ORİJİNAL MAKALE / ORIGINAL ARTICLE
Balıkesir Sağlık Bilimleri Dergisi/ BAUN Sağ Bil Derg
Balıkesir Health Sciences Journal / BAUN Health Sci J
ISSN: 2146-9601- e ISSN: 2147-2238
Doi: https://doi.org/10.53424/balikesirsbd.1606303

Pediatric Hardware Removal Complications; Are They Really Easy Surgeries?

Ortaç GÜRAN [1]

[1]Sancaktepe Şehit Prof. Dr. İlhan Varank Training and Research Hospital, Orthopaedics and Traumatology Clinic

GelişTarihi / Received: *23.12.2024,* ***Kabul Tarihi / Accepted:*** *05.03.2025*

ABSTRACT
Objective: The aim of this study was to investigate the complications and challenges encountered in pediatric implant removal cases. **Materials and Methods:** This retrospective study was conducted in Sancaktepe Şehit Prof. Dr. İlhan Varank Research and Training Hospital and data was collected from patients' charts, operating room registrations, and operation notes, who underwent hardware removal surgery between January 2024 and October 2024. The normality of the data was assessed with the Q-Q plot test. The Student's t-test was used to compare two independent groups with normal distribution, whereas the Kruskal-Wallis test was used for non-normally distributed data. **Results:** Forty-two cases of pediatric implant removal patients were included in the study and significant correlation was found between the duration of surgery and the type of implant removed (p=0.006). After the removal of implants, the following complications were observed: superficial infection occurred in 3 patients (7%), deep tissue infection in 2 patients (5%), failure to remove the implant in 2 cases (5%), refracture in 1 patient (2%), and extensor tendon injury in 1 patient (2%). **Conclusion:** To minimize the risk of complications during implant removal, it is recommended to choose the correct and high-quality implant, apply appropriate surgical techniques, and plan the removal surgery while performing fracture fixation, adjusting the treatment accordingly.
Keywords: Hardware Removal, Complication, Pediatric Implant.

Pediatrik İmplant Çıkarım Komplikasyonları; Gerçekten Kolay Ameliyatlar mı?

ÖZET
Amaç: Bu çalışmanın amacı, pediatrik implant çıkarma vakalarında karşılaşılan komplikasyonları ve nedenlerini ortaya koymaktır. **Gereç ve Yöntem:** Bu retrospektif çalışma Sancaktepe Şehit Prof. Dr. İlhan Varank Eğitim ve Araştırma Hastanesi'nde gerçekleştirilmiş ve veriler Ocak 2024 ile Ekim 2024 tarihleri arasında pediatrik implant çıkarım ameliyatı geçiren hastaların dosyalarından, ameliyathane kayıtlarından ve ameliyat notlarından elde edilmiştir. Verilerin normalliği Q-Q plot testi ile değerlendirilmiştir. Student's t-testi ile normal dağılıma sahip iki bağımsız grubu karşılaştırırken, normal dağılıma sahip olmayan veriler için Kruskal-Wallis testi kullanılmıştır. **Bulgular:** Kırk iki pediatrik implant çıkarım hastası çalışmaya dahil edilmiş ve ameliyat süresi ile çıkarılan implant tipi arasında anlamlı korelasyon bulunmuştur (p = 0.006). İmplantların çıkarılmasından sonra 3 hastada (%7) yüzeyel enfeksiyon, 2 hastada (%5) derin doku enfeksiyonu, 2 vakada (%5) implantın çıkarılamaması, 1 hastada (%2) refraktür ve 1 hastada (%2) ekstansör tendon yaralanması gibi komplikasyonlar gözlendi. **Sonuç:** İmplant çıkarılması sırasında komplikasyon riskini en aza indirmek için, doğru ve yüksek kaliteli implantın seçilmesi, uygun cerrahi tekniklerin uygulanması ve kırık fiksasyonu yapılırken çıkarma ameliyatının planlanması, tedavinin buna göre ayarlanması önerilir.
Anahtar Kelimeler: Pediatrik İmplant, Komplikasyon, İmplant Çıkarımı.

