Research Article / Araştırma Makalesi

Influence of Initial Displacement on Union in Collum Femoris Fractures

Femur Boyun Kırıklarında Başlangıç Deplasmanının Kırık Kaynamasındaki Önemi

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Abstract: Many factors affect the union of the fracture in collum femoris fractures in adults. We aimed to examine the relationship between the preoperative displacement, the postoperative displacement, and the preoperative waiting time with the union of the fracture. The present study was carried out retrospectively with 52 patients. The patients were divided into three groups according to the union time. Fracture union took 12 weeks or less constituted Group 1 (n=25), patients with the union over 12 weeks constituted Group 2 (n=19), and patients with nonunion formed Group 3 (n=8). Computed tomography was used for the preoperative measurements, and postoperative displacement measurements were made with X-ray.There was no statistically significant difference between the 3 groups regarding the preoperative waiting time and postoperative displacement. While there was no statistically significant difference between Groups 1 and 3, and Groups 2 and 3 for preoperative displacement, the difference was statistically significant in the comparison of Groups 1 and 2 (p=0.046). Between Groups 1 and 2, it was observed with 78.3% accuracy, 73.7% sensitivity, and 72% specificity that there was delayed union in patients with the preoperative displacement of 9.5 mm and above.In the present study, in which the relationship between initial displacement, postoperative displacement, and preoperative waiting time with the fracture union was examined, it was concluded that delayed fracture union could occur when the initial displacement is more than 9.5 mm.
Keywords: Collum femoris fracture, initial displacement, delayed union, nonunion,

Özet: Erişkin kollum femoris kırıklarında birçok faktör kırığın kaynamasını etkiler. Bu çalışmada preoperatif deplasman miktarı, postoperatif deplasman miktarı ve ameliyat öncesi bekleme süresi ile kırık kaynaması arasındaki ilişkiyi incelemeyi amaçladık. Çalışma retrospektif olarak 52 hasta ile gerçekleştirildi. Hastalar kaynama zamanına göre üç gruba ayrıldı. 12 hafta ve daha kısa sürede kaynama olan hastalar Grup 1 (n=25), kaynama süresi 12 haftayı geçen hastalar Grup 2 (n=19), kaynamayan hastalar Grup 3 (n=8) olarak belirlendi. Ameliyat öncesi ölçümlerde bilgisayarlı tomografi, ameliyat sonrası yer değiştirme ölçümleri ise direk grafi ile yapıldı.Preoperatif bekleme süresi ve postoperatif deplasman bakımından 3 grup arasında istatistiksel olarak anlamlı fark yoktu. Preoperatif deplasman açısından Grup 1 ve 3 ile Grup 2 ve 3 arasında istatistiksel olarak anlamlı fark bulunmazken, Grup 1 ve 2 karşılaştırıldığında fark istatistiksel olarak anlamlı bulundu (p=0,046). Grup 1 ve 2 arasındaki değerlendirmede preoperatif deplasmanın 9,5 mm ve üzerinde olan hastalarda %78,3 doğruluk, %73,7 duyarlılık ve %72 özgüllük ile kaynamada gecikme olduğu görüldü. Kırık kaynaması ile başlangıç deplasmanı, postoperatif deplasman ve ameliyat öncesi bekleme süresi arasındaki ilişkinin incelendiği bu çalışmada başlangıç deplasmanının 9,5 mm'den daha fazla olduğu kollum femoris kırıklarında kırık kaynamasının geçiktiği görüldü.
Anahtar Kelimeler: Femur boyun kırığı, başlangıç deplasmanı, kaynama gecikmesi, kaynamama

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Received 18.08.2023 ***Accepted*** 27.10.2023 ***Online published*** 07.11.2023

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1. Introduction

Annually, 4.5 million individuals worldwide experience disability due to hip fractures, and the incidence of hip fractures is on the rise(1). Collum femoris fractures in adults typically result from high-energy trauma and present a relatively low incidence (2). Although not a common occurrence, they can result in severe complications for the patients (3) While the preferred treatment for collum femoris fractures in elderly patients is hemiarthroplasty or total hip replacement, the primary goal in younger patients is to protect the femoral head (4).

