



Pediatric önkol diyaferiz kırıklarında elastik stabil intramedüller çivileme sonrası açıkta bırakılan ve gömülen çivi uçlarının karşılaştırılması

Exposed versus buried nail ends following elastic stable intramedullary nailing for paediatric diaphyseal forearm fractures

Sinan YÜKSEL¹, Eren YILMAZ¹, İbrahim Faruk ADIGÜZEL², Orhan KUNU, MD¹, Mustafa Kemal YENİDÜNYA¹, Önder ERSAN¹

ÖZET

AMAÇ: Pediatrik diyaferiz önkol kırıklarının cerrahi tedavisinde elastik stabil intramedüller çivileme (ESIN) yaygın olarak kullanılmaktadır. Ancak çivi uçlarının cilt altına gömülmesi veya açıkta bırakılması konusunda görüş birliği bulunmamaktadır. Bu çalışmada, açıkta bırakılan ve gömülen çivi uçlarının fonksiyonel sonuçlar ve komplikasyon oranları açısından karşılaştırılması ve açıkta bırakma yönteminin rutin klinik uygulamada pratik bir alternatif olup olmadığının değerlendirilmesi amaçlandı.

GEREÇ VE YÖNTEM: Bu retrospektif karşılaştırmalı kohort çalışmaya, Ocak 2018–Aralık 2024 tarihleri arasında iki travma merkezinde diyaferiz önkol kırığı nedeniyle ESIN uygulanan 15 yaş altı hastalar dahil edildi. Yaralanmadan sonraki 10 gün içinde opere edilen hastalar çalışmaya alındı. Hastalar çivi ucu yönetimine göre gömülen ve açıkta bırakılan olmak üzere iki gruba ayrıldı. Birincil sonlanım ölçütü toplam komplikasyon oranıydı. İkincil sonlanım ölçütleri ise kırık kaynama süresi, postoperatif immobilizasyon süresi, implant çıkarılma zamanı ve Price kriterlerine göre değerlendirilen fonksiyonel sonuçlardı.

BULGULAR: Toplam 122 hasta çalışmaya dahil edildi; bunların 68'i gömülen, 54'ü açıkta bırakılan gruptaydı. Kaynama süresi, postoperatif immobilizasyon süresi, refraktür oranları, enfeksiyon oranları ve toplam komplikasyon oranları açısından gruplar arasında istatistiksel olarak anlamlı fark gösterilemedi. Implant çıkarılma zamanı açıkta bırakılan grupta anlamlı olarak daha erkendi. Fonksiyonel sonuçlar her iki grupta da olumluydu ve hastaların büyük çoğunluğunda Price kriterlerine göre mükemmel sonuç elde edildi; ancak fonksiyonel sonuçların dağılımı açısından gruplar arasında istatistiksel olarak anlamlı fark gösterilemedi.

SONUÇ: ESIN sonrası açıkta bırakılan çivi uçları, gömülen çivi uçları ile benzer klinik ve fonksiyonel sonuçlarla ilişkili bulunurken, implantların poliklinik koşullarında daha erken çıkarılmasına olanak sağlamıştır. Bu kohortta açıkta bırakma yöntemi ile komplikasyon veya refraktür oranlarında istatistiksel olarak anlamlı bir artış gösterilememiştir. ESIN sonrası açıkta bırakılan çivi uçları, uygun hasta seçimi ve güvenilir takip koşullarında, implantın poliklinik şartlarında çıkarılmasını kolaylaştırması ve anestezi altında ikinci bir cerrahi işleme duyulan gereksinimi azaltabilmesi nedeniyle pratik bir alternatif olarak değerlendirilebilir. Bununla birlikte, komplikasyon sayısının düşük olması nedeniyle yöntemlerin göreceli güvenliği konusunda kesin sonuçlara varılmaz ve bu konuda daha büyük örneklemli prospektif karşılaştırmalı çalışmalara ihtiyaç vardır.