Sorumlu Yazar / Corresponding Author: Ortaç GÜRAN, Sancaktepe Şehit Prof. Dr. İlhan Varank Training and Research Hospital, Orthopaedics and Traumatology Clinic, İstanbul, Türkiye.
E-mail:ortacguran@gmail.com

Bu makaleye atıf yapmak için / Cite this article: Güran, O. (2025). Pediatric hardware removal complications; are they really easy surgeries? *BAUN Health Sci J,14*(1), 199-203. https://doi.org/10.53424/balikesirsbd.1606303

INTRODUCTION

Extremity fractures are two times more common in pediatric than in adults (Schalamon et al., 2011; Wells, 2012). Approximately one out of every three children is treated for extremity fracture at least one time before reaching adulthood (Boutis, 2020). Due to the implants used in the treatment of these fractures, implant removal procedures are among the most common operations performed in orthopedic surgery. The most common concern of patients and their relatives after fracture surgeries is whether the existing implant should be removed or not. Advancements in implant technology significantly contribute to a decline in orthopedic implant removal rates for adult fractures. In pediatric cases, it is advisable to remove implants because of ongoing bone growth, which raises concerns about the implant disrupting the natural process of bone remodeling (Kahle, 1994; Schildhauer, 2021; Stanitski, 2005; Wentzensen, 1991). However in recent years, it has been reported that implant removal is not necessary unless specific complications arise, such as persistent pain, limitations in joint movement, or fracture of the implant (Clement, Yousif, Duckworth, Teoh, & Porter, 2012). The decision to remove an implant should not be underestimated, as complication rates during the process can reach as high as 40% (Evers, 2004).

The aim of this study was to investigate the complications and challenges encountered in pediatric implant removal cases through a retrospective single-center analysis.

MATERIALS AND METHODS

Study type

This retrospective study was conducted in Sancaktepe Şehit Prof. Dr. İlhan Varank Research and Training Hospital between January 2024 and October 2024.

Study group

The research universe consisted of patients who underwent hardware removal surgery and younger than 18 years of age.

Dependent and independent variables

The independent variables of this research are implant types, anatomical locations, BMI, and the dependent variable is the complications.

Procedures

In this retrospective analysis, data was collected from patients' charts, operating room registrations, and operation notes for those who underwent hardware removal surgery between January 2024 and October 2024. Patients younger than 18 years at the time of implant removal surgery were included in this study. Outpatient patients and those with inadequate surgical documentation were excluded from the study. The following prognostic factors were identified and recorded: gender, age, body mass index (BMI), history of previous surgeries, type of hardware used, location of implantation, side of the body, duration of hardware implantation until removal, length of surgery, number of fluoroscopies performed during surgery, and any complications that occurred. Complications were classified using the Goslings and Sink grading systems.

Statistical analysis

Datasets were analyzed using SPSS (Statistical Package for Social Sciences) for Windows version 22.0 (SPSS Inc, Chicago, IL). The normality of the data was assessed with the Q-Q plot test. For normally distributed data, mean values and standard deviations were reported, while frequency and percentage were used for categorical variables. The Student's t-test compared two independent groups with normal distribution, whereas the Kruskal-Wallis test was used for non-normally distributed data. A significance level of $p<0.05$ was set for all statistical tests.

Ethical considerations

Before the study was started, written permissions were obtained. Written approval was obtained from the Ethics Committee approval (Ethic Committee of Sancaktepe Şehit Prof. Dr. İlhan Varank Research and Training Hospital 11.12.2024, File No: 372).

RESULTS

Forty-two cases of pediatric implant removal performed at our hospital between January 2024 and October 2024 that met all the established criteria. The patient population consisted of 6 female and 36 male children with a mean age of 12.1 at the time of hardware removal. The mean BMI was 20.49 kg/m^2. The implants were retained for an average of 17.8 months, and the median surgery duration was 55 minutes (Table 1).