Nonunion and avascular necrosis (AVN) may be encountered after collum femoris fracture operations in young patients (3). Despite the various factors reported to influence treatment outcomes in the current literature, the degree of preoperative displacement, achieving anatomical reduction, and expediting the surgery take precedence over other factors in ensuring treatment success (3,5).

It was reported that the initial displacement increased the complications in collum femoris fractures (6,7). The Garden classification is the most commonly used in evaluating collum femoris fractures and is based on whether the fracture is displaced or not (8,9,10). Nondisplaced fractures are classified as Garden Types 1 and 2, while displaced fractures are classified as Garden Types 3 and 4. The major problem with this classification is that it is done subjectively without using any measurement method, so its reliability is low (11). No study in the current literature has specifically examined the influence of the amount of displacement in collum femoris fractures on fracture union. The objective of this study was to explore the effects of initial displacement, as determined by parametric measurements, postoperative displacement, and preoperative waiting time on fracture union in collum femoris fractures.

2.Materials and Methods

The present study was conducted retrospectively after the ethics committee's approval was obtained from the hospital. It was not considered necessary to get consent from the patients because the study was a retrospective data analysis. Adult patients under 65 years old were admitted to the emergency department with collum femoris fracture and treated surgically between 2007 and 2020. Patients with pathological fractures who had undergone endoprosthesis did not attend their regular follow-up visits, did not complete a follow-up period of at least one year, and were excluded from the study. The study included 52 patients with collum femoris fractures treated with internal fixation. All operated patients were mobilized without weight bearing on the first day of the operation. Routine outpatient clinic checks after discharge were performed at 2, 4, 6, 10, 12 weeks and 4, 5, 6, 9 and 12 months. Patients who did not have pain during follow-up and have adequate union on X-ray were allowed to mobilize with full weiht bearing

Demographic data such as age and gender, along with fracture site, trauma mechanism, follow-up duration, preoperative waiting period, type of reduction (open/closed), and specifics of the implant used for fixation were meticulously extracted from patients' medical records. The fractures were classified according to the Garden classification, and radiological evaluations encompassed the extent of preoperative displacement, postoperative displacement, and fracture union. Two orthopedic surgeons conducted the radiological measurements, yielding excellent intraclass correlation coefficients (ICC= 0.95 $p < 0.001$). The initial measurements by the first observer were considered for analysis.

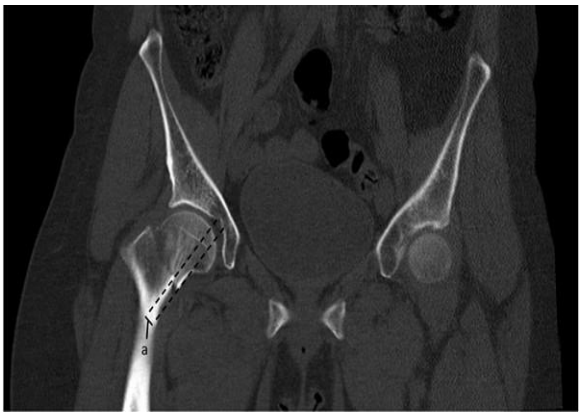


Figure 1. *Measurement of the preoperative displacement on CT*

All radiological measurements were facilitated using the hospital's Picture Archiving and Communication System (PACS). The plane displaying the highest displacement in the computed tomography (CT) scan was utilized for preoperative displacement assessment. A line was drawn proximal and distal to the fracture line, where cortical integrity was compromised. The gap between these lines was measured using the PACS system (see Figure 1). Postoperative displacement was evaluated using the anteroposterior (AP) view of radiographs taken on the first postoperative day. The extent of stepping at the fracture line and the implant widths were measured using PACS (see Figure 2). As the implant widths were predetermined (e.g., 6.5 mm cannulated screw), they were leveraged for calibration, enabling precise assessment of the stepping at the fracture line (11,12).

Figure 2. *Measurement of the postoperative displacement on X-ray c: Measurement of the cannulated screw diameter on X-ray.*

The fracture union was evaluated with X-rays taken during the outpatient clinic follow-ups. The fracture union was accepted in patients who showed union on the radiographs and experienced full weight bearing without pain. Twelve weeks was determined as the expected duration of union (3,13). Patients whose fracture union occurred in 12 weeks and earlier comprised Group 1, patients whose fracture union occurred after 12 weeks included Group 2, and patients who still do not have fracture union at the end of the first

year comprised Group 3(14).The preoperative waiting time, amount of preoperative displacement, and amount of postoperative displacement were measured in the determined groups, and their relationship with the fracture union was examined.

