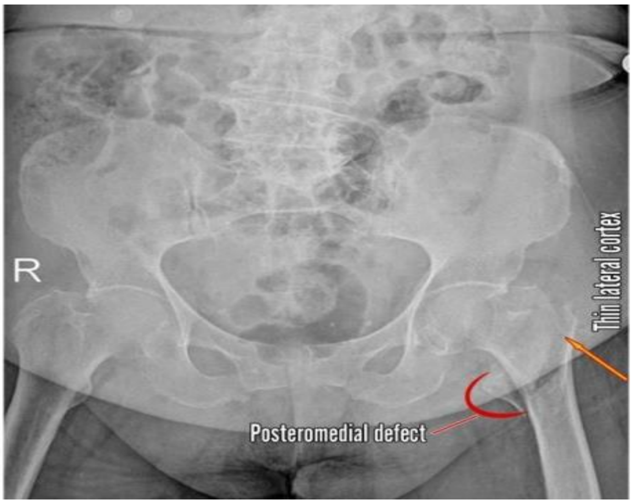

Figure 5. *Pre-operative trochanteric femur fracture AO/OTA type A2.1 thin lateral cortex*

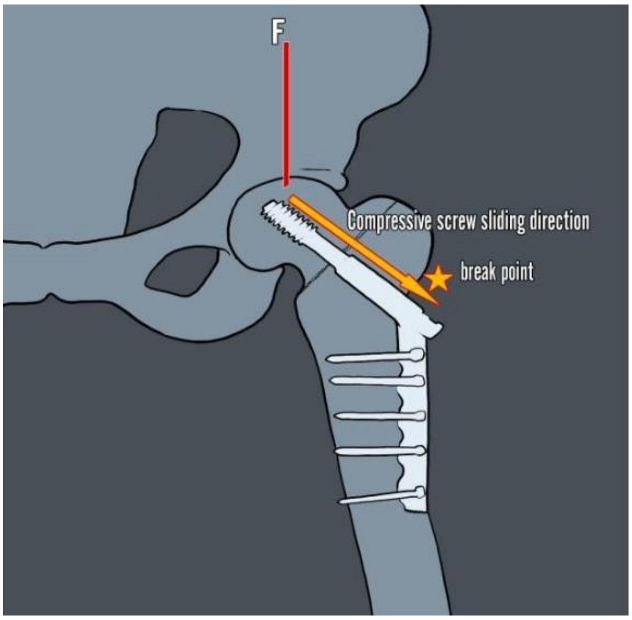

Figure 6. *Schematic drawing fracture / Dislocation of the screw and break point of the bone due to inability to resist load (F)*

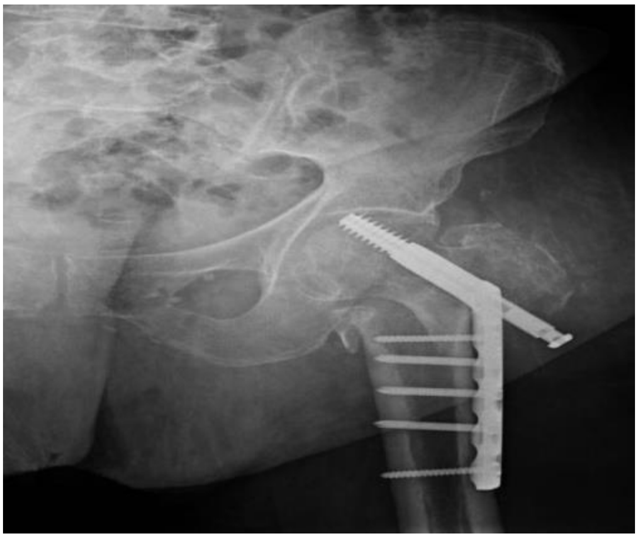

Figure 7. *Post- operative month 2 lateral diclocation in yhe lag screw*

Table 3. Distribution of the association between posteromedial cortex continuity and complications

			Complications						Chi-square	
			No complications		No complications		Total			
			n	%	n	%	n	%	Chi-sguare	p
Surgery	DHS	No PMCC	68	95,8	3	4,2	71	100,0	Fisher's Exact	0,011
		PMCC	1	33,3	2	66,7	3	100,0		
	PF-LCP	No PMCC	11	100,0	0	0,0	11	100,0	Fisher's Exact	0,033
		PMCC	1	33,3	2	66,7	3	100,0		
	PFN	No PMCC	87	94,6	5	5,4	92	100,0	Fisher's Exact	0,0001
		PMCC	2	33,3	4	66,7	6	100,0		