Patients who underwent implant removal surgery were categorized by the anatomical location of the implants. The distribution was as follows: 13 patients in the forearm (31%), 9 in the tibia shaft (21%), 8 in the ankle (19%), 8 in the femur shaft and knee (19%), and 4 in the humerus shaft and elbow (9.5%) (Table 1, figure 1).

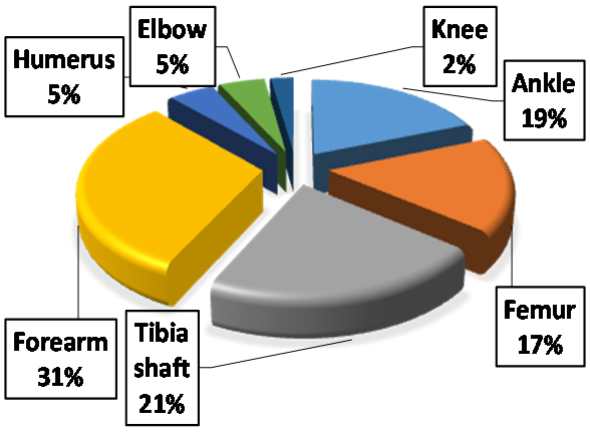

Figure 1. Anatomical localization of the implants.

The types of implants used in fracture fixation included 22 titanium elastic nails (TEN) (52%), 9 free screws (22%), 8 plate screws (19%), and 3 Kirschner wires (7%) (Table 1, Figure 2).

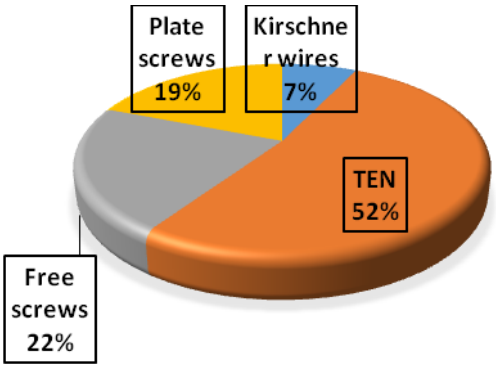

Figure 2. The types of implants.

After the removal of implants, the following complications were observed: superficial infection occurred in 3 patients (7%), deep tissue infection in 2 patients (5%), failure to remove the implant in 2 cases (5%), refracture in 1 patient (2%), and extensor tendon injury in 1 patient (2%) (Table 1, Figure 3).No statistically significant association was found between implant type and specific complications.

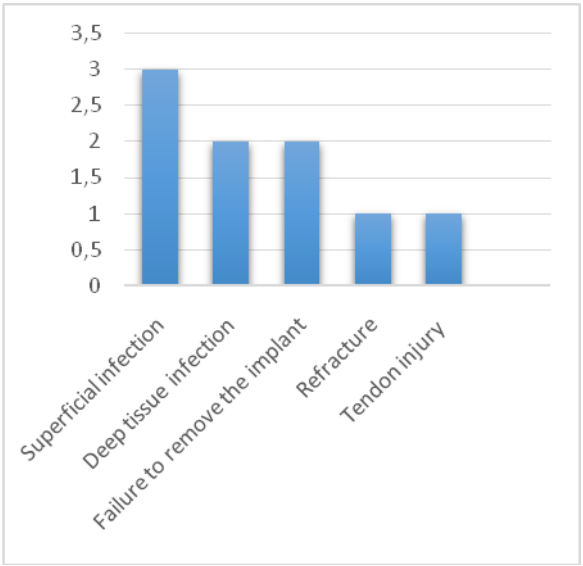

Figure 3. Complications.

A significant correlation was found between the duration of surgery and the type of implant removed (p=0.006). However, surgery durations were similar across different anatomical locations (p=0.225). The number of fluoroscopy images taken did not differ significantly among the various types of surgeries (p=0.177), nor did it vary across different anatomical localizations (p=0.488). Additionally, surgery durations were not statistically correlated. with BMI (p=0.172), and the number of fluoroscopy images also showed no correlation with BMI (p=0.321).

