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Radiological and clinical outcomes of Metaizeau technique in treatment of Judet type 3 and 4 radial neck fractures in children

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Abstract

Radial neck fractures occur in 5–10% of severe elbow injuries in children. Conservative care primarily treats fractures with minimal angulation, while closed reduction is necessary for fractures significantly displaced. If reduction is not achievable, surgical intervention is necessary. The aim of this study was to evaluate treatment outcomes and possible complications associated with radial neck fractures managed via the metaizeau technique. A retrospective analysis was conducted on 29 patients aged 4 to 14 years who received surgery for radial neck fractures from 2016 to 2023. The mean arm-carrying angle of the unaffected was 13.79 degrees, while the mean arm-carrying angle of the affected was 14.13 degrees. The mean arm-carrying angle in patients were increased by an average of 0.34 degrees compared to the unaffected arm. The percutaneous leverage reduction using Kirschner wire (K- wire) was applied in 6 cases that could fail with closed reduction. Avascular necrosis was detected in 5 patients, and 3 of these patients were type 3 and 2 were type 4a. In patients with avascular necrosis, reduction was performed only with the mateizeau technique. No patients were seen with epiphyseal arrest. Our study shows that the mateizeau technique is an effective and safe choice of treatment for displaced radial neck fractures in pediatric patients. Especially in type 4 fractures, it is difficult to perform closed reduction; the percutaneous leverage technique with K-wire can be added to the metaizeau technique without the requirement for open surgical intervention.

Keywords: Radial neck fractures, metaizeau technique, children

Introduction

Radial neck fractures occur in 5–10% of severe elbow injuries in children, and their treatment is very difficult and controversial [1]. The damage mechanism is primarily caused by falling on an extended hand [2]. It has numerous possible implications that are often damaging to elbow function. Although the degree of the initial anatomical disruption, especially to the vascular circulation and physeal injury, plays an important role in the prognosis, the inadequacies of treatment similarly affect the prognosis [1].

Fractures with minimal angulation are managed just with immobilization, whereas significantly displaced fractures require surgical intervention [3]. Conservative treatment is insufficient for significantly displaced fractures, and even if reduction is achieved with many maneuvers, the possibility of subsequent displacement is elevated, and it will result in malunion [1].

Surgical treatment with open surgical intervention frequently leads to articular calcification, avascular necrosis, epiphyseal arrest, and articular rigidity [1]. For this reason, elastic intramedullary nailing for the management of radial neck fractures has been recommended in January 1980 by Métaizeau [4]. This technique involves inserting a Kirschner wire (K- wire) into the medullary canal of the radius and advancing it proximally

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until its tip contacts the inferior part of the epiphysis, therefore elevating the epiphysis. The primary benefit of this procedure is its ability to provide precise reduction and stable fixation at the same time with no damage to joint function [4]. This technique allows complete reduction without opening of the joint in most cases, and it has a very low complication frequency. Moreover, the retention of the pin stabilizes the epiphysis and inhibits secondary displacement [1].

The aim of this study was to evaluate treatment outcomes and possible complications of radial neck fractures managed utilizing the metaizeau technique in children.

Material and Methods

A retrospective analysis was conducted on 29 patients aged 4 to 14 years who received surgery for radial neck fractures from 2016 to 2023. All imaging and medical records were retrieved from the electronic patient records (Picture Archiving and Communication System—PACS software) at our institution. The Fırat University non-interventional research ethics committee granted approval for the study on (2023/12-05). Data collection and assessment were conducted according to the Declaration of Helsinki. All patients were apprised of the treatment, and their written consent was secured.

All patients received a conventional radiological assessment, comprising lateral and anteroposterior (AP) views upon presentation. The study inclusion criteria were significantly angulated and displaced radial neck fractures, as well as patients with open growth plates in the elbow at the moment of injury. The open fractures, >16 years, angulation ≤30°, pathological fractures, Judet type I and II fractures, and utilizing open surgical intervention were excluded from the study.

