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Functional and radiological results of the surgical treatment of pediatric femoral neck fractures

Pediatrik femur boyun kırıklarının cerrahi tedavisinin fonksiyonel ve radyolojik sonuçları

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ABSTRACT

Objective: Our aim in this study was to evaluate the demographic data on femoral neck fractures, postoperative complications, and functional and radiological results following its surgical treatment in the pediatric age group. Pediatric femoral neck fractures often occur after high-energy trauma and seen rarely.

Material and Methods: Twenty-six patients who underwent surgery after the diagnosis of femoral neck fracture in our clinic between 2012 and 2019 were examined. Demographic data, trauma mechanism, accompanying injuries, and postoperative complications of the patients were recorded from our registry system. Functional radiological evaluation was performed using Ratliff criteria.

Results: The mean age of the participants in the study was 11.11 (3–16) year, and the mean follow-up time was 29.34 (12-60) months. According to Ratliff criteria, 18 patients (69.2%) achieved good, 6 patients achieved (23.1%) moderate, and 2 patients achieved (7.7%) poor results after surgery. Avascular necrosis was observed in 5 patients (19.2%) in total. Avascular necrosis did not occur in 10 patients who underwent surgery within first 6 hours. Avascular necrosis occurred in 5 (31.25%) out of 11 patients who underwent surgery after 6 hours. This result was statistically significant (p = 0.049). Of the 5 patients with avascular necrosis, 3 were female and 2 were male. The clinical and radiological results were evaluated according to the Ratliff criteria, and the results were found to be worse in females than in men. There was a statistically significant difference between the genders (p=0.029).

Conclusion: Although femoral neck fractures are rare injuries in the pediatric age group, they are important due to the high risk of complications. The most important complication is avascular necrosis. Results are better males than in females. The results of surgical treatments aimed at anatomical reduction in the shortest possible time are satisfactory.

Keywords: Femoral neck fracture, pediatric, avascular necrosis, Delbert classification.

ÖZ

Amaç: Bu çalışmamızda pediatrik yaş grubunda femur boyun kırığı nedeniyle opere edilen hastaların demografik verilerini, komplikasyonlarını ve tedavi sonuçlarını değerlendirmeyi amaçladık.

Materyal ve Metot: 2012-2019 yılları arasında kliniğimizde femur boyun kırığı tanısı ile opere edilen 26 hasta incelendi. Kayıt sistemimizden hastaların demografik bulguları, travma mekanizması, eşlik eden yaralanmaları ve ameliyat sonrası gelişen komplikasyonları kaydedildi. Hastalarda fonksiyonel radyolojik değerlendirme Ratliff kriterleri kullanılarak yapıldı.

Bulgular: Çalışmaya katılanların yaş ortalaması 11,11 (3-16) yıl, ortalama takip süresi 29,34 (12-60) aydı. Hastaların %65,4' ü erkek (n=17), %34,6 'sı (n=9) kadın hastaydı. Delbert sınıflama sistemine göre ameliyat öncesi 14 hasta tip 2, 12 hasta tip 3 kırıktı. Ameliyat sonrası Ratliff skorlama sistemine göre 18 hasta (%69,2) iyi, 6 hasta (%23,1) orta, 2 hasta (%7,7) kötü sonuç olarak değerlendirildi.

Toplamda 5 hasta da (%19,2) avasküler nekroz görüldü. Bu 5 hastanın 2' si delberte göre tip 2, 3 tanesi delbert tip 3 kırıktı. İlk 6 saat içinde ameliyat edilen 10 hastada avasküler nekroz görülmedi. 6. Saatten sonra opere edilen 11 hastadan 5'inde (%31,25) avasküler nekroz gözlendi. İki grup arasında istatiksel olarak anlamlı fark saptandı (p=0,049). Avasküler nekroz görülen 5 hastanın 3'ü kız, 2'si erkek idi. Ratlife göre kadın hastaların 7'sinde iyi-orta sonuç, 2'sinde kötü sonuç saptandı. Erkek hastaların tamamında iyi-orta sonuç görülürken kötü sonuç saptanmadı. Klinik ve radyolojik sonuçlar Ratliff kriterlerine göre değerlendirildi ve sonuçların kadınlarda erkeklere göre daha kötü olduğu görüldü. Cinsiyetler arasında istatistiksel olarak anlamlı bir fark vardı (p=0.029).

Sonuç: Pediatrik yaş grubunda femur boyun kırıkları nadir görülen yaralanmalar olsa da yüksek komplikasyon riski sebebiyle önem taşır. En önemli komplikasyon avasküler nekrozdur. Sonuçlar erkeklerde kadınlara göre daha iyidir. Mümkün olan en kısa sürede anatomik redüksiyonu amaçlayan cerrahi tedavinin sonuçları tatmin edicidir.

