CLINICAL SCIENCE

COMPARISON OF ESIN AND OPEN REDUCTION IN PEDIATRIC CAPITULUM RADII FRACTURES: RETROSPECTIVE STUDY

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Abstract

Radial neck fractures (RNFs) in children present a clinical challenge due to variability in displacement and risk of complications. This retrospective study compared clinical outcomes between elastic stable intramedullary nailing (ESIN) and open reduction with transcondylar fixation in pediatric patients with Judet type III and IV fractures. From 2010 to 2015, 80 children aged 5.5–14.5 years with isolated RNFs were treated at the University Clinic for Pediatric Surgery in Skopje. Patients were divided into two groups: closed reposition with ESIN (n = 39) and open reposition with transcondylar fixation (n = 41). Postoperative outcomes were evaluated using the Mayo Elbow Performance Score (MEPS), radiographic alignment, and periosteal callus formation. Closed reposition with ESIN resulted in significantly higher rates of periosteal callus formation (97.44% vs. 56.10%, p = 0.000014), indicating better biological healing. Fracture alignment was comparable between groups (p = 0.13). Open reduction was more frequently required for Judet type IV fractures (63.41%). No significant differences were found in MEPS scores. The retrospective design limited structured complication reporting. ESIN is an effective, biologically favorable option for Judet type III RNFs, while open reduction remains necessary for more complex type IV fractures. Standardized long-term follow-up is essential for evaluating safety outcomes.

КЛИНИЧКИ ИСТРАЖУВАЊА

СПОРЕДБА НА ESIN И ОТВОРЕНА РЕПОЗИЦИЈА КАЈ CAPITULUM RADII ФРАКТУРИ КАЈ ДЕЦА: РЕТРОСПЕКТИВНА СТУДИЈА

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Клучни зборови: фрактура на вратот на радиусот, еластична стабилна интрамедуларна остеосинтеза, отворена репозиција, педијатриски фрактури, класификација според Judet

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Печатарски права: ©2025 Маријан Камилоски, Шабан Мемети, Харис Сулејмани, Роза Соколова, Моника Арџанова. Оваа статија е со отворен пристап дистрибуирана под условите на нелокализирана лиценца, која овозможува неограничена употреба, дистрибуција и репродукција на било кој медиум, доколку се цитираа торигиналниот(ите) автор(и) и изворот.

Конкурентски интереси: Авторот изјавува дека нема конкурентски интереси.

Извадок

Фрактурите на вратот на радиусот (ФВР) кај децата претставуваат клинички предизвик поради варијабилноста во дислокацијата и ризикот од компликации. Целта на оваа ретроспективна студија беше да ги спореди клиничките исходи помеѓу еластичната стабилна интрамедуларна остеосинтеза (ESIN) и отворената репозиција со транскондиларна фиксација кај педијатриски пациенти со фрактури од тип III и IV според Judet. Во периодот 2010–2015 година, на Универзитетската клиника за детска хирургија во Скопје беа третирани 80 деца (возраст 5,5–14,5 години) со изолирани ФВР. Пациентите беа поделени во две групи: едната група третирана со затворена репозиција со ESIN (n = 39), а другата со отворена репозиција со транскондиларна фиксација (n = 41). Исходите беа евалуирани преку MEPS, радиографско порамнување и формирање периостален калус. Затворената репозиција со ESIN покажа значајно повисока стапка на формирање периостален калус (97,44% vs. 56,10%, p = 0,000014), што укажува на подобро биолошко заздравување. Квалитетот на репозицијата беше споредлив (p = 0,13). Отворената репозиција беше почеста кај фрактурите од тип IV (63,41%). Не беа најдени значајни разлики во MEPS скорот. Ретроспективниот дизајн ја ограничуваше евиденцијата за компликации. ESIN претставува ефикасна и биолошки поволна опција за фрактури од тип III според Judet, додека отворената репозиција останува неопходна за покомплексните тип IV фрактури. Потребно е стандардизирано долгорочно следење за оценка на безбедносните исходи.