Anahtar Kelimeler: pediatrik önkol kırıkları, elastik stabil intramedüller çivileme, radius ve ulna kırıkları, cerrahi komplikasyonlar

ABSTRACT

AIM: Elastic stable intramedullary nailing (ESIN) is widely used in the surgical treatment of paediatric diaphyseal forearm fractures. However, there is no consensus regarding whether nail ends should be buried subcutaneously or left exposed. This study aimed to compare functional outcomes and complication rates between exposed and buried nail ends and to evaluate whether leaving nail ends exposed represents a safe alternative in routine clinical practice.

MATERIAL AND METHOD: This retrospective comparative cohort study included paediatric patients younger than 15 years who underwent ESIN for diaphyseal forearm fractures at two trauma centres between January 2018 and December 2024. Patients treated within 10 days of injury were included. Patients were divided into two groups according to nail-end management: buried or exposed. The primary outcome was the overall complication rate. Secondary outcomes included fracture union, duration of postoperative immobilisation, implant removal time, and functional outcomes assessed using the Price criteria.

RESULTS: A total of 122 patients were included, with 68 in the buried group and 54 in the exposed group. No statistically significant differences could be demonstrated between the groups in terms of union time, duration of postoperative immobilisation, refracture rates, infection rates, or overall complication rates. Implant removal was performed significantly earlier in the exposed group. Functional outcomes were favourable in both groups, with the majority of patients achieving excellent results according to the Price criteria; however, no statistically significant difference in the distribution of functional outcomes could be demonstrated between the groups.

CONCLUSION: Exposed nail ends were associated with clinical and functional outcomes similar to those of buried nail ends, while allowing earlier outpatient implant removal. No statistically significant increase in complications or refracture rates was demonstrated with the exposed technique in this cohort. Leaving nail ends exposed following ESIN may be considered a practical alternative in appropriately selected paediatric patients because it facilitates outpatient implant removal and may reduce the need for a secondary procedure under anaesthesia. However, the relatively low number of complications precludes definitive conclusions regarding comparative safety, and further prospective comparative studies with larger sample sizes are warranted.

Keywords: Pediatric forearm fractures, Elastic stable intramedullary nailing, Radius and ulna fractures, Surgical complications

¹ Ankara Etik City Hospital, Department of Orthopaedics and Traumatology, Ankara, Türkiye

² Eskişehir Osmangazi University, Department of Orthopaedics and Traumatology, Eskişehir, Türkiye

INTRODUCTION

Diaphyseal forearm fractures represent the third most common fracture type in childhood, following distal radius and supracondylar humerus fractures [1]. The primary treatment approach for paediatric forearm fractures is conservative management, and closed reduction followed by cast immobilisation provides adequate stability and satisfactory functional outcomes in the majority of cases (2). However, surgical intervention becomes necessary in diaphyseal forearm fractures when acceptable anatomical alignment cannot be achieved or maintained with closed reduction.

Recent epidemiological studies have demonstrated an increasing incidence of paediatric forearm diaphyseal fractures, accompanied by a notable shift towards surgical management, particularly for diaphyseal fracture patterns(3–6). In this patient population, elastic stable intramedullary nailing (ESIN) has become the preferred surgical technique over plate osteosynthesis, owing to its ability to provide sufficient stability through a minimally invasive approach(4,6). ESIN offers several advantages, including reduced soft-tissue disruption, smaller incisions with improved cosmetic outcomes, shorter operative time, lower overall cost, and relative ease of implant removal(7,8).

Despite the widespread use of ESIN, there is currently no consensus regarding whether the nail ends should be buried subcutaneously or left exposed following surgery. Traditionally, subcutaneous burial of the nail ends has been preferred, as it allows for longer implant retention and may reduce implant-related soft-tissue complications and refractures. Conversely, leaving the nail ends exposed has emerged as a practical alternative, primarily because it facilitates implant removal in an outpatient setting without the need for additional anaesthesia or operating room utilisation. However, concerns have been raised regarding exposed nail ends, including skin irritation, pin-site infection, and a potentially increased risk of refracture associated with earlier implant removal(9–13). Although several comparative studies have evaluated buried and exposed nail-end techniques, the available evidence remains limited and inconclusive. In particular, it is still unclear whether exposed nail ends are associated with higher complication rates in paediatric forearm ESIN and whether the practical advantages of outpatient implant removal justify their routine use. The aim of this study was to compare functional outcomes and complication rates between subcutaneous and exposed nail ends following ESIN in paediatric diaphyseal forearm fractures, and to assess whether nail exposure represents a safe and clinically advantageous alternative in routine practice.

