The Effect of Family Socioeconomic Status on the Outcomes of Titanium Elastic Nailing in Pediatric Both-Bone Forearm Fractures

Yasin Erdoğan[1], Hilmi Alkan[1]

1 Department of Orthopedics and Traumatology, Ankara Etlik City Hospital, Ankara, Türkiye

Abstract

Aim: This study aimed to evaluate the effects of parental socioeconomic status, including education and occupation levels, on bone healing and functional recovery in pediatric both-bone forearm fractures treated with titanium elastic nailing.

Methods: A retrospective analysis was conducted on 84 pediatric patients (55 males, 29 females; mean age 9.7 ± 2.2 years) who underwent titanium elastic nailing fixation for both-bone forearm fractures between November 2022 and August 2024. Patients with open, pathological, or multiple fractures were excluded. Socioeconomic status was determined using a modified Hollingshead Index based on parental education and occupation. Clinical outcomes were assessed using Price criteria and goniometric measurements of elbow and wrist range of motion. Statistical analyses included the Mann–Whitney U, Kruskal–Wallis, and Spearman correlation tests.

Results: All fractures achieved union, and no major complications such as nonunion or refracture were observed. Seven patients (8.3%) developed minor superficial wound infections, which resolved with conservative treatment. According to Price criteria, 52.4% of patients had excellent, 39.3% good, and 8.3% fair results. Higher socioeconomic levels were significantly correlated with better Price scores ($p = 0.001$) and decreased elbow extension loss ($p = 0.007$). There was no significant correlation between socioeconomic status and wrist flexion/ extension, elbow flexion range of motion.

Conclusions: Higher parental socioeconomic status was associated with improved functional recovery, particularly in forearm rotation and elbow extension, following titanium elastic nailing fixation of pediatric forearm fractures. Emphasizing the importance of postoperative rehabilitation among families with lower socioeconomic levels may help prevent residual joint limitations.

Keywords: *Pediatric forearm fracture; titanium elastic nail; socioeconomic status; functional outcome*

1. Introduction

Upper extremity fractures are among the most common injuries in children [1]. Among these, forearm fractures involving both bones account for approximately 5% of all pediatric fractures, whereas their prevalence in the general population is reported to be 2.9% [1,2]. These injuries occur more frequently in boys and are usually caused by falls on an outstretched hand involving a rotational mechanism [3,4]. Forearm fractures are most frequently observed in school-aged children but also occur relatively often in preschool-aged children [5].

Although acceptable degrees of reduction vary according to age and sex, surgical intervention should be considered in cases with angulation greater than 15° or rotation exceeding 30°, as the remodeling capacity significantly decreases after the age of 10 [6]. Elastic intramedullary nailing has become the preferred surgical method because it can be performed through small incisions and provides favorable union rates, shorter operative times, and reduced hospital stays [3,7,8].

Several studies have examined the effects of socioeconomic status on pediatric fractures [9-11]. Previous research has also investigated the influence of factors such as treatment modality, psychological effects, pain management, time to treatment, and post-discharge care in relation to race, insurance type, and geographic region [12-14]. However, most existing studies have focused on supracondylar humerus and femoral fractures or have been designed to include all pediatric fracture types [15-17]. The literature remains limited regarding the impact of parental socioeconomic status on the outcomes of forearm fractures treated with titanium elastic nails (TEN).

Therefore, the present study aimed to investigate the effects of parental education level, occupation, and income on mobility limitation and fracture union in pediatric patients with forearm fractures treated using titanium elastic nailing.

Corresponding Author: Yasin Erdoğan, yasin-erdgn@hotmail.com, Received: 06.10.2025, Accepted: 05.02.2026, Available Online Date: 15.03.2026. https://doi.org/10.36516/jocass.1797900

2. Materials and Methods

Patient Selection and Data Gathering

This retrospective study was conducted with the approval of the institutional ethics committee (approval no: AEŞH-BADEK1-2025-419). It included pediatric patients who underwent surgical fixation using titanium elastic nails for both-bone forearm fractures between November 2022 and August 2024. Only patients with at least one year of postoperative follow-up and complete clinical and radiographic data were included. Exclusion criteria comprised open or pathological fractures, multiple extremity injuries, and fractures managed conservatively with casting.