Introduction

Proximal radius fractures are not common; they only make up 1% of all fractures and 4.5–21% of elbow fractures in children. Radial neck fractures (RNF) are the most common type. Treatment complexity arises from the possibility of spontaneous realignment and challenges with vascular supply. Although both surgical and conservative methods demonstrate favorable results, complication rates vary between 27% and 37%. Elements such as unpredictable growth-associated remodeling, excessive treatment, and a rise in surgical procedures contribute to this variability. The variability of fracture types and patient ages complicates routine examination.1 The primary injury mechanism involves a fall onto an outstretched arm, resulting in valgus tension at the elbow.[2]

The classification of radial neck injuries is determined by the angle between the radial head and neck. The Judet and O'Brien classification systems are the most often utilized. Normal x-rays can make it hard to see undisplaced fractures. The posterior fat pad, which may be present and indicate a hidden fracture, is another sign to look for.[3]

The Judet classification categorizes fractures into four patterns based on the displacement of the radial head. Type I is a non-displaced fracture, while Type II entails an angulation of less than 30°, with Type III encompassing an angulation range of 30° to 60°. Type IV fractures are characterized by an angulation of the radial head exceeding 60°.2

Radial head ossification begins around the age of four, with fusion happening at approximately 14 years in females and 17 years in males. By this age, the head and neck have reached their adult shape, with a natural lateral angulation of 12.5° in the anteroposterior (AP) plane and 3.5° anteriorly in the lateral plane. Therapy planning must take these characteristics into account.

Displaced fractures are uncommon yet difficult to treat. Complications in children encompass elbow stiffness, avascular necrosis (AVN), and radial head enlargement. The elastic stable intramedullary nailing (ESIN) method helps reduce and stabilize fractures indirectly while keeping the connections between soft tissues. This report delineates a set of pediatric instances managed using this strategy.[4]

Although more commonly used for diaphyseal forearm fractures, ESIN has also proven effective in pediatric radial neck fractures due to its minimally invasive nature and reliable stabilization.[5]

The objective of this study was to retrospectively compare the clinical outcomes of closed reduction with retrograde elastic stable intramedullary nailing (ESIN, Metaizeau technique) versus open reduction with transcondylar fixation in the treatment of pediatric radial neck fractures.

Materials and Methods

This retrospective study was conducted at the University Clinic for Pediatric Surgery in Skopje between 2010 and 2015, including 80 pediatric patients (aged 5.5–14.5 years) with isolated Judet type III or IV radial

neck fractures. Patients were divided into two treatment groups: one group treated with closed reduction with retrograde intramedullary nailing using the ESIN (Metaizeau technique, n = 39) and the other one with open reduction with transcondylar fixation (n = 41). Exclusion criteria included polytrauma, Monteggia fractures, pathological lesions, or Judet type V fractures. Surgical procedures were performed under general anesthesia. In the ESIN group, closed reposition was achieved using a titanium elastic nail (1.5–2.5 mm) introduced retrogradely under fluoroscopic guidance (Figures 1 and 2). In the open reduction group, a Kocher lateral approach was used with fixation by transcondylar screws or Kirschner wires. Clinical and radiographic data were extracted from hospital records, including patient demographics, injury mechanism, fracture classification, and treatment outcomes. Functional results were assessed using the Mayo Elbow Performance Score (MEPS). Statistical analysis was performed using SPSS software with Chi-square and Student's t-tests, and repeated-measures ANOVA where appropriate. Ethical approval was obtained from the Ethics Committee of the Faculty of Medicine in Skopje (June 2018), in accordance with the Declaration of Helsinki. Informed consent was obtained from parents or guardians of all participants.