MATERIAL AND METHOD

Study Design and Patient Selection

This retrospective comparative cohort study was conducted following approval from the local institutional ethics committee (approval number:2023-525) and in accordance with the Declaration of Helsinki. Written informed consent was obtained from the parents or legal guardians of all participants.

Patients who underwent ESIN for diaphyseal forearm fractures at two trauma centres between January 2018 and December 2024 were retrospectively reviewed. Patients younger than 15 years who underwent ESIN for traumatic diaphyseal fractures of the radius and/or ulna within 10 days of injury were included. Exclusion criteria were Gustilo–Anderson type II or III open fractures, a history of forearm fracture within the preceding year, pathological fractures, malunion, and polytrauma patients. Both participating trauma centres followed similar postoperative management protocols, including postoperative immobilisation, follow-up intervals, radiographic assessment, and implant removal policies.

Data Collection and Outcome Measures

Demographic characteristics, fracture patterns, surgical technique, duration of postoperative immobilisation, and timing of implant removal were recorded. Complications assessed during follow-up included loss of reduction, refracture (defined as re-fracture occurring within the first six months after initial union), malunion, nonunion, implant-related irritation, tendon or nerve injury, and superficial or deep infection.

The primary endpoint of the study was the comparison of overall complication rates between the buried and exposed nail-end groups. Secondary endpoints included time to fracture union, duration of postoperative immobilisation, implant removal time, and functional outcomes assessed using the Price criteria.

Fracture union was defined as successful healing with radiographic evidence of union in at least three of four cortices. Infections

managed with oral antibiotics and local wound care were classified as superficial, whereas infections requiring implant removal or surgical debridement were defined as deep infections.

Functional outcomes were assessed at the final follow-up visit by an independent orthopaedic surgeon who was not involved in the surgical treatment, using the Price criteria based on forearm rotation and activity-related symptoms at a minimum follow-up of six months. According to these criteria, outcomes were categorised as excellent (no complaints during strenuous activity and $<10^\circ$ loss of forearm rotation), good (mild complaints during strenuous activity and/or 11° – 30° loss of rotation), fair (mild complaints during daily activities and/or 31° – 90° loss of rotation), or poor (persistent pain or $>90^\circ$ loss of forearm rotation).

Surgical Technique

All procedures were performed under general anaesthesia. Closed reduction was attempted in all patients, with limited open reduction performed when necessary to achieve acceptable alignment. Following reduction, fixation was achieved using one intramedullary nail per bone. The radius was stabilised using a retrograde technique through a dorsal or lateral entry point proximal to the distal physis, while the ulna was stabilised using an antegrade technique through a lateral entry point distal to the proximal physis.

Patients were divided into two groups according to nail-end management. In Group 1, the nail ends were cut close to the bone and buried subcutaneously. In Group 2, the nail ends were cut leaving a short segment exposed above the skin. The decision to bury or expose the nail ends was based on the surgeon's preference rather than predefined clinical criteria or random allocation