Acceptable alignment limits in pediatric forearm fractures vary according to age. In children younger than 10 years, angulation up to 15° and malrotation up to 45° are considered acceptable, whereas in children aged 10 years and older, these limits decrease to less than 10° of angulation and less than 30° of malrotation [18].

Patient demographic data (age, sex, injured side, and follow-up duration) and family socioeconomic variables were collected from medical records and follow-up visits. Socioeconomic status (SES) was determined using a modified Hollingshead Index of Social Status, which incorporates education and occupation levels for both parents. Education and occupation were each rated on a 0–4 scale (no education/unemployed = 0; primary = 1; secondary/blue-collar = 2; high school/white-collar = 3; university/professional = 4). The combined scores defined four classes: 0–4 = Class I, 5–8 = Class II, 9–12 = Class III, 13–16 = Class IV. According to Turkish standards, Classes I–II represented low to middle SES, whereas Classes III–IV represented high SES [19].

During the surgical procedure, the ulna was fixed in a retrograde manner and the radius in an antegrade manner. Lister's tubercle was used as the entry point for the radius. The diameter of the titanium elastic nail (TEN) was determined as 40% of the medullary canal diameter measured on preoperative radiographs [6]. (Figure 1)

Anteroposterior and lateral radiographs were obtained preoperatively and at scheduled intervals 1, 2, 4, and 6 weeks and at 3, 6, 12 months and the last outpatient follow-up postoperatively. After surgery, all patients were immobilized in a short-arm splint for two weeks. After removal of the splint, elbow and wrist range of motion exercises were initiated in all patients in the same manner. During follow-up, passive range of motion (ROM) of the elbow and wrist joints (flexion–extension, pronation–supination) was measured with a standard goniometer by the same orthopedic surgeon.

Additionally, postoperative complications including compartment syndrome, superficial or deep infection, refracture, nonunion, delayed union, malalignment, synostosis, and loss of reduction were evaluated during the follow-up period. Final outcomes were graded as excellent, good, fair, or poor according to the clinical criteria described by Price et al. [20]. Excellent outcome was defined as a loss of less than 15 degrees of forearm rotation with no complaints during strenuous activities. Good outcome corresponded to a 15-30 degree rotation loss with mild complaints during strenuous activity. Moderate outcome was characterized by a 30-90 degree loss of forearm rotation with mild complaints during daily activities. Poor outcome included a loss of more than 90 degrees of forearm rotation or any other outcome that did not meet the criteria mentioned above. (Figure 2) Implant removal was performed no earlier than 6 months postoperatively.

Figure1

Price's criteria

Outcome	Loss of forearm rotation (°)	Symptoms
Excellent	15	No complaints with sternous exercises
Good	15-30	Mild complaint with sternous activity
Fair	30-90	Mild complaint with Daily activity
Poor	90	All other results

Figure1

A. Preoperative anteroposterior radiograph, B. Preoperative lateral radiograph, C. Postoperative anteroposterior radiograph demonstrating bone union, D. Postoperative lateral radiograph demonstrating bone union, E. Anteroposterior radiograph obtained after TEN removal, F. Lateral radiograph obtained after TEN removal