The fractures were categorized based on the Judet classification [5], which was subsequently revised by Metaizeau et al. [4,6] (Table 1). All patients utilized surgical intervention with the Metaizeau technique, but percutaneous leverage reduction using K-wire was used in addition to the Metaizeau technique to aid reduction in a few patients. Open reduction was not performed in any of the patients. After four weeks in a cast-splint, the exercises of the elbow and forearm started gently, and the k-wire was removed after 6 weeks. Avascular necrosis was observed on X-ray as periarticular ossification and loss of reduction with enlargement of the head (Figure 1). Magnetic resonance imaging (MRI) was used for definitive diagnosis.

Table 1. Judet classification

Type	Angulated angle	Displacement(%)
I	Undisplaced	No
II	< 30 degrees	<½ of transverse diameter
III	30-60 degrees	>½ of transverse diameter
IVa	60-80 degrees	Total
IVb	More than 80 degrees	Total

Figure 1. A, B. Radiographic views of 6 months after avascular necrosis of the radius head; **C, D.** Radiographic views of 1 year after avascular necrosis of the radius head

All patients were assessed clinically and radiologically at postoperative 2, 4, and 6 weeks and 3 months and at the last follow-up. Postoperative radiological assessments occurred in accordance with the Ursei classification [7] (Table 2). Flexion and extension of the elbow, supination and pronation of the forearm, and the arm-carrying angle were measured bilaterally using a goniometer. The radiographic assessment recorded the dimensions of the radial head, premature physeal closure, the existence of avascular necrosis, and cubitus valgus. Furthermore, the operating time, surgical timing, removal of casting, and other complications were evaluated at follow-ups. The functional scale of Metaizeau [6] was employed to assess the function of the forearm and elbow at the last follow-up (Table 3).

Table 2. Ursei radiological evaluation classification

Excellent	Anatomic reduction achieved
Good	Translation or angulation under 20°
Acceptable	Angulation between 20° and 40°
Poor	Angulation over 40°

Table 3. Functional scale of metaizeau

Excellent	no loss of motion
Good	< 20% loss of motion/any direction
Fair	20%-40% loss of motion
Poor	> 40% loss of motion

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Surgical Technique

All operations were conducted with general anesthesia and at control C-arm fluoroscopy. For a decrease of angulation to up <30°, every patient was applied an elastic bandage from the wrist to above the elbow, and pressure was applied to the radial head through traction in a varus posture of the forearm after supination of the forearm and extension of the elbow (Elastic bandage technique and Patterson maneuver).

Then, all patients applied the surgical technique described by Metaizeau [1]. A K-wire with a diameter of 1.2–2.0 mm is shaped, and the final 3 mm are bent. The 1 cm skin incision runs along the lateral edge of the distal radial metaphysis, beginning above the proximal epiphyseal plate. Soft tissues are dissected bluntly, while avoiding the superficial nerves and veins. A drill bit enters the cortex 2 cm proximal to the physis and is oriented obliquely relative to the long axis of the bone. Then, K-wire is inserted into the medullary canal of the radius. The K-wire is advanced by moderate mallet taps to fix it within the epiphysis. After repositioning the split epiphysis, the slope is adjusted, and the K-wire is rotated 180° along its longitudinal axis. After control of reduction at c-arm fluoroscopy, the lower end at the metaphyseal entrance of the K-wire is then cut, and the skin is closed [1] (Figure 2). However, we had to use K-wire as a joystick in a few patients with a residual displacement of more than 20° or failed reduction [8,9].