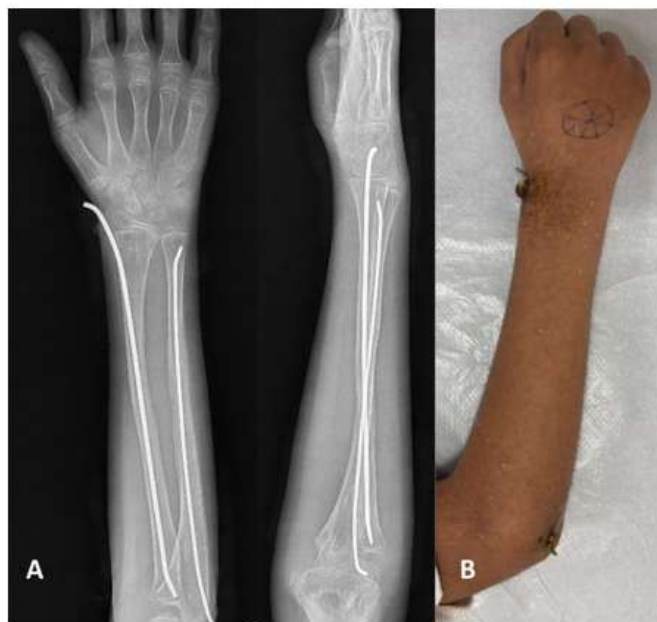


Figure 1: The decision to bury or expose the nail ends was based on the surgeon's preference

rather than predefined clinical criteria or random allocation

All patients in both groups were immobilised with a short-arm splint postoperatively.

Implant Removal

In Group 1, implant removal was performed in the operating theatre under anaesthesia, followed by a one-night hospital stay. In Group 2, implant removal was performed in the outpatient setting without sedation, in the cast room, after radiographic evidence of fracture union and the absence of tenderness at the fracture site. None of the patients required analgesia, local anaesthesia, sedation, or conversion to implant removal in the operating room. The timing of implant removal in Group 2 was determined on a case-by-case basis by the treating surgeon, with informed consent obtained from the patient's family.

No additional immobilisation was applied following implant removal in either group.

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics (version 24; IBM Corp., Armonk, NY, USA). Continuous variables were assessed for normality using the Shapiro–Wilk test. Normally distributed continuous variables were presented as mean (standard deviation), whereas non-normally distributed variables were reported as median (interquartile range). Categorical variables were expressed as frequencies and percentages. Comparisons between the buried and exposed nail-end groups were performed using the independent-samples *t* test for normally distributed continuous variables and the Mann–Whitney *U* test for non-normally distributed data. Categorical variables were compared using the chi-square test or Fisher's exact test, as appropriate. Functional outcomes according to the Price criteria were analysed as categorical variables. All statistical tests were two-tailed, and a *p* value < 0.05 was considered statistically significant.

RESULTS

A total of 122 paediatric patients treated with elastic stable intramedullary nailing for diaphyseal forearm fractures were included in the study, comprising 68 patients in the buried ESIN group and 54 patients in the exposed ESIN group.

Baseline demographic and fracture characteristics

Baseline demographic and fracture-related characteristics of the two groups are summarized in Table 1.

The buried ESIN group had a significantly higher mean age compared with the exposed ESIN group. Sex distribution, injured side, and dominance of the injured extremity were comparable between groups. Similarly, no significant intergroup differences were observed with respect to the injured bone, fracture location, fracture type, or reduction method.

Follow-up and treatment-related outcomes

Follow-up duration and treatment-related outcomes are presented in Table 2.

Table 2. Comparison of follow-up and treatment-related outcomes between buried and exposed ESIN groups

	Buried ESIN (n = 68)	Exposed ESIN (n = 54)	<i>p</i> value
Follow-up duration (months), mean ± SD	10.72 ± 4.75	10.76 ± 5.85	0.968
Duration of casting (days), mean ± SD	19.24 ± 3.16	18.85 ± 3.01	0.498
Union time (days), mean ± SD	32.76 ± 5.08	31.93 ± 5.41	0.381
Implant removal time (weeks), mean ± SD	30.71 ± 14.43	9.39 ± 9.80	<0.001

Footnote: Values are presented as mean ± standard deviation. ESIN: elastic stable intramedullary nailing.

There were no significant differences between the buried and exposed ESIN groups regarding follow-up duration, duration of casting, or time to union. In contrast, implant removal time differed significantly between groups, with earlier removal observed in patients treated with exposed ESIN.

Complications and functional outcomes

Complication rates and functional outcomes are summarised in Table 3.