Anahtar kelimeler: Femur boyun kırığı, Çocuk, Avasküler nekroz, Delbert sınıflaması

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Introduction

In the pediatric age group, a femoral neck fracture is a rare injury that accounts for <1% of all pediatric fractures [1, 2]. This is due to the strong periosteum and bone structure in children [3]. The anatomy and supply of the proximal femur is different in the pediatric and adult age groups. The primary blood supply of the proximal femur is from the medial circumflex artery. Damage to the superior retinacular branch of the medial circumflex artery is often considered to be the cause of the development of avascular necrosis [4].

Pediatric femoral neck fractures often occur after high-energy trauma. It is categorized by Delbert classification, which both guides the treatment and helps determine the risk of developing avascular necrosis [5]. The Ratliff criteria are used in the classification of functional and radiological results after surgery and they are the most commonly used assessment system in the pediatric age group [6]. Femoral neck fractures have a high rate of complications despite proper diagnosis and treatment [5]. Complications at a rate of 20%–50% have been reported in long-term follow-ups [3, 7, 8]. The most important complication is the development of avascular necrosis and other significant ones include coxa vara, physeal arrest, limb-length inequality and nonunion. Damage to the trochanteric apophysis and abductor musculature during trauma disrupts the angulation and growth of the femoral neck, causing coxa valga, whereas excessive growth causes coxa vara [5]. The main factors affecting the treatment results include age, gender, fracture type and time until surgery.

The aim of this study was to evaluate the etiology of femoral neck fractures and functional and radiological results after surgical treatments, in the pediatric age group.

Materials and Methods

The study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the Ethical Committee of Kahramanmaras Sutcu Imam University (Approval Date: 2020-08-26, Decided Number: 08, Session: 2020/16). In this study, thirty-five patients aged between 3 to 16 years who underwent surgery after a diagnosis of femoral neck fracture in the clinic between 2012 and 2019, were retrospectively analyzed. Patients with open proximal epiphysis without additional injury were included in the study. Patients younger than age 3 and with metabolic diseases and pathological fractures, were excluded from the study. Nine additional patients who did not meet the criteria were excluded from the study. Demographic findings, trauma mechanism, accompanying injuries, and complications of the patients were recorded from our registry system.

Prior to surgery, fractures of the patients were classified according to the Delbert classification: type 1 fractures are transepiphyseal fractures, type 2 fractures are transcervical fractures, type 3 fractures are cervicotrochanteric fractures and type 4 fractures are intertrochanteric fractures. The Ratliff criteria were used for the classification of postoperative functional and radiological results. Based on this criteria, the patients were evaluated according to postoperative pain, joint range of motion, activity status and radiological features of the proximal femur. Avascular necrosis was diagnosed by magnetic resonance imaging [Figure 1].

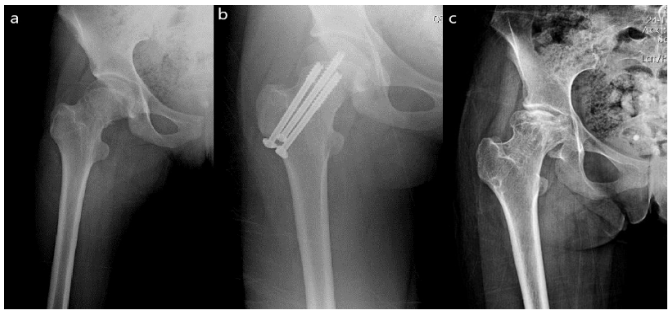

Figure 1. Preoperative (a), early postoperative (b) and postoperative first-year (c) radiography of the patient who developed avascular necrosis.

The patients underwent surgery as soon as possible after being evaluated in the emergency department. All patients were placed in the supine position under general anesthesia and closed reduction was achieved with the help of fluoroscopy. After reduction was achieved, percutaneous fixation was performed with two cannulated screws (2 cannulated screws 4 mm or 5 mm, depending on the patient's bone structure and age). The entry points of the screws were fixed proximal to the trochanter minor, parallel to each other in the coronal plane, with one screw

anterior and one screw posterior in the sagittal plane. All patients were operated by the same surgical team. Open reduction was performed in one patient in whom closed reduction could not be performed. Fixation was performed using the same brand of cannulated screws (4 mm or 5 mm) in all patients [Figure 2]. Antibiotic prophylaxis was given to all patients. Splint was not applied to any patient after the surgery. All patients were told not to bear any weight while walking for 6 weeks, and they were allowed to bear partial weight after 6 weeks as well as full weight after 12 weeks.