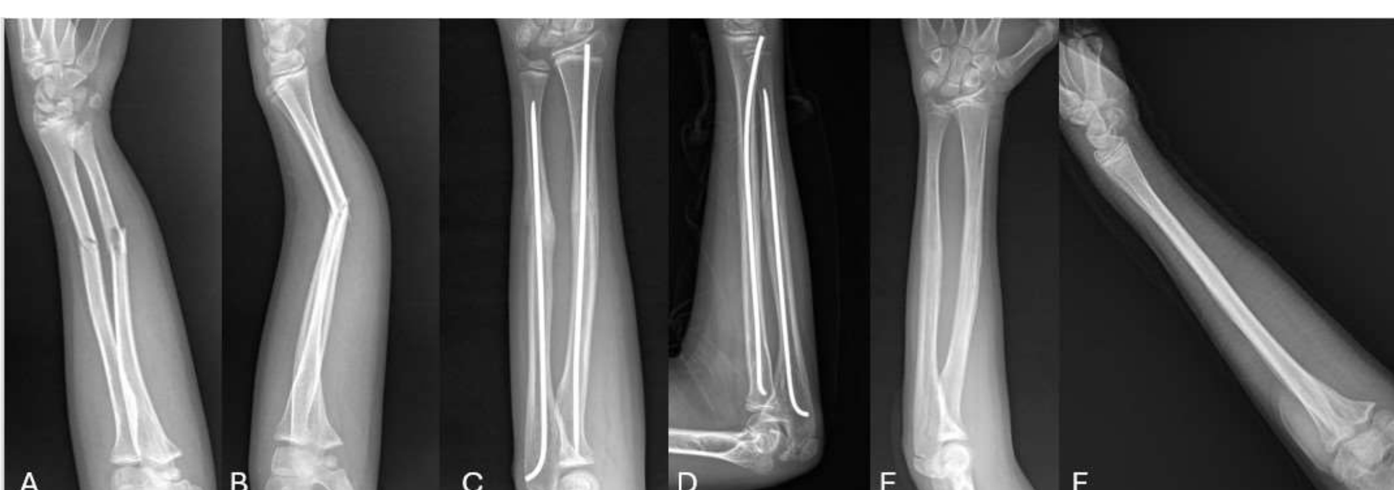

Table 1

Demographic characteristics of the study cohort

	Study cohort (n=84)
Age (years)	
Mean ± SD	9.7 ± 2.2
Median (min-max)	9.0 (6 – 14)
Side (%)	
Right	52 (61.9%)
Left	34 (38.1 %)
Sex	
Male	55 (65.5 %)
Female	29 (34.5%)
Follow-up period (months)	
Mean ± SD	31.1 ± 7.0
Median (min-max)	32.3 (14.7 – 45.1)
Complications	
Yes	7 (8.3%)
No	77 (91.7%)

Table 2

Range of motion and socioeconomic status-related data of the study cohort

	Study cohort (n=84)
Elbow range of motion (°)	
Extension	0.8 ± 3.5
Flexion	142.9 ± 6.2
Wrist range of motion (°)	
Extension	81.3 ± 4.6
Flexion	87.5 ± 2.3
Hollingshead Index	
1 (Low)	34 (40.5%)
2 (Middle)	23 (27.4%)
3 (High)	27 (32.1%)
Price's Criteria	
1 (Poor)	0 (0.0%)
2 (Fair)	7 (8.3%)
3 (Good)	33 (39.3%)
4 (Excellent)	44 (52.4%)

Table 3

Correlation analysis between the Hollingshead index and the study variables

	Spearman's rank correlation coefficient	p-value*
Elbow extension	-0.294	0.007
Elbow flexion	0.183	0.095
Wrist extansion	0.161	0.144
Wrist flexion	0.112	0.312
Price criteria	0.352	0.001
Complication	-0.169	0.123

Statistical analysis

All statistical analyses were performed using SPSS version 22.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as means ± standard deviations and categorical data as frequencies and percentages. Normality of data distribution was evaluated using the Shapiro–Wilk test. Since the data were non-normally distributed, nonparametric tests were applied. Comparisons between two groups used the Mann–Whitney U test, while multiple groups were analyzed with the Kruskal–Wallis test. Categorical variables were compared using Pearson's chi-square or Fisher's exact test, depending on cell size.

Correlations between the Hollingshead Index and clinical outcomes (ROM values, Price scores, and complication rates) were assessed using Spearman's rank correlation coefficient (ρ). A p-value <0.05 was regarded as statistically significant. A post-hoc power analysis was performed for the primary correlation analyses using the observed effect sizes and a two-tailed alpha level of 0.05.

3. Results

A total of 84 patients with complete data and follow-up were included in the study. Of these, 55 (65.5%) were male and 29 (34.5%) were female. The operated side was the right in 52 patients (61.9%) and the left in 32 patients (38.1%). The mean age of the cohort was 9.7 ± 2.2 years, and the mean follow-up duration was 31.1 ± 7.0 months. (Table 1)

During postoperative follow-up, superficial wound complications developed in 7 patients (8.3%), whereas no complications were observed in 77 patients (91.7%). No major complications occurred other than superficial wound infections, all of which resolved with oral antibiotics and simple wound care. Radiographic union was achieved in all fractures.