Table 3. Complications and functional outcomes according to Price criteria

	Buried ESIN (n = 68)	Exposed ESIN (n = 54)	<i>p</i> value
Refracture, n (%)	1 (1.5%)	2 (3.7%)	0.59
Infection, n (%)	3 (4.4%)	3 (5.6%)	1.00
Local irritation (pin-site), n (%)	3 (4.4%)	2 (3.7%)	1.00
Delayed union, n (%)	1 (1.5%)	2 (3.7%)	0.59
Total complications, n (%)	8 (11.8%)	9 (16.7%)	0.44
Price criteria, n (%)			0.27
Excellent	64 (94.1%)	50 (92.6%)	
Good	4 (5.9%)	4 (7.4%)	

Footnote: Data are presented as number (%). Functional outcomes were assessed using the Price criteria. ESIN: elastic stable intramedullary nailing.

Refracture occurred in 1 patient (1.5%) in the buried ESIN group and in 2 patients (3.7%) in the exposed ESIN group, with no statistically significant difference between groups (*p* = 0.59). In the buried ESIN group, refracture occurred at postoperative week 10 following a new traumatic event while the implant was still in situ. In the exposed ESIN group, both refractures occurred following new traumatic events two weeks after implant removal, which had been performed at postoperative week 8 and 10.

Infection rates were low and comparable between groups, observed in 3 patients (4.4%) in the buried ESIN group and 3 patients (5.6%) in the exposed ESIN group (*p* = 1.00). All infections were superficial and were successfully managed with oral antibiotic therapy and local wound care. None of these patients required premature implant removal, and implants were removed according to the planned schedule.

Local implant-related irritation was noted in 3 patients (4.4%) in the buried ESIN group and 2 patients (3.7%) in the exposed ESIN group, without a significant intergroup difference (*p* = 1.00). Implant removal was performed earlier than planned in all patients with local irritation in the buried ESIN group, whereas early implant removal was required in only one patient in the exposed ESIN group. Delayed union was uncommon and occurred in 1 patient (1.5%) in the buried group and 2 patients (3.7%) in the exposed group (*p* = 0.59).

Table 1. Baseline demographic and fracture characteristics of patients treated with buried and exposed ESIN

Variable	Buried (n = 68)	ESIN Exposed (n = 54)	ESIN <i>p</i> value
Age, years, mean±SD	10.8±2.6	9.8±2.6	0.037
Sex, n (%)			0.81
Male	54 (79.4%)	41 (75.9%)	
Female	14 (20.6%)	13 (24.1%)	
Injured side, n (%)			0.72
Right	31 (45.6%)	22 (40.7%)	
Left	37 (54.4%)	32 (59.3%)	
Dominance of injured extremity, n (%)			0.79
Dominant	30 (44.1%)	26 (48.1%)	
Non-dominant	38 (55.9%)	28 (51.9%)	
Injured bone, n (%)			0.13
Both radius and ulna	61 (89.7%)	45 (83.3%)	
Only radius	4 (5.9%)	5 (9.3%)	
Only ulna	3 (4.4%)	4 (7.4%)	
Fracture location, n (%)			0.19
Proximal third	5 (7.4%)	1 (1.9%)	
Middle third	51 (75.0%)	38 (70.4%)	
Distal third	12 (17.6%)	15 (27.8%)	
Fracture type, n (%)			0.29
Closed	53 (77.9%)	47 (87.0%)	
Open (Gustilo–Anderson type I)	15 (22.1%)	7 (13.0%)	
Reduction method, n (%)			0.718
Both bones closed	39 (57.4%)	31 (57.4%)	
One bone open	17 (25.0%)	16 (29.6%)	
Both bones open	12 (17.6%)	7 (13%)	

Footnote: Data are presented as mean ± standard deviation or number (%). ESIN: elastic stable intramedullary nailing.

Overall, no statistically significant difference in total complication rates could be demonstrated between the buried and exposed ESIN groups (11.8% vs 16.7%, respectively; $p = 0.44$). Functional outcomes assessed using the Price criteria were favourable in both groups, with the majority of patients achieving excellent results (94.1% in the buried group and 92.6% in the exposed group). No statistically significant difference in the distribution of functional outcomes could be demonstrated between groups ($p = 0.27$).