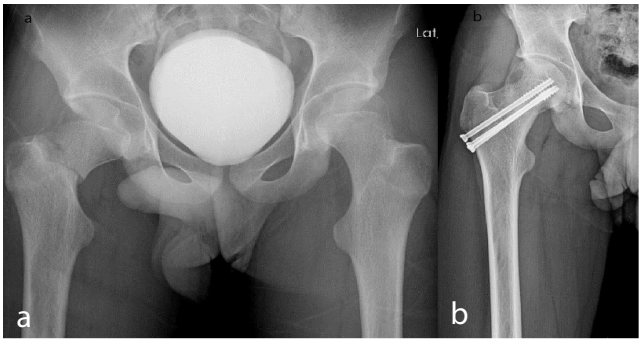

Figure 2: Preoperative (a) and postoperative second-year (b) radiography of a male patient with a femoral neck fracture

Results

The mean age of the participants in the study was 11.11±4.42 (3–16) year, and the mean follow-up time was 29.34±17.34 (12–60) months. The right side was operated in 15 patients (57.7%) and the left side in 11 patients (42.3%). Of the patients, 65.4% (17 patients) were male and 34.6% (9 patients) were female. Before surgery, 14 patients (53.8%) had type 2 and 12 patients (46.2%) had type 3 fractures according to the Delbert classification. The most common etiology was fractures due to motor vehicle accidents, with a rate of 38.5%. Moreover, 5 patients had fractures due to falling indoors, 3 patients due to falling from a height, 2 patients as a result of sports injuries, 2 patients due to falling from a bicycle, and 4 patients due to falling from stairs. Among the patients, 38.5% (10 patients) underwent surgery within first 6 hours, 42.3% (11 patients) between 6 and 24 hours and 19.2% (5 patients) after 24 hours (Table 1).

According to the Ratliff criteria, 18 patients (69.2%) achieved good results, 6 patients (23.1%) achieved moderate results and 2 patients (7.7%) achieved poor results after surgery. Additionally, there was no statistically significant difference between fracture types (p=0.241). Comparison of clinical and radiological results of cases according to constant variables is shown in Table 2. Avascular necrosis occurred in 5 patients (19.2%) in total and of these 5 patients, 2 had type 2 fractures and 3 had type 3 fractures, according to the Delbert classification (Table 1).

Table 1. Demographics of the patients and fractures

Age (year)		11,11±4,42 (3-16)
Follow-up (months)		29,34±17,34 (12-60)
Gender	Female	9 (34.6%)
	Male	17 (65.4%)
Fracture classification (Delbert)	Type 2	14 (53.8%)
	Type 3	12 (46.2%)
Side	Right	15 (%57.7)
	Left	11 (%42.3)
Operation time (hour)	0-6	10 (38.5%)
	6-24	11 (42.3%)
	>24	5 (19.2%)
Ratliff's Classification of Avascular Necrosis	Type 2	2 (7.7%)
	Type 3	3 (11.5%)
	Female	3 (11.5 %)
	Male	2 (7.7 %)

There was no statistically significant difference between fracture types in terms of development of avascular necrosis (p=0.150). Comparison of the incidence of AVN according to constant variables is shown in Table 3. Of the 5 patients with avascular necrosis, 3 were female and 2 were male [Figure 2]. There was no statistically significant difference between genders in terms of the development of avascular necrosis (p=0.184). Seven of the female patients achieved good to moderate results and 2 achieved poor results, again according to the Ratliff criteria. All male patients achieved good to moderate results and no bad results. According to the applied criteria, the results were worse in female and there was a statistically significant difference between the genders (p=0.029). Avascular necrosis did not occur in 10 patients who underwent surgery within first 6 hours, although it was observed in 5 (31.25%) out of 16 patients who underwent surgery after 6 hours [Table 2]. This result was statistically significant (p=0.049). Ten patients who underwent surgery in the first 6 hours achieved good to moderate results, whereas 14 patients achieved good to moderate results and

2 patients achieved poor results, according to the Ratliff criteria, among patients who underwent surgery after 6 hours. It was found that the time of surgery did not have any statistically significant effect on functional and radiological results [Table 2].

Table 2. Comparison of radiological and functional results of cases according to constant variables

		Good	Fair	Poor	P value
Gender	Female	7	0	2	0.029
	Male	11	6	0	
Fracture type (Delbert classification)	Type 2	9	3	2	0.241
	Type 3	9	3	0	
Operation time	<6 hour	9	1	0	0.177
		9	5	2	

Table 3. Comparison of AVN incidence of cases according to constant variables

		AVN -	AVN +	P value
Gender	Female	6	3	0.184
	Male	15	2	
Fracture type (Delbert classification)	Type 2	12	2	0.150
	Type 3	9	3	
Operation time	<6 hour	10	0	0.049
		11	5	

Discussion

Femoral neck fractures are relatively rare injuries in the pediatric age group compared to the adult age group [9]. Due to the growth pattern of the pediatric femur and the high risk of complications, treatment should be planned and provided as soon as possible. Femoral neck fracture occurs as a result of high-energy trauma in this age group due, resulting from the characteristics of the bone structure. Falling from a height and motor vehicle accidents have been reported as the most common etiological factors in the literature [6, 10]. Apart from this, femoral neck fracture can also occur due to slipped proximal femoral epiphysis, bone cysts and stress fractures [11, 12]. In the present study, motor vehicle accidents constituted the most common etiological factor, with a rate of 38.5%.