Table 1.Patients characteristics.

	All Patients	
	n=42	(%)
Age (years), Median (min-max)	12.1 (7-17)	
Gender		
Boy	36	(85.7%)
Girl	6	(14.3%)
Body mass index (kg/m^2)		
<25	38	(90.5%)
≥25	4	(9.5%)
Body part		
Ankle	8	(19.0%)
Femur and knee	8	(19.0%)
Tibia shaft	9	(21.4%)
Forearm	13	(31.0%)
Humerus and elbow	4	(9.5%)
Type of surgery		
TEN	22	(52.4%)
Kirschner wire	3	(7.1%)
Free screw	9	(21.4%)
Plate screw	8	(19.0%)
Duration between first and second surgery, (Months) Mean (min-max)	17.8 (4-48)	
Duration of surgery (Minutes) Median (min-max)	55 (8-150)	
Number of fluoroscopy Median (min-max)	5 (1-50)	
Rate of complications	9	(21.4%)
Superficial infection	3	(7.0%)
Deep tissue infection	2	(5.0%)
Failure to remove the implant	2	(5.0%)
Refracture	1	(2.0%)
Extensor tendon injury	1	(2.0%)

DISCUSSION

Although implant removal is generally regarded as one of the simpler procedures in orthopedic surgery, it is imperative that it be conducted with utmost care and attention. The average duration of these operations is 62 minutes, and the reported complication rate may reach up to 21%. This emphasizes the necessity for careful execution in line with the standards of any surgical intervention.

The complication rates of the removal surgeries were 21.4% was in our study. The complication rate of 17.1% in Scheider et al.'s series of 449 cases is comparable to our study (Scheider, Ganger, & Farr, 2020).

We treated superficial infections encountered after implant removal with dressings, local debridement, and antibiotic treatment in an outpatient clinic, while deep tissue infections necessitated reoperation.

In certain medical practices, the tips of titanium elastic nails employed in the management of long bone shaft fractures may be intentionally left exposed outside the skin. This approach, while feasible, carries a heightened risk of infection. Therefore, it is imperative to ensure meticulous care of the pin base, along with rigorous and consistent follow-up assessments. Moreover, one must consider that in the event of any discharge, timely interventions, including the removal of the implant, debridement, and administration of antibiotics, will be necessary to mitigate complications.

In our study, we found that the existing implant could not be removed in 5% of the cases (2 out of 42 patients). In a related investigation, Simanovsky et al. (2006) documented that the implant was unable to be removed in 3 patients within their cohort of 149 individuals. Thus, it is important to explain to the patients and their families that it may not always be possible to remove the existing implants. It should be made clear what procedure will be followed in such cases, and written consent from the parents should be obtained.

In our analysis of cases in which the implant could not be removed, we identified a significant issue related to the stripping of the screw head. The primary contributors to the deterioration of the screw head include the quality of the implant, recurrent strains applied to the screw head during surgical procedures, and the embedding of the screw head in the cortex, which occurs over time following the initial surgery.

The other case in which the implant could not be removed involved a patient with a humeral shaft fracture who was treated with a titanium elastic nail. In our study, the average time between the first operation and implant removal was 17.8 months. In this specific case, however, the implant was removed after 21 months. Although the implant was located in a non-load-bearing area, it was removed later than the average timeframe. There are varying opinions on the optimal timing for implant removal. This timeframe can differ based on factors such as patient age, the location of the fracture, and the type of fracture. Studies indicate that the recommended periods for implant removal are 4 to 32 weeks for forearm fractures, 3 to 12 months for femur fractures, and an average of 6.2 months for tibial fractures (Doğan, 2024; Gölgelioğlu, 2023; Jain et al., 2023; Küçük, 2022).