PMCC:Posteromedial cortex continuity

Table 4. Kruskal-Wallis H test results associated with the difference between Baumgaertner groups in accordance with clinical score

				CLINICAL SCORE (Salwati-Wilson rating system)							Kruskal-Wallis H Test	
				n	Mean	Med	Min	Max	sd	Rank sum.	H	p
Surgery	DHS	BAUMGAER-TNER REDUCTION	ACCEPT-ABLE	28	24.3	26.0	12.0	34.0	6.3	25.34	30.347	0.001
			GOOD	41	31.1	32.0	18.0	36.0	3.9	48.74		
			POOR	5	17.2	16.0	14.0	22.0	3.0	8.4		
			Total	74	27.5	30.0	12.0	36.0	6.5		1-2 1-3 2-3	
	PFN	BAUMGAER-TNER REDUCTION	ACCEPT-ABLE	20	22.8	24.0	12.0	32.0	7.0	29.53	31.152	0.001
			GOOD	71	29.7	30.0	14.0	36.0	3.8	58.13		
			POOR	7	15.4	14.0	12.0	24.0	4.3	9.21		
			Total	98	27.3	28.0	12.0	36.0	6.3		1-2 1-3 2-3	

Although, no statistically significant difference was detected in the PF-LCP group due to the small number of patients (p>0.05), clinical scores were higher in the group where the reduction scale was regarded as 'good.'

The SWS values were determined as >31 excellent (n=67 patients), 24-31 good (n=81), 23-16 fair (n=24), and <16 poor (n=14).

Varus deformity was detected in 2 of 14 patients who received PF-LCP. In the early period, screw cut-out was detected in 1 patient, and loosening and dislocation of screws were detected in 1 patient. The reduction was found to be inadequate in the portion involving the trochanter minor where medial cortex impaction could not be achieved. Delayed union was detected in 2 patients, but was not regarded as failure, as union developed after a longer period. Grafting was performed in 1 patient.

Radiological examinations were made at 1, 2, 3 and 6 months postoperatively. Patients were evaluated in respect of walking, pain, and function. Patients in all groups were mobilised from postoperative day 1 by weight- bearing with a walker. The use of supportive equipment was ended in patients who underwent PFN and DHS who could achieve body balance in week 6. The use of supportive equipment(walker) was ended after adequate union was visualised radiographically (average 8 weeks) in patients who received PF-LCP.

DISCUSSION

Fractures of the trochanter region are common in elderly patients due to a decrease in bone quality. Comorbid diseases in these patients lengthen hospital stay and cause serious complications such as deep vein thrombosis, pulmonary embolism, urinary tract infection, and decubitus ulcers. Therefore, immediate mobilisation of elderly patients must be enabled (2,8). The first step is the accurate classification of the fracture as stable or unstable, and selection of the appropriate fixation method (6). A reverse oblique fracture line, fractures with subtrochanteric extension, varus angulation, right-angled fractures of the fracture line to the intertrochanteric line, and fractures with a medialised femur are regarded as unstable fractures. Generally, fractures involving the trochanter minor may be regarded as unstable fractures because there is a posteromedial defect (7-9). However, further research is needed because the size of the defect in that region, and the exact length (cm^2) that cause instability in the fracture have not yet been clarified. Achieving continuity of the medial and posteromedial cortex, sequencing that allows cortical impaction with loading, and slight valgus impaction are the criteria for a stable reduction. DHS is regarded as the gold standard in stable intertrochanteric fractures because the implant load will be smaller due to intact medial support. However, DHS does not provide the same success in unstable fractures (8,9,10,13). Lateral cortical support against excessive dislocating of DHS due to the telescope effect is prevented by a buffer effect (14). Gotfried et al. reported that preop 31A2 fractures of 24 patients transformed to 31A3 fractures after fracture of the lateral cortex (14). In the current series, evaluation of the contribution to instability of fracturing the lateral cortex revealed that lateral wall fractures developed in 2 patients, (preop 31A2.1 transformed to 31A2.3) and subsequently, failure was observed. Although they appear to be stable fractures, it can be recommended that osteoporotic fractures with a thinner lateral cortex are evaluated as unstable fractures and careful surgical technique and accurate fixation material should be selected. The cortex fracturing point due to the inability to resist loading, and the direction of dislocation of the screw are presented in schematic form in Figure 6. Dislocation of up to 15 mm in lag screws in the fixation of unstable fractures with DHS is acceptable. Steinberg et al. reported that adequate stability could not be provided and failure developed with medialisation in the femoral shaft in dislocation of the lag screw more than 15 mm (15). Failure was detected in 1 patient in the current study due to >15 mm lateral dislocation in the lag screw (Figure7). Wolfgang et al. reported the complication rate of DHS in stable fractures as 9% and as 19% in unstable fractures (16). In the current study, a high rate of failure was determined in 31A2. fractures, with thin lateral cortex and posteromedial cortex discontinuity (n=5)