The collected data were evaluated using IBM SPSS Statistics for Windows 20.0 (IBM Corp., Armonk, NY, USA). The statistical significance of the difference between preoperative displacement, postoperative displacement, and preoperative waiting times was determined using the Kruskal-Wallis test for the sample divided into three groups according to the duration of fracture union. Bonferroni correction was used in the post hoc analyses. In the sub-analysis, which included the groups with the fracture union and those with the delayed union, the reference number of displaced fractures that completed the union process in 12 weeks or longer was determined using receiver operating characteristic (ROC) analysis. P <0.05 was considered significant.

3.Results

Of the 52 patients included in the study, 33 (63.5%) were male, and 19 (36.5%) were female. The mean age was 41.9 ± 9.9 years. The mean follow-up period of the patients was 51.5 ± 26.2 months. 30 patients (57.6%) had right collum femoris fracture, while 22 (42.3%) patients had left collum femoris fracture. Collum femoris fractures occurred in 23 (44.2%) patients as a result of a ground-level fall, while 16 (30.8%) had it due to falling from a height, 12 (23.1%) from traffic accidents, and 1 (1.9%) as a result of the assault.

Concerning the Garden Type, 5 (9.6%) of the fractures were Garden Type 1, 8 (15.4%) were Type 2, 26 (50%) were Type 3, and 13 (25%) were Type 4. While open reduction was applied for only one patient, the other patients were reduced as closed and internal fixation was carried out. Cannulated screws were used for fixation in 49 (94%) patients, cephalomedullary nails were used in 2 (3.8%) patients, and a plate was used in 1 (1.9%) patient. The mean preoperative waiting time for all patients was 22.77 (median 10) hours, the amount of preoperative displacement was 10.73 ± 7.11 mm, and the amount of postoperative displacement was 1.03 ± 1.65 mm.

Table 1. Relationship between the Pre-postoperative Amount of Displacement and Preoperative Waiting Time with Union Times

		N	Mean	SD. Deviation	SD. Error	95% Confidence Interval for the Mean		Min.	Max.
						Lower Bound	Upper Bound		
PREOP DISPLACEMENT (mm)	≤12 weeks	25	8.32	6.688	1.338	5.56	11.08	0	27
	>12 weeks	19	13.79	7.391	1.696	10.23	17.35	6	28
	Nonunion	8	11.00	5.398	1.909	6.49	15.51	7	22
	Total	52	10.73	7.118	0.987	8.75	12.71	0	28
POSTOP DISPLACEMEN	≤12 weeks	25	0.340	1.0075	0.2015	-0.076	0.756	0	4.0
	>12 weeks	19	1.432	1.8589	0.4265	0.536	2.328	0	6.0

T (mm)	Nonunion	8	2.250	1.9086	0.6748	0.654	3.846	0	4.0
	Total	52	1.033	1.6505	0.2289	0.573	1.492	0	6.0
PREOP WAITING TIME (hours)	≤12 weeks	25	31.64	56.086	11.217	8.49	54.79	3	240
	>12 weeks	19	11.32	5.860	1.344	8.49	14.14	3	24
	Nonunion	8	22.25	23.414	8.278	2.68	41.82	6	72
	Total	52	22.77	40.684	5.642	11.44	34.10	3	240