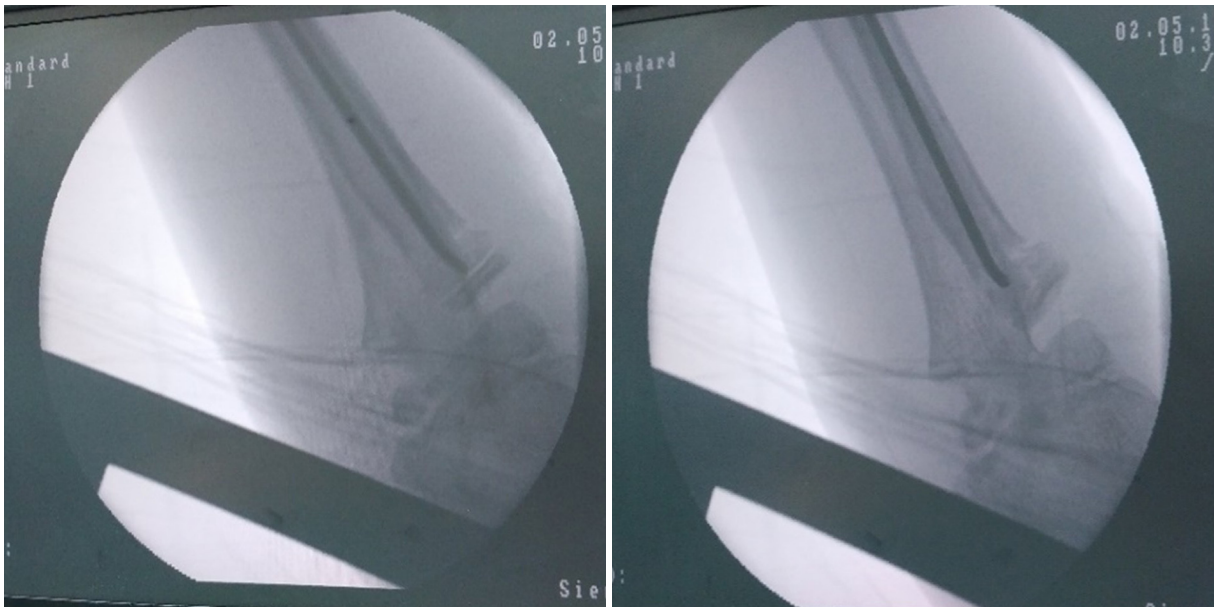


Figure 1 and 2: Repositioning of the radial head

Results

A total of 80 pediatric patients with capitulum radii fractures were included, comprising 52 males (65%) and 28 females (35%). The gender distribution was comparable between the open reposition (27 males, 14 females) and closed reposition (25 males, 14 females) groups, with no significant difference (p = 0.88) (Table 1).

Falls (53.8%), sports/play (32.1%), and traffic accidents (14.1%) were the most common injury mechanisms. Falls predominated in the open reposition group (60.98%),

Table 1. Gender distribution between treatment groups

Gender	Method			p - value
	n	Open reposition n (%) (41)	Closed reposition n (%) (39)	
Male	52	27 (65.85)	25 (64.1)	0.88
Female	28	14 (34.15)	14 (35.9)	

while sports/play was more common in the ESIN group (41.03%). No significant difference was observed between groups regarding injury mechanism (p = 0.18) (Table 2).

Table 2. Judet classification distribution between treatment groups

Mechanism of injury	Method			p - value
	n	Open reposition n (%) (41)	Closed reposition n (%) (39)	
Traffic accident	12	7 (17.07)	5 (12.82)	0.18
Fall	43	25 (60.98)	18 (46.15)	
Sports/play	25	9 (21.95)	16 (41.03)	

Judet classification revealed a significant difference in fracture type distribution (p = 0.000003). Closed reposition was predominantly used for type III fractures (87.18%), whereas open reposition was more common for type IV (63.41%) (Table 3).

Table 3. Judet classification distribution between treatment groups

Judet Classification	Method			p - value
	n	Open reposition n (%) (41)	Closed reposition n (%) (39)	
Type III	49	15 (36.59)	34 (87.18)	0.000003
Type IV	31	26 (63.41)	5 (12.82)	

All patients in the ESIN group had a good reduction (100%). In the open reposition group, 92.68% had good and 7.32% had satisfactory outcomes. No poor reductions were recorded. The difference was not statistically significant (p = 0.13). Figures 3 and 4 show representative imaging from both groups (Table 4).