Upon analyzing the reasons for the non-removal of intramedullary nails (TEN), it was found that one significant factor was the length of the nail left protruding outside the bone. During TEN procedures, it is important to balance leaving the nail tips short enough to avoid irritating the soft tissue while ensuring they are long enough to facilitate easy removal later. This approach helps in planning for implant removal surgery without unnecessary delays after the fracture has healed. Additionally, sociocultural evaluations of implant removal cases indicate that factors such as younger age, Caucasian ethnicity, and higher socioeconomic status are often associated with a preference for these procedures (Dodwell et al., 2016). To mitigate the risk of future complications, it is imperative to conduct closer follow-up for disadvantaged cases and to strategically plan for implant removal surgery at the appropriate time. This approach should be implemented without disrupting the ongoing follow-up of patients who are already scheduled for implant removal.

An analysis of the anatomical sites for implant removal revealed that the most common sites were the forearm, tibia shaft, ankle, and femur shaft, in that order. The data indicates that more distal locations, such as the forearm and metacarpals, were associated with higher complication rates, which aligns with existing literature (Langkamer & Ackroyd, 1990; Sanderson et al., 1992).

Our findings indicated that the plates remained in place the longest, with an average retention time of 20.75 months. The screws followed with an average of 18.3 months, while the TENs lasted for 16.5 months. Kirschner wires had the shortest retention time at approximately 14.6 months. These findings were consistent with expectations, as Langkamer & Ackroyd established an average persistence of 23.7 months for the extracted plates in 1990. Additionally, in the context of supracondylar humerus and distal radius fractures, where Kirschner wires are frequently utilized, the extraction of these wires was not addressed in our study. This omission is due to the fact that the removal procedures were conducted in an outpatient clinic setting. Consequently, the durations for the removal of Kirschner wires appear to be comparable to those associated with other implant types.

Schmalzried et al. (1991) conducted a study to examine the effect of implant type on surgical duration. Their findings indicated that the removal of plates necessitates the longest surgical time, whereas the removal of K-wires requires the least time. In our own research, we also identified a significant correlation between surgery type (the specific implant being removed) and surgical duration ($p=0.006$). These results corroborate the findings of Schmalzried and colleagues in this aspect.

Study Limitations and Strengths

The limitations of this study include its retrospective design and the fact that we only included patients who had hardware removal performed in an inpatient setting under general anesthesia.

CONCLUSION

In summary, implant removal will remain a common procedure in orthopedic practices as long as pediatric trauma persists. To reduce the risk of complications

during implant removal, it is advisable to plan for the removal surgery while performing fracture fixation and to organize treatment accordingly.

Acknowledgement
The author would like to extend their sincere thanks to anyone who contributed to this study.

Conflict of Interest
The author declares no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Author Contributions
Plan, design: OG; **Material, methods and data collection:** OG; **Data analysis and comments:** OG; **Writing and corrections:** OG.

Funding
None

Ethical Approval
Institution: Sancaktepe Şehit Prof. Dr. İlhan Varank Research and Training Hospital
Date:11.12.2024
Approval no:372

REFERENCES

Boutis, K. (2020). The Emergency Evaluation and Management of Pediatric Extremity Fractures. *Emergency Medicine Clinics of North America, 38*(1), 31-59. doi:10.1016/j.emc.2019.09.003

Clement, N. D., Yousif, F., Duckworth, A. D., Teoh, K. H., & Porter, D. E. (2012). Retention of forearm plates: risks and benefits in a paediatric population. *The Journal of Bone and Joint Surgery, 94*(1), 134-137. doi:10.1302/0301-620X.94B1.27155

Dodwell, E., Wright, J., Widmann, R., Edobor-Osula, F., Pan, T. J., & Lyman, S. (2016). Socioeconomic Factors Are Associated With Trends in Treatment of Pediatric Femoral Shaft Fractures, and Subsequent Implant Removal in New York State. *Journal of Pediatric Orthopaedics, 36*(5), 459-464. doi:10.1097/BPO.0000000000000494

Doğan, N., Büyükdoğan, H., Çalışkan, G., & Ertürk, C. (2024). Is it safe and effective to leave Titanium Elastic Nail (TEN) tips outside the skin in pediatric femoral diaphyseal fractures?. *Acta Medica Alanya, 8*(1), 3-7.