At the final follow-up, the mean elbow extension was 0.8 ±3.5, and flexion was 142.9 ± 6.2°. Mean wrist extension and flexion were 81.3 ±4.6° and 87.5 ± 2.3, respectively (Table 2). A significant negative correlation was found between the Hollingshead Index and elbow extension (p = 0.007), indicating that loss of extension decreased as socioeconomic status increased. (Table 2) Post-hoc power analysis demonstrated a power of 0.92 for the correlation between the Hollingshead Index and the Price criteria (r = 0.352, p = 0.001) and a power of 0.80 for the correlation between the Hollingshead Index and elbow extension loss (r = –0.294, p = 0.007).

When family socioeconomic status was classified according to the Hollingshead Index, 34 patients (40.5%) were in Group 1 (low), 23 (27.4%) in Group 2 (middle), and 27 (32.1%) in Group 3 (high). (Table 2)

According to the Price criteria, 44 patients (52.4%) had excellent outcomes, 33 (39.3%) were rated as good, and 7 (8.3%) as fair; no patient was rated as poor. (Table 2) A significant positive correlation was found between the Hollingshead Index and the Price criteria (p = 0.001), indicating that functional outcomes, including forearm supination and pronation, improved with higher socioeconomic status. No significant correlations were found for elbow flexion or wrist flexion/extension. (Table 3)

4. Discussion

The most important finding of this study was that, in pediatric patients undergoing titanium elastic nailing (TEN) for forearm fractures, supination, pronation, and elbow extension improved with increasing socioeconomic status. No significant differences were observed in elbow flexion or wrist joint flexion and extension.

The titanium elastic nailing (TEN) technique is an increasingly popular method for the surgical management of pediatric forearm fractures, offering the advantages of a short operative time and a small incision [6,7]. Complication rates ranging from 17% to 42% have been reported following fixation with titanium elastic nails (TEN) [21]. These complications include surgical site infection, skin irritation, nonunion, refracture, bursitis, synostosis, and extensor tendon injury [22-24]. Implant removal is generally recommended after 6 months, as earlier removal may increase the risk of refracture [25]. We believe that the absence of extensor tendon injury and skin irritation in our patients was attributable to the careful determination of the TEN length protruding outside the bone.

Various methods have been used to determine socioeconomic status, including the postal code of the family's residence, family income, type of health insurance, parental education level, and occupation [26,27]. The Hollingshead Index, which evaluates parental education and occupation to determine socioeconomic status, was used in this study. However, some studies in the literature have suggested that direct parental income may serve as a better predictor of socioeconomic status [27,28]. However, because information regarding parental income could not be reliably obtained, the Hollingshead Index was used instead and was found to be effective [27-30].

Socioeconomic factors influence children's behavioral and cognitive development as well as their overall health status [31,32]. It has also been reported that a low socioeconomic status affects the time to hospital admission, duration of surgery, and postoperative follow-up [12]. Landau et al. [33] reported no significant differences in the rates of complications such as postoperative infection, compartment syndrome, and readmission between insurance types in pediatric tibial and forearm fractures. Heath et al. [26] reported that as socioeconomic status decreased, the number of physician visits declined and fracture union was adversely affected. Another study on pediatric femoral fractures reported that lower socioeconomic status was associated with delays in surgery [34]. In a study on supracondylar humerus fractures, it was reported that surgical intervention was more frequently performed in patients with private insurance and those of white race [16]. Studies such as these demonstrate that, despite good intentions, inequalities persist in healthcare practices. Shenoy et al. [12] reported in their review that lower socioeconomic status was associated with fewer postoperative follow-up visits. While postoperative compliance is multifactorial, both child and family adherence to rehabilitation were shown to be influenced by socioeconomic status.

The retrospective design of this study, the relatively small sample size, and the limited postoperative follow-up represent its main limitations. However, unlike previous studies that primarily focused on socioeconomic status, the present study emphasizes mobility limitations and functional outcomes in pediatric forearm fractures—a topic with limited representation in the existing literature. We believe that studies with larger sample sizes and prospective designs would provide stronger evidence and contribute more substantially to the literature.