The Delbert classification is the most commonly used system for the classification of pediatric femoral neck fractures [6]. It is an anatomical classification that provides useful information about the development of avascular necrosis. In a meta-analysis study, it has been reported that fracture type and patient age at the time of injury, are the most important factors in the development of avascular necrosis [13]. The increase in the risk of avascular necrosis in elderly patients is due to a decrease in the revascularization ability of the femoral head with age [4]. In studies about femoral neck fractures in the literature, type 2 fractures have been reported most frequently, followed by type 3 fractures. Type 2 and type 4 fractures account for 65% to 85% of all pediatric femoral neck fractures [12, 14]. Some studies in the literature report that the development of avascular necrosis is most common in type 1 fractures and least common in type 4 fractures [15]. In the present study, 14 patient (53.8%) had type 2 fractures and 12 patients (46.2%) had type 3 fractures, which was consistent with the literature.

Some studies in the literature have reported that open reduction and internal fixation cause fewer complications than closed reduction and internal fixation [1, 14]. Additionally, there are studies reporting that open reduction and internal fixation reduces the incidence of avascular necrosis [16]. They attributed this to the reduction of intracapsular pressure by capsulotomy and the chance for better evaluation of fracture reduction in open reduction. Since we believed that open reduction would not be appropriate in the pediatric age group, we primarily preferred closed reduction and internal fixation in our patients. We performed open reduction and internal fixation in only one patient, on whom we could not perform closed reduction.

Implant selection depends on the child's weight, age, bone structure and the surgeon's preference. There are studies in the literature suggesting that the use of fewer implants reduces the rate of complications, since it causes less damage to the vascular structure [17]. In our patients, we performed fixation with two cannulated screws (4 mm or 5 mm), depending on the bone structure and age of the patient.

Complication rates of pediatric femoral neck fractures are high. There are studies in the literature reporting complications at rates of 10%

to 60% [3, 15, 18]. Avascular necrosis is the most common complication after femoral neck fracture in children [10]. In addition, other potential complications include infection, nonunion or delayed union, coxa vara and leg length inequality. Postoperative infection occurs in <1% of cases [19]. No postoperative infections occurred in our patients, although the risk of avascular necrosis depends on a number of factors such as age, time until surgery and fracture type. The most important risk factor is the degree of vascular damage that occurs during trauma [20-22]. In our study, the rate of avascular necrosis was 19.2%. Coxa vara, leg length inequality and nonunion, which have been reported in the literature, were not observed in the present study.

Another factor that increases the risk of avascular necrosis is the time between injury and surgery. In the literature, there are studies reporting that the risk of avascular necrosis increases as the time until surgery increases [23, 24]. Bombaci reported the rate of avascular necrosis to be 54.6% in patients who underwent surgery after 24 hours [25]. In another study in which patients underwent surgery within the first 12 hours, this rate was reported to be 25%. Moreover, there are studies reporting that the time until surgery does not increase the risk of avascular necrosis [26]. In our study, avascular necrosis did not occur in patients who underwent surgery within first 6 hours, whereas the incidence of avascular necrosis was 31.25% in patients who underwent surgery after 6 hours. This result was also statistically significant (p=0.049). According to the Ratliff criteria, the rate of good results was 90% in patients underwent surgery within first 6 hours, whereas the rate of good results was 56.25% in patients who underwent surgery after 6 hours. According to our study, avascular necrosis rates were lower in patients who underwent surgery early and the results were better according to the Ratliff criteria.

In our study, 18 patients (69.2%) achieved good results, 6 patients (23.1%) achieved moderate results and 2 patients (7.7%) achieved poor results, according to the Ratliff criteria. Our results were consistent with the data in the literature [6, 24, 27]. The avascular necrosis rate was 11.76% in males and 33.33% in females. Although this result was not statistically significant, the avascular necrosis rate in females was higher in our study. The clinical and radiological results were evaluated according to the Ratliff criteria, and the results were found to be worse in females than in males and there was therefore a statistically significant difference between the genders.

The limitations of the study are that it is a retrospective study and the low number of cases.

Conclusion

Although femoral neck fractures are rare injuries in the pediatric age group, they are significant due to the high risk of complications, the most important of which is avascular necrosis. The patient's age, gender, fracture pattern and time until surgery are the main factors that determine the results of the treatment. Results are better in males than in females. The results of surgical treatment aiming at anatomical reduction and internal fixation within the shortest possible time are promising.

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critical review.

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