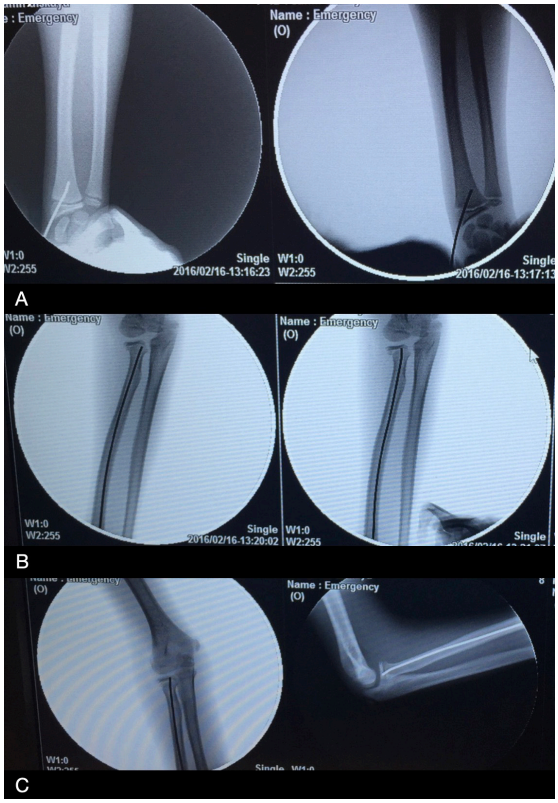

Figure 2. A. K-wire is entered at the lateral border of the distal radial metaphysis. **B.** The K-wire is advanced by gentle taps of the mallet so that it fixes in the epiphysis; After repositioning the split epiphysis, the slope is adjusted, and the K-wire is rotated 180° along its longitudinal axis, **C.** Control of reduction at c-arm fluoroscopy

Statistical Analysis

The Shapiro-Wilk test was employed to assess the normality of the measurement data distribution. Descriptive statistics are presented as mean with standard deviation or as frequency (%). The clinical outcomes were categorized into two groups: good-excellent and moderate-poor. The Functional Scale of Metaizeau is categorized as outstanding, good, fair, and poor. Statistical analyses were performed utilizing SPSS version 20.0 software (SPSS Inc., Chicago, IL, USA).

Results

This study included 29 patients (range, 4-14) with a mean age of 9.20±2.53 years. All patients were classified via the Judet classification. Table 4 presents the demographic characteristics of the groups.

Table 4. The demographic characteristics of patients

Age (years),	**Mean±SD**	9.20±2.53
Side (left)	**n (%)**	16 (55.2)
Gender (male)		19 (34.8)
Judet classification		
Type 3		17 (58.6)
Type 4a		10 (34.5)
Type 4b		2 (6.9)
Associated lesions		
Olecranon		2 (6.9)
Radius		1 (3.4)
Mechanism of injury		
Simple fall		21 (72.4)
Bike accident		8 (27.6)

SD: standard deviation, n: number

The mean period of follow-up was 17.48 (range, 12-26) months. The mean time from injury to surgical intervention was 1.13 (range, 1-2) days. The mean operating time was 32.75 (range, 25-45) minutes. The mean hospital stay was 2.02 (range, 1-3) days.

The mean arm carrying angle of the unaffected was 13.79 (range, 11-17) degrees, while the mean arm carrying angle of the affected was 14.13 (range, 11-18) degrees. The mean arm-carrying angle in patients who underwent surgery was increased by an average of 0.34 degrees compared to the intact arm.

Concomitant injuries were detected in 3 patients, two of whom had olecranon fractures and one had a distal radius fracture.

No patient required open surgical intervention. In addition to the metaizeau technique, the percutaneous leverage reduction using K-wires was applied in 6 cases that could fail with closed reduction. 5 of these patients were Judet type 4a, and 1 patient was Judet type 4b (Figures 3,4).

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We noted avascular necrosis in 5 patients, of which 3 were type 3 and 2 were type 4a. In patients with avascular necrosis, reduction was performed only with the mateizeau technique. No patients were seen with epiphyseal arrest.