5. Conclusion

Emphasizing the importance of postoperative rehabilitation among families with low socioeconomic status could play a key role in preventing joint motion limitations after both-bone forearm fractures.

Statement of ethics

This retrospective study was conducted with the approval of the institutional ethics committee (approval no: AEŞH-BADEK1-2025-419).

genAI

No artificial intelligence-based tools or generative AI technologies were used in this study. The entire content of the manuscript was originally prepared, reviewed, and approved by both authors.

Funding

None.

Conflict of interest statement

The authors declare that they have no conflict of interest.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Author contributions

Both authors were involved in the conception and design of the study, literature search, analysis and interpretation of data, and writing of the manuscript. YE additionally performed the data collection. Both authors read and approved the final version of the manuscript.

References

1. Rennie L, Court-Brown CM, Mok JY, Beattie TF. The epidemiology of fractures in children. Injury. 2007;38(8):913-922. Crossref
2. Ulgen NK, Nazligul AS, Yigit N, Erginoglu SE, Akkurt MO. Epidemiologic Patterns of Musculoskeletal Disorders by Body Region Across 1.2 Million Orthopedic Visits: A 15-Year Experience From a Middle-Income Country. J Eval Clin Pract. 2025;31(5):e70230. Crossref
3. 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. Crossref
4. Chia B, Kozin SH, Herman MJ, Safier S, Abzug JM. Complications of pediatric distal radius and forearm fractures. Instr Course Lect. 2015;64:499-507.
5. Joeris A, Lutz N, Wicki B, Slongo T, Audige L. An epidemiological evaluation of pediatric long bone fractures - a retrospective cohort study of 2716 patients from two Swiss tertiary pediatric hospitals. BMC Pediatr. 2014;14:314. Crossref
6. Caruso G, Caldari E, Sturla FD, et al. Management of pediatric forearm fractures: what is the best therapeutic choice? A narrative review of the literature. Musculoskelet Surg. 2021;105(3):225-234. Crossref
7. Truntzer J, Vopat ML, Kane PM, Christino MA, Katarincic J, Vopat BG. Forearm diaphyseal fractures in the adolescent population: treatment and management. Eur J Orthop Surg Traumatol. 2015;25(2):201-209. Crossref
8. Wall L, O'Donnell JC, Schoenecker PL, et al. Titanium elastic nailing radius and ulna fractures in adolescents. J Pediatr Orthop B. 2012;21(5):482-488. Crossref
9. Modest JM, Brodeur PG, Kim KW, Testa EJ, Gil JA, Cruz AI Jr. Social Disparities in Outpatient and Inpatient Management of Pediatric Supracondylar Humerus Fractures. J Clin Med. 2022;11(15):4573. Crossref
10. Fletcher ND, Sirmon BJ, Mansour AS, Carpenter WE, Ward LA. Impact of insurance status on ability to return for outpatient management of pediatric supracondylar humerus fractures. J Child Orthop. 2016;10(5):421-427. Crossref
11. Farrell C, Hannon M, Monuteaux MC, Mannix R, Lee LK. Pediatric Fracture Epidemiology and US Emergency Department Resource Utilization. Pediatr Emerg Care. 2022;38(7):e1342-e1347. Crossref
12. Shenoy DA, Shabana S, Hunter E, et al. The impact of individual and regional socioeconomic identity on pediatric extremity fracture management: A scoping review. Injury. 2025;56(10):112674. Crossref
13. Goyal MK, Johnson TJ, Chamberlain JM, et al. Racial and Ethnic Differences in Emergency Department Pain Management of Children With Fractures. Pediatrics. 2020;145(5):e20193370. Crossref
14. Gultekin MZ, Dogar F, Sari AS, Coskun F, Yildirim A. The role of the psychological attributes of parents and children, and fracture history in upper extremity fractures in school-age and adolescents: A case-control study. Jt Dis Relat Surg. 2024;35(2):315-323. Crossref