Evers, B., Habelt, R., & Gerngross, H. (2004, March). O2109 indication, timing and complications of plate removal after forearm fractures: Results of a metanalysis including 635 cases. In *Orthopaedic Proceedings* (Vol. 86, No. SUPP_III, pp. 289-289). Bone & Joint.

Gölgelioğlu, F., & Yalın, M. (2023). Pediatric forearm fractures: evaluating implant removal timing and complications with exposed titanium-elastic nail tips. *Journal of Health Sciences and Medicine, 6*(6), 1366-1372.

Jain, S., Mohanachandran, J., & Mohan, R. (2023). Outcomes and complications of Titanium elastic nailing for forearm bones fracture in children: our experience in a district general hospital in the United Kingdom. *Acta Orthopaedica Belgica, 89*(3), 539-546. doi:10.52628/89.3.12032

Kahle, W. K. (1994). The case against routine metal removal. *Journal of Pediatric Orthopaedics 14*(2), 229-237. doi:10.1097/01241398-199403000-00019

Küçük, A., Asfuroğlu, Z. M., & Köse, N. (2022). Closed reduction and titanium elastic nailing in diaphyseal femoral and tibial fractures in children. *Cukurova Medical Journal, 47*(2), 563-569.

Langkamer, V. G., & Ackroyd, C. E. (1990). Removal of forearm plates. A review of the complications. *The Journal of Bone and Joint Surgery, 72*(4), 601-604. doi:10.1302/0301-620X.72B4.2380210

Sanderson, P. L., Ryan, W., & Turner, P. G. (1992). Complications of metalwork removal. *Injury, 23*(1), 29-30. doi:10.1016/0020-1383(92)90121-8

Schalamon, J., Dampf, S., Singer, G., Ainoedhofer, H., Petnehazy, T., Hoellwarth, M. E., & Saxena, A. K. (2011). Evaluation of fractures in children and adolescents in a Level I Trauma Center in Austria. *Journal of Trauma and Acute Care Surgery, 71*(2), E19-25. doi:10.1097/TA.0b013e3181f8a903

Scheider, P., Ganger, R., & Farr, S. (2020). Complications of hardware removal in pediatric upper limb surgery: A retrospective single-center study of 317 patients. *Medicine (Baltimore), 99*(5), e19010. doi:10.1097/MD.0000000000019010

Schildhauer, T. (2021). Metallentfernungen. *Trauma und Berufskrankheit*(21(Suppl 1)), 28-32.

Schmalzried, T. P., Grogan, T. J., Neumeier, P. A., & Dorey, F. J. (1991). Metal removal in a pediatric population: benign procedure or necessary evil? *Journal of Pediatric Orthopaedics, 11*(1), 72-76. doi:10.1097/01241398-199101000-00014

Simanovsky, N., Tair, M. A., Simanovsky, N., & Porat, S. (2006). Removal of flexible titanium nails in children. *Journal of Pediatric Orthopaedics, 26*(2), 188-192. doi:10.1097/01.bpo.0000218534.51609.aa

Stanitski, C. L. (2005). Metal removal in asymptomatic children and adolescents. *Journal of Pediatric Orthopaedics, 25*(4), 557. doi:10.1097/01.bpo.0000166345.86879.9a

Wells, J. C. (2012). Obesity as malnutrition: the role of capitalism in the obesity global epidemic. *American Journal of Human Biology, 24*(3), 261-276.

Wentzensen, A., & Magin, M. (1991). Plattenosteosynthese. In Die Plattenosteosynthese und ihre Konkurrenzverfahren: Von Hansmann bis Ilisarow. *Springer*.