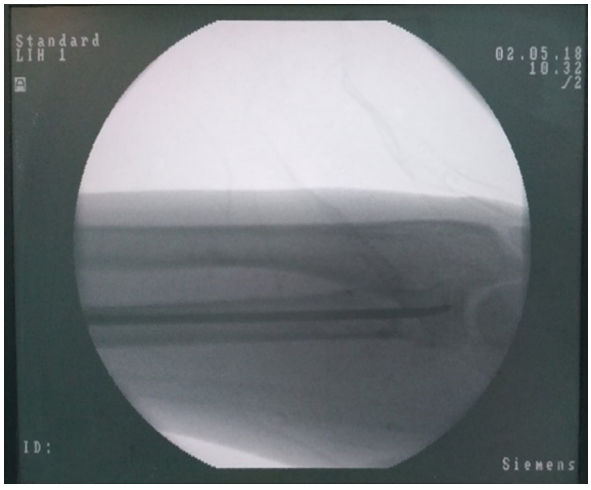


Figure 3: Postoperative fluoroscopy showing alignment after ESIN



Figure 4: Postoperative radiograph confirming anatomic reduction in open reposition group

Table4. Quality of reduction between treatment groups

Quality of reposition after primary treatment	Method			p - value
	n	Open reposition n (%) (41)	Closed reposition n (%) (39)	
Good	77	38 (92.68)	39 (100)	0.13
Satisfactory	3	3 (7.32)	0	
Poor	/	0	0	

Periosteal callus was present in 97.44% of the closed reposition group, compared to 56.10% of the open reposition group (p = 0.000014) (Table 5).

Table 5. Periosteal callus formation between treatment groups

Periosteal Callus Formation	Method			p - value
	n	Open reposition n (%) (41)	Closed reposition n (%) (39)	
Absent	19	18 (43.90)	1 (2.56)	0.000003
Present	61	23 (56.10)	38 (97.44)	

No significant complications were recorded, although the absence of structured documentation limited the reliability of complication assessment.

Discussion

Our findings align with previous studies demonstrating that fracture severity plays a central role in surgical decision-making, with Judet type IV fractures more often necessitating open reduction, while type III fractures respond well to minimally invasive treatment approaches.[6] Closed reposition with ESIN was particularly effective for Judet type III injuries, consistent with the broader trend favoring less invasive tech-

niques when anatomical alignment is achievable. [8]

ESIN demonstrated clear biological advantages in our study, reflected by significantly higher rates of periosteal callus formation compared to open reposition. This supports existing evidence that ESIN preserves periosteal integrity and facilitates bone healing.[7]

Although our analysis did not include Kirschner wire (KW) fixation, prior research positions it as a cost-effective alternative. [8] It allows for outpatient implant removal but is associated with higher rates of pin tract infections and risk of reduction loss.[9] Tian *et al.* reported no major differences between ESIN and KW fixation regarding function, hospital stay, or operative time, suggesting that the choice of technique should be tailored to individual case specifics and resource availability. [8]

While ESIN is widely accepted for pediatric fractures, complications such as nail migration, joint protrusion, and nonunion have been reported.[6] We did not observe these in our patients; however, their possibility underscores the need for consistent postoperative monitoring.

Age also influences outcomes. Studies show children ≥10 years may experience less favorable remodeling.[9] Although age-specific outcomes were not analyzed in our patients, future studies should explore age-based protocols.

Du *et al.* found that minimally invasive techniques using Kirschner wires with the Métaizeau method offered higher success and fewer complications than open reduction in Judet IV fractures.[10] Their findings support a shift toward closed techniques when feasible.

The reduction quality in our study was comparable between both methods, with no significant differences noted. This reinforces that both techniques can achieve anatomical alignment when appropriately selected.[8]

Although our results favor ESIN, especially for Judet type III fractures, KW fixation remains a relevant option where cost or implant removal logistics are a concern. However, the absence of a standardized complication registry limited our ability to draw firm conclusions about safety. Comprehensive documentation of postoperative outcomes is critical in future research to evaluate long-term safety and efficacy.