15. Montgomery BK, Joseph G, Segovia N, et al. The Influence of Race, Income, and Sex on Treatment and Complications of Common Pediatric Orthopedic Fractures. Orthopedics. 2023;46(3):e156-e160. Crossref
16. Li NY, Bruce WJ, Joyce C, Decker NM, Cappello T. Obesity's Influence on Operative Management of Pediatric Supracondylar Humerus Fractures. J Pediatr Orthop. 2018;38(3):e118-e121. Crossref
17. Chua WJ, Klein EJ, Al-Haddad BJS, Quan L. Factors Associated With Opioid Prescribing for Distal Upper Extremity Fractures at a Pediatric Emergency Department. Pediatr Emerg Care. 2021;37(12):e1093-e1097. Crossref
18. Warwick D. Injuries of the forearm and wrist. In: Apley A, Solomon L, eds. Apley's System of Orthopaedics and Fractures. 9th ed. Chapter 25:768-776.
19. Ersoy B, Hanedan N, Ozyurt B. Socioeconomic Status and Age at Menarche in Turkiye. Am J Hum Biol. 2025;37(1):e24181. Crossref
20. Price CT, Scott DS, Kurzner ME, Flynn JC. Malunited forearm fractures in children. J Pediatr Orthop. 1990;10(6):705-712. Crossref
21. Pace JL. Pediatric and Adolescent Forearm Fractures: Current Controversies and Treatment Recommendations. J Am Acad Orthop Surg. 2016;24(11):780-788. Crossref
22. Lee AK, Beck JD, Mirenda WM, Klena JC. Incidence and Risk Factors for Extensor Pollicis Longus Rupture in Elastic Stable Intramedullary Nailing of Pediatric Forearm Shaft Fractures. J Pediatr Orthop. 2016;36(8):810-815. Crossref
23. Murphy HA, Jain VV, Parikh SN, Wall EJ, Cornwall R, Mehlman CT. Extensor Tendon Injury Associated With Dorsal Entry Flexible Nailing of Radial Shaft Fractures in Children: A Report of 5 New Cases and Review of the Literature. J Pediatr Orthop. 2019;39(4):163-168. Crossref
24. Han B, Wang Z, Li Y, Xu Y, Cai H. Risk factors for refracture of the forearm in children treated with elastic stable intramedullary nailing. Int Orthop. 2019;43(9):2093-2097. Crossref
25. 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. J Pediatr Orthop B. 2016;25(5):439-446. Crossref
26. Heath DM, Ghali AN, Momtaz DA, et al. Socioeconomic Status Affects Postoperative Time to Union in Pediatric Patients with a Surgically Treated Fracture. JB JS Open Access. 2023;8(3). Crossref
27. Cassedy A, Drotar D, Ittenbach R, et al. The impact of socio-economic status on health related quality of life for children and adolescents with heart disease. Health Qual Life Outcomes. 2013;11:99. Crossref
28. Limbers CA, Ripperger-Suhler J, Boutton K, Ransom D, Varni JW. A comparative analysis of health-related quality of life and family impact between children with ADHD treated in a general pediatric clinic and a psychiatric clinic utilizing the PedsQL. J Atten Disord. 2011;15(5):392-402. Crossref
29. Ozguven I, Ersoy B, Ozguven AA, Erbay PD. Evaluation of nutritional status in Turkish adolescents as related to gender and socioeconomic status. J Clin Res Pediatr Endocrinol. 2010;2(3):111-116. Crossref
30. Marino BS, Tomlinson RS, Wernovsky G, et al. Validation of the pediatric cardiac quality of life inventory. Pediatrics. 2010;126(3):498-508. Crossref
31. Bradley RH, Corwyn RF. Socioeconomic status and child development. Annu Rev Psychol. 2002;53:371-399. Crossref
32. Poulain T, Vogel M, Kiess W. Review on the role of socioeconomic status in child health and development. Curr Opin Pediatr. 2020;32(2):308-314. Crossref
33. Landau AJ, Oladeji AK, Hosseinzadeh P. Assessment of Ethno-racial and Insurance-based Disparities in Pediatric Forearm and Tibial Fracture Care in the United States. J Am Acad Orthop Surg Glob Res Rev. 2022;6(7). Crossref
34. Vazquez S, Dominguez JF, Jacoby M, et al. Poor socioeconomic status is associated with delayed femoral fracture fixation in adolescent patients. Injury. 2023;54(12):111128. Crossref