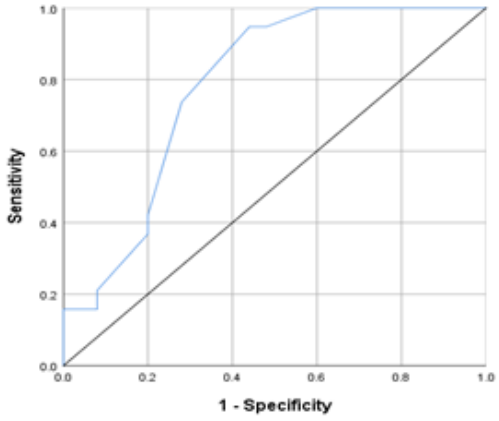
With the grouping that was carried out according to the 12-week union time, there were 25 (48%) patients in Group 1, which consisted of patients whose fracture healed within 12 weeks, and 19 (36%) patients in Group 2, where the union of the fracture took longer than 12 weeks, and 8 (15%) patients with nonunion in Group 3. The mean values of the preoperative waiting times, preoperative amount of displacement, and postoperative amount of displacement for these three groups were given in Table I. The statistical analysis of factors affecting unions according to groups was shown in Table II. There was no statistically significant difference between the groups regarding the preoperative waiting time and postoperative displacement ($P > 0.05$). In the post hoc analyses, no statistically significant difference was found between Groups 1 and 3 or Groups 2 and 3 with the preoperative amount of displacement ($P = 0.60$ and $P = 0.64$, respectively). In comparing the amount of preoperative displacement between Groups 1 and 2, it was seen that the preoperative displacement of the patients in Group 2 was statistically significantly higher than in Group 1 ($P = 0.046$).

Table 2. Statistical analysis between groups

	Group		**Mean Difference (I-J)**	**SD. Error**	**Sig.**	**95% Confidence Interval**	
						Lower Bound	**Upper Bound**
PREOP DISPLACEMENT (mm)	1	2	–5.469*	2.160	0.046	–10.87	-0.07
		3	–2.680	2.331	0.609	–8.96	3.60
	2	1	5.469*	2.160	0.046	0.07	10.87
		3	2.789	2.553	0.640	–3.93	9.51
	3	1	2.680	2.331	0.609	–3.60	8.96
		2	-2.789	2.553	0.640	–9.51	3.93
	1	2	–1.0916	0.4717	0.084	–2.295	0.112

	1	3	–1.9100	0.7042	0.075	–4.008	0.188
POSTOP DISPLACEMENT		1	1.0916	0.4717	0.084	–0.112	2.295
	2	3	–0.8184	0.7983	0.691	–3.006	1.369
(mm)		1	1.9100	0.7042	0.075	–0.188	4.008
	3	2	0.8184	0.7983	0.691	–1.369	3.006
		2	20.324	11.298	0.232	–8.61	49.25
	1	3	9.390	13.941	0.879	–25.98	44.76
PREOP WAITING TIME		1	–20.324	11.298	0.232	–49.25	8.61
	2	3	–10.934	8.387	0.546	–36.68	14.81
(hours)		1	–9.390	13.941	0.879	–44.76	25.98
	3	2	10.934	8.387	0.546	–14.81	36.68

The relationship between the amount of preoperative displacement of these two groups (Groups 1 and 2) that differed significantly and the time of union of the fracture was examined. In the evaluation made with ROC curve analysis, it was observed with 78.3% accuracy, 73.7% sensitivity, and 72% specificity that the patients with the preoperative displacement of 9.5 mm and above had delayed union. The relationship between the amount of displacement and the union of the fracture is given in Graph 1.



Graphic 1. *ROC curve analysis the relationship between the amount of displacement and the union of the fracture*

4. Discussion

Although a fracture of the collum femoris is rare among young patients, its significance for orthopedic surgeons and patients is paramount due to the challenging treatment and potential severe complications (4). These fractures typically result from high-energy trauma, causing a disruption in the blood supply to the femoral head (6). Particularly in cases of displaced fractures, vascular structures supplying the femoral head sustain greater damage, leading to a higher incidence of complications such as nonunion and avascular necrosis (15). Consequently, orthopedic surgeons strive to promptly achieve stable fixation with anatomically reduction in treating collum femoris fractures among young patients, aiming to maintain a sustained blood flow to the femoral head. (16).

One longstanding debate in orthopedics pertains to whether the preoperative waiting period influences outcomes in collum femoris fractures(16). Manninger et al. reported fewer complications associated with early surgical intervention in collum femoris fractures (17). Jain et al. suggested that delayed surgery could result in higher radiological findings and AVN compared to early surgical intervention(18). Conversely, Upadhyay et al. found no detrimental effect on fracture union due to delayed surgery, as demonstrated in their study involving patients operated on after 48 hours (19). Butt et al. similarly concluded that delayed surgery was not a significant factor contributing to nonunion in collum femoris fractures (20). In the present study, there was no statistical difference between the three groups (union/delayed union/non-union) regarding preoperative waiting times. These results were in agreement with the opinion of Butt et al., in that the preoperative time is not one of the major causes of nonunion in collum femoris fractures (20).