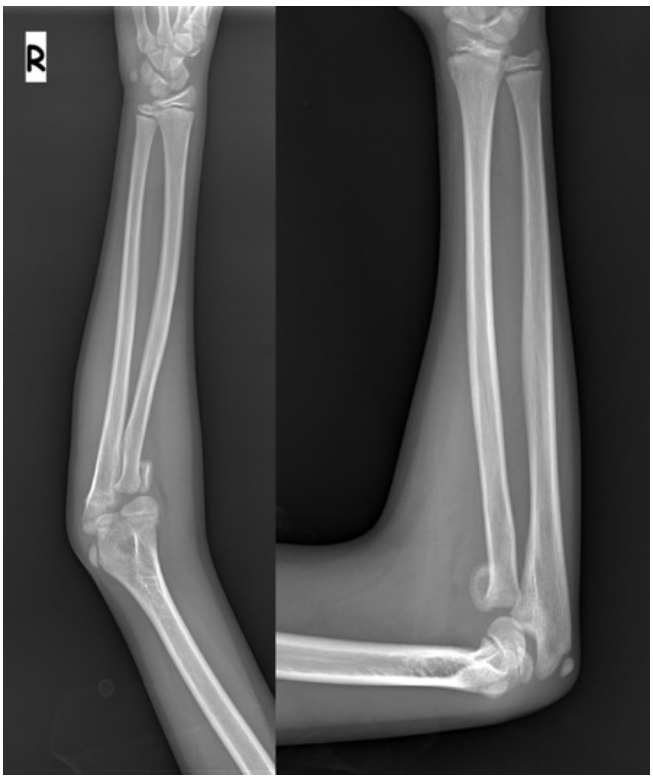

Figure 3. Preoperative radiographic views of Judet type 4 radial neck fractures

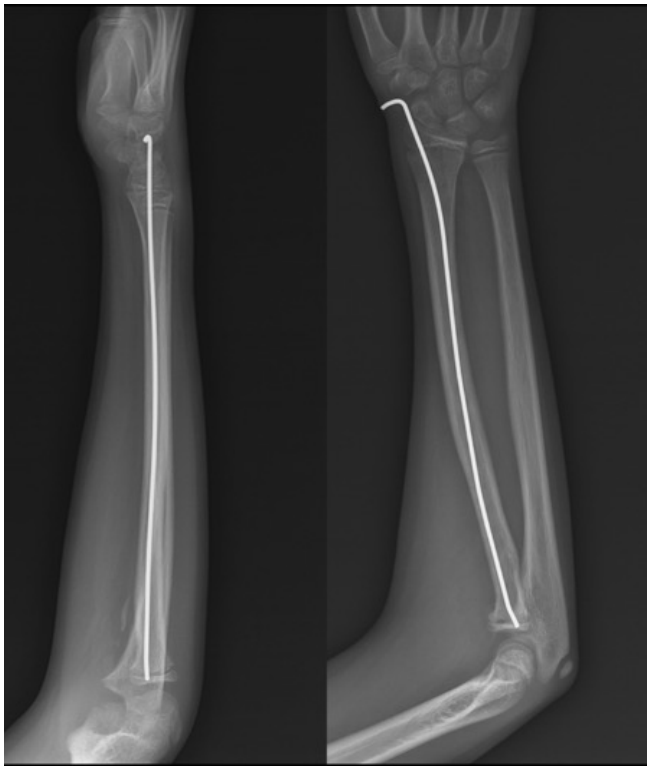

Figure 4. Postoperative radiographic views of Judet type 4 radial neck fractures

Ursei radiological evaluations were excellent in 25 patients and good in 4 patients. The functional scale of Metaizeau was excellent in 24 of the patients and good in 5 of the patients (Table 5).

Table 5. Results

Operating time (minutes)			32.75±5.84
Remove of casting (days)			24.93±6.60
Hospital stay (days)			2.02±0.26
Surgical timing (days)		**Mean±SD**	1.13±0.35
Follow-up (months)			17.48±4.74
Arm carrying angle of unaffected (degree)			13.79±1.87
Postoperative arm carrying angle of affected (degree)			14.13±2.03
Hand dominance	**Dominant**	**n (%)**	13 (44.8)
	Non-dominant		16 (55.2)
Surgical type	**Metaizeau**	**n (%)**	23 (79.3)
	Metaizeau+percutaneous leverage with K-wires		6 (20.7)
Complications	**Avascular necrosis**	**n (%)**	5 (17.2)
	Epiphyseal arrest (premature physeal closure)		-
Ursei radiological results	**Excellent**	**n (%)**	25 (86.2)
	Good		4 (13.8)
	Acceptable		-
	Poor		-
Functional scale of Metaizeau	**Poor (>40% loss of motion)**	**n (%)**	-
	Fair (20%-40% loss of motion)		-
	Good (<20% loss of motion/any direction)		5 (17.2)
	Excellent (no loss of motion)		24 (82.8)

SD: standard deviation, n: number

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Discussion

The study demonstrated that the Metaizeau technique is a highly efficient approach for treating pediatric radius neck fractures with Judet type 3 and type 4 injury. In addition, no patient had a poor outcome in postoperative evaluations using the Ursei radiologic scale and the Metaizeau functional scale. However, the small sample size and lack of comparison with open surgical intervention affect the power of the study.