PFN is the method that must mainly be used in unstable fractures (5,16-18). The complication rate that required revision after PFN has been reported in literature as 3-28%, and the rate of development of secondary varus as 0.8-8.6% (4,6). Furthermore, Bonneville et al reported that unstable intertrochanteric fractures in elderly patients had a higher rate of mechanical failure in the nailing group compared to arthroplasty (19). The failure rate in the current series was 9% (9/98), and the rate of development of secondary varus was 6% (6/98). The view that PFN can be safely applied to the patients with acceptable quality of reduction should be regarded with suspicion. It can be suggested that the fractured calcar region may be opened, reducted, and cortical continuity must be achieved and tied using cables to prevent failure in patients for whom medial cortical continuity and fragment stabilisation cannot be provided using closed reduction. Because patients with good reduction have a less insufficiency ($p<0.05$).

However, flexible fixation could be achieved using a minimally invasive approach in PF-LCP. In some patients, it may also enable open reduction and primary compression. Unlike DHS and PFN, PF-LCP does not allow controlled impaction (20). PF-LCP is not used in 31A1 and 31A2 intertrochanteric fractures, but is used together with multiple locked screws and provides biomechanical characteristics equivalent to a plate with a 95° angle (20,21).

Fracture assessment may be performed using bi-directional conventional radiography. However, the posteromedial edge must be evaluated using CT in multiple comminuted fractures, or in fractures with no posteromedial cortical continuity or suspected continuity. After CT imaging, posteromedial cortical contact was found to be absent in some stable 31A2-1 fractures (28/78) in the current study. Contrary to the common definition in the literature, 31A2.1-type fractures were not always stable fractures.

The most common mechanical failure in both DHS and PFN is the cut-out of head-neck fixation tools (screw, wedge or blade) (6,22-26). In addition, fixation of lag screws in the proper location, avoiding varus positioning during reduction, and tip-apex distance have been reported to cause failure in both methods. Researchers in some studies have reported that the best way to avoid failure was by preventing varus reduction (23,27-31). In the current study, it was shown that the most significant cause of failure among the 3 different fixation methods, particularly in unstable fractures, was failure to provide medial and posteromedial continuity ($p<0.001$)(table3).

PF-LCP fixation is mostly used in complex proximal femur fractures, and particularly in subtrochanteric extension fractures, multiple locked screws are advantageous for fixation in patients with poor bone quality, or with increased bone involvement in the femoral neck (32,33). Although some studies have reported 100% union rates in pertrochanteric fractures after PF-LCP fixation (34), others have reported failures at a rate of 38% because of screw cut-out accompanying varus collapse (35). Failure was detected as 14% in the current study. Screw breaks and varus collapse may be detected after axial loading forces when posteromedial edge continuity cannot be provided in pertrochanteric fractures (33). Therefore, it can be recommended that proximal plates should not be used in osteoporotic unstable comminuted fractures unless medial cortex continuity and primary impaction can be provided

There were some limitations to this study. The preoperative classification of patients in accordance with activity levels, comorbidities, bone quality and osteoporosis degree was not evaluated. These are factors that affect the rate of mechanical complications. In addition, the required reduction may not have been accomplished as surgery was performed without the use of a traction table. Other limitations were that it was a retrospective study, and development of failure was dependent on surgeon-related factors.

CONCLUSION

Implants must be selected after the classification of the fracture as stable or unstable. The quality of reduction is the determinant of failure and SWS score. As stated in literature, 31A2.1 fractures should not always be accepted as stable. In the evaluation of the posteromedial corner, CT imaging should be applied in cases of suspected AO 31 A2.1 and 31 A2.2 type fractures.To avoid failure, it is essential that achieving medial calcar and posteromedial cortex continuity is not ignored.

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