DISCUSSION

The present study found no statistically significant differences in functional outcomes or overall complication rates between exposed and buried nail ends following ESIN for paediatric diaphyseal forearm fractures. Union time, duration of postoperative splint immobilisation, refracture rates, infection rates, and total complication rates did not differ significantly between the two groups. Despite earlier outpatient implant removal, the exposed ESIN group showed similar functional outcomes, and no statistically significant difference in overall complication rates could be demonstrated. However, these findings should not be interpreted as evidence of equivalence between the techniques.

Elastic stable intramedullary nailing is widely accepted as the preferred surgical technique for unstable paediatric forearm diaphyseal fractures due to its minimally invasive nature, preservation of fracture biology, and reliable functional recovery(5–7,14,15). However, optimal nail-end management remains controversial. Subcutaneous burial has traditionally been favoured to permit longer implant retention and to minimise soft-tissue irritation, whereas exposed nail ends have been advocated for their practical advantages, particularly the possibility of implant removal in an outpatient setting without general anaesthesia or operating room utilisation. The ongoing debate reflects the balance between theoretical safety concerns and pragmatic clinical benefits. A significant difference in age was observed between the two groups, with patients in the buried nail group being older. Although no statistically significant differences were demonstrated in fracture union or complication rates, age may have influenced fracture healing, implant removal timing, and the surgeon's treatment preference. Therefore, the potential confounding effect of this baseline imbalance should be considered when interpreting the study findings.

Complications related to nail-end management represent the primary concern when choosing between buried and exposed techniques. In line with previous studies, including the work by Kelly et al., overall complication rates in the present study were low and comparable between groups(10). Superficial infections, one of the most frequently reported complications, occurred at similar rates in both groups and were successfully managed with conservative treatment, without the need for premature implant removal. No deep infections or cases of osteomyelitis were observed, supporting the view that infection risk is more closely related to surgical technique and postoperative care than to nail-end position alone. Refracture is among the most clinically relevant complications following ESIN, particularly in relation to implant removal timing. Although prolonged implant retention has been suggested to reduce refracture risk, most comparative studies have reported similar refracture rates between buried and exposed techniques (9,10,13,16,17). In our cohort, refractures were infrequent and occurred after new traumatic events in all cases. In the exposed group, both refractures occurred following new trauma after implant removal. No statistically significant difference in refracture rates could be demonstrated between the groups; however, the small number of events limits the strength of this comparison. The substantial difference in implant removal timing between the groups should also be considered when interpreting these findings. Implant retention time may independently influence refracture and other implant-related complications. Longer retention may provide continued mechanical support during fracture remodelling, whereas earlier removal may reduce implant-related irritation and facilitate outpatient management but could theoretically increase vulnerability to refracture. Therefore, the refracture findings cannot be attributed solely to nail-end position and should be interpreted cautiously in the context of differing implant retention periods.

Local implant-related irritation is often cited as a disadvantage of nail-end management strategies. Ohshima et al. reported a higher rate of irritation-related pain in the buried group compared with the exposed group, whereas Dündar et al. found no significant difference between techniques(9,13). In the present study, implant-related irritation occurred at similar rates in both groups; however,

early implant removal due to local irritation was more frequent in the buried ESIN group, whereas only one patient in the exposed group required early removal for this reason, highlighting that subcutaneous burial does not necessarily eliminate implant-related discomfort.

Functional recovery remains the primary goal in the treatment of paediatric forearm fractures. Functional outcomes assessed using the Price criteria were favourable in both groups, and no statistically significant difference in their distribution could be demonstrated. Nevertheless, the study design does not allow definitive conclusions regarding the independent effect of nail-end management on forearm function. From a clinical perspective, the ability to remove implants in the outpatient setting without anaesthesia may represent a practical advantage of exposed nail ends. Previous studies have shown that non-opioid analgesics do not significantly reduce pain scores or heart rate responses associated with percutaneous pin removal in children compared with placebo(18). Furthermore, studies on exposed pin fixation in lateral humeral condyle fractures have demonstrated substantially lower treatment costs(19). In the present study, parents of children in the exposed ESIN group were fully informed, and informed consent was obtained prior to outpatient implant removal. We believe that avoiding a secondary surgical procedure in this patient population may reduce health-care resource utilisation, eliminate anaesthesia-related risks, and lessen the physical and psychological burden on both children and their families. However, these potential benefits were not directly evaluated in the present study. Although exposed nail ends may facilitate outpatient implant removal, they may also cause discomfort or anxiety in children and their parents and require careful pin-site care during the postoperative period. In addition, cosmetic concerns may influence treatment preference. These patient- and family-centred outcomes were not formally assessed in the present study and should be evaluated in future prospective studies.