Radial neck fractures in children are considered intraarticular fractures. If untreated, it can cause disability and deformity by affecting the malunion or growth plate, so it must be treated. Different surgical methods have been employed to address radial neck fractures, such as closed reduction, indirect and/or reduction utilizing percutaneous K-wire, fixation with percutaneous K-wire as a joystick or leverage technique, and open reduction. In 1980, the stabilization technique with an elastic stable intramedullary K-wire was defined by Metaizeau [6,9-11].

Falciglia et al. [12] reported that open surgical intervention is warranted when the radial head is entirely displaced and lacks contact with the metaphyseal rim. Kiran et al. [13] reported that open surgical intervention may be needed in patients with Judet IV fractures. However, the damage to the blood supply, periarticular ossification, or adhesion of the proximal radioulnar joint can be observed after open surgical intervention. These factors may account for the unsatisfactory outcomes and significant problems [12,14]. To avoid these complications of open surgical intervention, the percutaneous leverage reduction utilizing K-wires together with the Métaizeau technique has been used to assist reduction in Judet type 3-4 fractures [8,9]. Qiao et al. [15] showed that the preservation of the lateral periosteal hinge and elbow capsule is a critical determinant for a successful closure reduction. They explained that in cases of O'Brien type III and Judet type IVb fractures, when initial percutaneous reduction was unsuccessful, a modified percutaneous leverage approach with radial intramedullary fixation may be effectively employed for avoiding open reduction [15]. However, many studies have reported that the metaizeau technique serves as an effective and appropriate strategy for treating Judet stage 3 and 4 misplaced radial neck fractures in children [1,4,6,11]. In our study, no patient required open surgical intervention. Percutaneous leverage reduction using K-wires assisted the closed reduction of these patients, particularly in 6 of the cases where closed reduction failed; 5 of these patients were Judet type 4a, and 1 was Judet type 4b. We think that closed reduction with Metaizeau may be insufficient, especially in Judet type 4 patients, and the percutaneous leverage method is a good option to assist closed reduction in these patients [12].

Iglesia et al. [16] showed that no significant differences existed in final functional outcomes or complications between open and closed surgical intervention. Consequently, they recommended open reduction for significantly displaced radial neck fractures while avoiding excessive percutaneous interventions. Du et al. [8] investigated the clinical efficacy of percutaneous leverage reduction utilizing two K-wires in conjunction with the Metaizeau technique vs. open reduction for the management of Judet IV radial neck fractures in pediatric patients. They suggested that percutaneous leverage reduction using two K-wires combined with the Metaizeau technique could significantly increase the rate of minimally invasive reduction, offering benefits such as reduced trauma, fewer complications, effective outcomes, and accelerated postoperative elbow function. We thought that to avoid complications of open reduction, in patients with residual angulation above 20°, percutaneous leverage reduction utilizing K-wires combined with the Metaizeau technique is a less invasive and efficacious therapeutic approach.