Conclusion

This study supports ESIN as a highly effective technique for managing pediatric radial neck fractures, particularly Judet type III, due to its capacity to preserve periosteal integrity and promote biological healing. Although open reduction remains necessary for more complex type IV fractures, KW fixation also presents a viable alternative, especially in resource-limited settings where outpatient implant removal is advantageous. Given the comparable functional outcomes between techniques, the choice of fixation should be individualized. Future prospective studies are warranted to evaluate long-term results, implant-related complications, and age-specific responses to treatment.

Abbreviations

ESIN – Elastic Stable Intramedullary Nailing

RNF – Radial Neck Fracture

MEPS – Mayo Elbow Performance Score

VAS – Visual Analog Scale

AVN – Avascular Necrosis

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Conflict of Interest

The authors declare no conflicts of interest in relation to this study.

References

1. Dietzel M, Scherer S, Esser M, Kirschner HJ, Fuchs J, Lieber J. Fractures of the proximal radius in children: management and results of 100 consecutive cases. Arch Orthop Trauma Surg. 2021;142:1903–10. Available from: https://link.springer.com/article/10.1007/s00402-021-03917-w
2. Kaiser M, Eberl R, Castellani C, Kraus T, Till H, Singer G. Judet type-IV radial neck fractures in children: Comparison of the outcome of fractures with and without bony contact. Acta Orthop. 2016;87(5):529–32. Available from: https://pubmed.ncbi.nlm.nih.gov/27348024/
3. Khajuria A, Tiwari V. Radial neck fracture repair in a child. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024. Available from: https://www.ncbi.nlm.nih.gov/books/NBK559171/
4. Prathapkumar KR, Garg NK, Bruce CE. Elastic stable intramedullary nail fixation for severely displaced fractures of the neck of the radius in children. J Bone Joint Surg Br. 2006;88(3):358–61.

   Available from: https://boneandjoint.org.uk/Article/10.1302/0301-620X.88B3.17099
5. Kwas K, Mostowy M, Szatanik K, Małecki K. Elastic stable intramedullary nailing in paediatric diaphyseal forearm fractures – a retrospective analysis of 201 cases. BMC Musculoskelet Disord. 2024;25(1):459.Available from:

   https://bmcmusculoskeletdisord.biomedcentral.com/articles/10.1186/s12891-024-07959-0#citeas
6. Liu Y, Zhu LQ, Zhang FY, Liu Y, Zhen YF, Zhao TT. Open reduction of displaced radial neck fractures in children by internal fixation techniques: comparison of percutaneous Kirschner wiring and elastic stable intramedullary nailing. Indian J Orthop. 2022;56(7):1192–8. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC9232670/
7. Yaokreh JB, Odéhouri-Koudou TH, Koffi KM, Sounkere M, Kouamé YGS, Tembely S, *et al.* Surgical treatment of femoral diaphyseal fractures in children using elas-

tic stable intramedullary nailing by open reduction at Yopougon Teaching Hospital. Orthop Traumatol Surg Res. 2015;101(5):589–92. Available from: https://www.sciencedirect.com/science/article/pii/S1877056815001528

8. Tian K, Cao J, Pei X, Liu Y, Li T, Li Y. Comparison of elastic stable intramedullary nailing versus Kirschner wires in treatment of pediatric radial neck fractures. J Child Orthop. 2024;18(3):266–76. Available from: https://journals.sagepub.com/doi/10.1177/18632521241233444?icid=int.sj-full-text.similar-articles.6

9. Tibone JE, Stoltz M. Fractures of the radial head and neck in children. J Bone Joint Surg Am. 1981;63(1):100–6. Available from: https://journals.lww.com/jbjsjournal/pages/articleviewer.aspx?year=1981&issue=63010&article=00013&type=Abstract

10. Du X, Yu L, Xiong Z, Chen G, Zou J, Wu X, *et al.* Percutaneous leverage reduction with two Kirschner wires combined with the Métaizeau technique versus open reduction plus internal fixation with a single Kirschner wire for treating Judet IV radial neck fractures in children. J Int Med Res. 2019;47(11):5497–507. Available from: https://journals.sagepub.com/doi/10.1177/0300060519825990