This study has several limitations. Its retrospective design and the surgeon-dependent decision regarding nail-end management introduce potential selection bias, as treatment allocation was not based on predefined criteria or randomisation. Consequently, unmeasured confounding factors may have influenced both treatment selection and clinical outcomes. In addition, the significant age difference between the groups represents a potential source of confounding, as age may influence fracture healing, implant removal timing, and complication risk. Owing to the limited number of complication events, a reliable multivariable analysis adjusting for age and other potential confounders could not be performed. The relatively low number of complications may also have limited the statistical power to detect differences between the groups, particularly for rare adverse events such as deep infection and refracture. Therefore, the absence of statistically significant differences should not be interpreted as evidence of equivalence. Furthermore, the relatively short follow-up period, particularly after implant removal in some patients in the buried nail group, may have limited the detection of late refractures. Patient-reported outcomes, including pain during implant removal, satisfaction, anxiety, and cosmetic concerns, were not formally assessed. Finally, although both centres followed similar postoperative and follow-up protocols, unmeasured centre-related differences in postoperative care, follow-up practices, or implant removal timing cannot be entirely excluded. Nevertheless, the inclusion of patients from two trauma centres may improve the generalisability of the findings.

In conclusion, no statistically significant differences in clinical and functional outcomes, complications, or refracture rates were demonstrated between exposed and buried nail ends following ESIN for paediatric diaphyseal forearm fractures in this cohort. In appropriately selected paediatric patients with reliable follow-up, leaving nail ends exposed may be considered a feasible and practical alternative because it facilitates outpatient implant removal and may reduce the need for a secondary procedure under anaesthesia. However, these findings should be interpreted with caution because of the retrospective design, non-randomized treatment allocation, potential selection bias, low number of complication events, and limited follow-up after implant removal in some patients. Further prospective comparative studies with larger sample sizes and longer follow-up are warranted.

Author Contributions:

SY: Study conception and design, data collection, data analysis, and manuscript writing.

EY: Data collection, data analysis, and manuscript writing.

IFA: Data collection and literature review.

OK: Data analysis and interpretation.

MKY: Study design and critical revision of the manuscript.

OE: Supervision and final approval of the manuscript.