Residual radial head deformity resulting from premature growth plate closure and avascular necrosis is linked to functional impairment [12]. Çevik et al. [11] suggested that children utilized treatment with percutaneous K-wire-aided Metaizeau technique in the treatment of displaced radial neck fractures observed 1 avascular necrosis of the radial head, 6 early fusions of the physeal plate, 2 heterotopic ossifications, and 2 enlargements of the radial head. Among the patients with early physeal plate fusion, 5 were asymptomatic, while 1 exhibited a mobility limitation of 15°. Their assessment indicated that these difficulties may have arisen from the interruption of blood flow to the radial head during the trauma, notwithstanding allegations of damage to the physis during the manipulation of the percutaneous K-wire utilized for closed reduction. Kim et al. [9] reported six complications, including nonunion, synostosis, and superficial skin infection, in children with radial neck fractures who were treated via the stepwise percutaneous leverage approach. One instance of synostosis was associated with the late pin removal, while one instance of nonunion was associated with the early pin removal. Pin site infection was observed in four cases: one of these in the early pin removal group and three of these in the late pin removal group. It was reported that the condition was managed without additional intervention following the administration of oral antibiotics and the removal of the pin. Trabelsi et al. [17] observed late complications, such as radial head necrosis, pseudarthrosis, and elbow stiffness, observed in five individuals. Furthermore, open reduction was required for one patient. They indicated that the stiffness of the elbow following the Metaizeau procedure is particularly observed in cases treated later. They asserted that elastic stable intramedullary pinning via the Metaizeau technique is the preferred treatment for displaced radial neck fractures in pediatric patients. In our study, pin site infection and epiphyseal arrest were not observed in any of the patients. Avascular necrosis was observed in 5 patients. There were no type 4b patients for these patients, and none of these patients had percutaneous leverage reduction utilizing K-wires. We think that this may be related to the mechanism of the trauma. Avascular necrosis may present clinically as new-onset pain or limitation of motion in the elbow region and may occur several

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years after the initial injury [18]. The diagnosis is confirmed by traditional radiographs. Initial treatment is conservative with a range of movement exercises and, in some cases, may provide relief. If severe symptoms persist, avascular necrosis can be treated surgically using bone grafting or radial head resection [18,19].

The leverage technique with percutaneous K-wires inflicts minimal iatrogenic damage to the radial proximal vascular structures and elbow peripheral muscular ligaments; it can cause complications such as pin tract infection, injury to the proximal radial epiphyseal plate, and the posterior interosseous nerve [8,10,20]. Percutaneous K-wires were used in the pronation position of the forearm without multiple attempts to avoid such complications in the leverage technique. In our study, such complications were not observed in any patient related to the use of joystick K-wire.

Kiran et al. [13] indicated that sharp-tipped intramedullary devices, including K-wires, were to be eschewed because of a considerable danger of penetrating the radiocapitellar joint. Blunt-tipped devices should not be utilized just as fixation instruments if they are incapable of preventing redisplacement. We have not used sharp-tipped K-wires. The blunt-ended K-wire is both easy to advance intramedullary and does not risk penetration during rotation of the radial head. It also preserves the reduction because the tip of the wire is curved.

Aydın et al. [21] had compared fixation with K-wire and titanium elastic nail for the Metaizeau Technique. They indicated that clinical outcomes are similar, and K-wire is more cost-effective. We used K-wire in all patients. Because the K-wire can be easily contoured, we can easily adjust the inclination of its tip to send intramedullary. It is also very advantageous in terms of cost. Early physical closure may be observed after radial neck fractures in children, but it is not always reported [19].

Early physical closure may present clinically as pain, limitation of motion, or a visible deformity such as cubitus valgus [22,23]. However, since early physis closure was not observed in any patient in our study, cubitus valgus deformity was not observed, and there was no statistically significant difference between the elbow carrying angles on the intact side and the elbow carrying angles on the operated side.

The limitation of the study is that it is a retrospective evaluation that does not compare various treatment approaches and strategies. Furthermore, there was an absence of long-term follow-up on the carrying angle.

Conclusion

The surgical method used is one of the essential factors that determine the functional outcome of the patients. Functional results are linked to the quality of reduction achieved without disturbing the blood circulation and damaging the epiphysis. Our study shows that the mateizeau technique is an effective and safe choice of treatment for displaced radial neck fractures in children. Especially in type 4 fractures, it is difficult to perform closed reduction; the percutaneous leverage technique with K-wire can be added to the Metaizeau technique without the need for open surgical intervention.

Conflict of Interests
The authors declare that there is no conflict of interest in the study.

Financial Disclosure
The authors declare that they have received no financial support for the study.

Ethical Approval
Approval for the study was given by the Fırat University non-interventional research ethics committee on (2023/12-05).

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