Anatomical reduction holds paramount importance in the treatment of collum femoris fractures in young adults (3,21). Kyle et al. emphasized that achieving anatomical reduction of the fracture is a critical aspect in treating collum femoris fractures among young patients (22). Haidukewych et al. underscored the importance of reduction quality in collum femoris fracture treatment. They defined a displacement of less than 2 mm as excellent reduction and up to 5 mm as good reduction in their study (23). In the present study, the mean postoperative displacement for all patients was 1.03 ± 1.65 mm, falling within the range considered excellent. However, 19 (36%) patients in Group 2 experienced delayed union, while 8 (15%) patients in Group 3 developed non-union. This finding supports Gottfried et al.'s assertion that successful anatomical reduction does not always guarantee fracture union without complications (24).

Parker et al. stated that although the most severe complications of collum fractures are nonunion and osteonecrosis, nonunion can be regarded as the most critical complication considering their incidence (25). Parker et al. reported a higher nonunion rate in displaced fractures than in nondisplaced fractures (25). In their study, Yang et al. reported that the risk of nonunion in displaced collum fractures was 2.93 times higher than in nondisplaced fractures (7). In these two studies and similar studies in the literature, the Garden classification was used to classify fracture. Although the Garden classification is the most preferred classification for collum femoris fractures, it has been stated by many researchers that its reliability is low (8,26,27). Alho et al. thought that the Garden classification was not sufficient to distinguish between nondisplaced and displaced due to the lack of a continuous scoring scale and thus, they measured the preoperative displacement in mm (11). In this study, we examined the relationship between the initial displacement amount and fracture union in collum femoris fractures. The initial displacement was measured in millimeters. There was no statistically significant difference in initial displacement between Groups 1 and 3, and Groups 2 and 3. However, the difference between Groups 1 and 2 was significant (P = 0.046). Groups 1 and 2 was examined by ROC curve analysis, it was found that union was delayed in fractures with a displacement of 9.5 mm and above. In contrast to the existing literature, our study concluded that displaced fractures lead to delayed union, rather than non-union. The key takeaway is that in cases of Collum femoris fractures with a high level of displacement, it's important not to rush into a decision for a second surgery (osteotomy, arthroplasty). Careful evaluation and consideration of the individual circumstances and the healing process should guide the decision-making for any additional surgical interventions.

The present study considered three parameters (preoperative waiting time, preoperative displacement, and postoperative displacement). However, the literature suggests that various factors such as age, comorbidities, osteoporosis, steroid usage, alcohol abuse, and screw placement may influence the treatment of collum femoris fractures in young adults (7,28,29). Although patients in Group 3 exhibited similar

preoperative waiting times, preoperative displacement amounts, and postoperative displacement amounts to the other two groups, their fractures did not heal within the one-year follow-up period. We believe that the non-union of these fractures may be linked to the aforementioned factors, which are beyond the scope of this study.

A limitation of the present study is its retrospective nature. Additionally, the measurement of postoperative displacement was conducted using X-rays due to the routine unavailability of postoperative CT imaging for our patients. The study's sample size is also a limitation, and more precise data may be obtained in larger patient grups.

In conclusion, preserving the femoral head is the primary objective in treating collum femoris fractures among young patients. Several factors influence the fracture healing process. This study investigated the relationship between initial displacement, preoperative waiting time, and postoperative displacement with fracture union. Fractures with an initial displacement of 9.5 mm or more experienced delayed union. Notably, essential factors affecting fracture union, such as preoperative waiting time and postoperative displacement, did not differ significantly between patient groups, reinforcing the significance of this result.

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Ethics

Ethics Committee Approval: The study was approved by Marmara University Clinical Research Ethical Committee (Decision no:09.2021.754, Date: 02.07.2021).
Informed Consent: The authors declared that it was not considered necessary to get consent from the patients because the study was a retrospective data analysis.
Authorship Contributions: Concept: ÖB. Design: HK.Data Collection ZS. Analysis and Interpretation: MK,BE. Writing: HK.**Copyright Transfer Form:** Copyright Transfer Form was signed by all authors.
Peer-review: Internally peer-reviewed.
Conflict of Interest: No conflict of interest was declared by the authors.
Financial Disclosure: The authors declared that this study received no financial support.