REFERENCES

1. Cheng JC, Ng BK, Ying SY, Lam PK. A 10-year study of the changes in the pattern and treatment of 6,493 fractures. *J Pediatr Orthop*. 1999;19(3):344-350.
2. Franklin CC, Robinson J, Noonan K, Flynn JM. Evidence-based medicine: management of pediatric forearm fractures. *Journal of Pediatric Orthopaedics*. 2012;32(Supplement 2):S131-S134. doi:10.1097/BPO.0b013e318259543b
3. Klein C. Management of forearm fracture in children. Elsevier Masson s.r.l. 2025;111(6):537-545. doi:10.1016/j.rcot.2025.04.007
4. Sinikumpu JJ, Lautamo A, Pokka T, Serlo W. The increasing incidence of paediatric diaphyseal both-bone forearm fractures and their internal fixation during the last decade. *Injury*. 2012;43(3):362-366. doi:10.1016/j.injury.2011.11.006
5. Hailer YD, Elvefors Wallin M, Wolf O. Epidemiology and treatment of forearm fractures in Swedish children and adolescents. *European Journal of Trauma and Emergency Surgery*. 2025;51(1). doi:10.1007/s00068-025-02986-5
6. Hansen RT, Borghegn NW, Gundtoft PH, Nielsen KA, Balslev-Clausen A, Viberg B. Change in treatment preferences in pediatric diaphyseal forearm fractures: a Danish nationwide register study of 36,244 fractures between 1997 and 2016. *Acta Orthop*. 2023;94:32-37. doi:10.2340/17453674.2023.7132
7. Patel A, Li L, Anand A. Systematic review: Functional outcomes and complications of intramedullary nailing versus plate fixation for both-bone diaphyseal forearm fractures in children. *Injury*. 2014;45(8):1135-1143. doi:10.1016/j.injury.2014.04.020
8. Poutoglidou F, Metaxiotis D, Kazas C, Alvanos D, Mpeletiotis A. Flexible intramedullary nailing in the treatment of forearm fractures in children and adolescents, a systematic review. *J Orthop*. Reed Elsevier India Pvt. Ltd. 2020;20:125-130. doi:10.1016/j.jor.2020.01.002
9. Ohshima K, Tokutake K, Takegami Y, et al. Longer time of implantation using the buried pin technique for intramedullary nailing would decrease refracture in the diaphyseal forearm fracture in children-retrospective multicenter (TRON) study. *Injury*. 2023;54(3):924-929. doi:10.1016/j.injury.2023.01.025
10. Kelly BA, Miller P, Shore BJ, Waters PM, Bae DS. Exposed Versus Buried Intramedullary Implants for Pediatric Forearm Fractures. *Journal of Pediatric Orthopaedics*. 2014;34(8):749-755. doi:10.1097/BPO.0000000000000210
11. Dinçer R, Köse A, Topal M, Öztürk IA, Engin MC. Surgical treatment of pediatric forearm fractures with intramedullary nails: Is it a disadvantage to leave the tip exposed? *Journal of Pediatric Orthopaedics Part B*. 2020;29(2):158-163. doi:10.1097/BPB.0000000000000635
12. Fernandez FF, Langendörfer M, Wirth T, Eberhardt O. Failures and complications in intramedullary nailing of children's forearm fractures. *J Child Orthop*. 2010 Apr;4(2):159-67. doi: 10.1007/s11832-010-0245-y.
13. Dündar A, Kaya Ş. Impact of buried versus exposed flexible intramedullary nails osteosynthesis on pediatric forearm fractures. *Andes Pediatrica*. 2024;95(3):263-271. doi:10.32641/andespediatr.v95i3.4926
14. Lyman A, Wenger D, Landin L. Pediatric diaphyseal forearm fractures: Epidemiology and treatment in an urban population during a 10-year period, with special attention to titanium elastic nailing and its complications. *Journal of Pediatric Orthopaedics Part B*. 2016;25(5):439-446. doi:10.1097/BPB.0000000000000278
15. Kwas K, Mostowy M, Szatanik K, Małeck K. Elastic stable intramedullary nailing in paediatric diaphyseal forearm fractures – a retrospective analysis of 201 cases. *BMC Musculoskelet Disord*. 2024;25(1). doi:10.1186/s12891-024-07959-0
16. Jordà Gómez P, Antequera Cano JM, Ferràs-Tarrago J, et al. Buried intramedullary implants for paediatric forearm fractures. Does the refracture rate improve? *Revista Española de Cirugía Ortopédica y Traumatología (English Edition)*. 2020;64(1):35-40. doi:10.1016/j.recote.2019.07.006
17. Lightdale-Miric NR, Obana KK, Fan BB, et al. Exposed Intramedullary Fixation Produces Similar Outcomes to Buried Fixation for Acute Pediatric Monteggia Fractures. *Journal of Pediatric Orthopaedics*. 2023;43(3):129-134. doi:10.1097/BPO.00000000000002343
18. Lim KBL, Tan SS, Abdullah SNS, Ong LL, Wong ML, Allen JC. Percutaneous pin removal in the outpatient clinic - Do children require analgesia? A randomized controlled trial. *Journal of Bone and Joint Surgery*. 2014;96(7):597-602. doi:10.2106/JBJS.M.00806
19. Das De S, Bae DS, Waters PM. Displaced Humeral Lateral Condyle Fractures in Children. *Journal of Pediatric Orthopaedics*. 2012;32(6):573-578. doi:10.1097/BPO.0b013e318263a25f