Original Article

HEALTH SCIENCES
MEDICINE

DOI: 10.32322/jhsm.1732198
J Health Sci Med. 2025;8(5):832-838

Comparison of clinical outcome, cost and union times in pediatric ankle fractures: a retrospective case series

Okan Ateş, Mustafa Altıntaş
Department of Orthopaedics and Traumatology, Diyarbakır Gazi Yaşargil Training and Research Hospital, Diyarbakır, Turkiye

Cite this article as: Ateş O, Altıntaş M. Comparison of clinical outcome, cost and union times in pediatric ankle fractures: a retrospective case series. *J Health Sci Med.* 2025;8(5):832-838.

Received: 01.07.2025 ◆ **Accepted**: 08.08.2025 ◆ **Published**: 16.09.2025

ABSTRACT

Aims: The aim of this study was to evaluate the effects of fracture type and implant used in ankle-related fractures in pediatric patients on functional outcome, union time, hospital stay and cost.

Methods: A total of 58 cases operated on due to ankle fractures between 2017 and 2023 were reviewed. Patients were divided into 4 groups according to diagnosis. The first group included patients with isolated malleolus fractures, the second group included patients with bimalleolar or trimalleolar fractures, the third group included patients with distal tibia fractures, and the fourth group included patients with distal tibia fractures with a lateral malleolus. Patients were divided into five groups according to the implants used. These were determined as: K-wire, cannulated screw, plate screw, cannulated screw and plate screw, cannulated screw and plate screw+fixator. Demographic characteristics, union times, implant costs, and the American Orthopaedic Foot and Ankle Society (AOFAS) score were examined between the groups.

Results: Union time was significantly shorter in patients with isolated malleolar fractures compared to other groups (p=0.042). Cost analysis by diagnosis showed that costs in the range of $100-300 were more common in isolated malleolar fractures, whereas costs exceeding $300 were more common in distal tibia fractures (p=0.001). Post-recovery AOFAS (American Orthopaedic Foot & Ankle Society) scores were significantly higher in the isolated malleolar fracture group compared to the bimalleolar/trimalleolar and distal tibia fracture groups (p=0.001). Comparison between all groups; implant comparison, the mean union time (in months) was significantly longer in the cannulated screw+plate and screw+fixator group compared to the K-wire, cannulated screw, plate and screw, and cannulated screw+plate and screw groups (p=0.0001). The plate and screw group also had significantly longer union times than the K-wire and cannulated screw groups (p=0.002, p=0.0001). Post-recovery AOFAS scores were significantly higher in the K-wire group compared to the plate and screw and cannulated screw+plate and screw+fixator groups (p=0.018).

Conclusion: In isolated malleolar fractures, due to the more minor nature of the trauma, shorter hospital stays, quicker fracture union, better functional outcomes, and lower implant costs were observed. Implant costs did not affect functional outcomes or time to union.

Keywords: Ankle fracture, cost analysis, surgical outcomes, pediatric trauma

INTRODUCTION

Tibial fractures rank as the third most common long bone injuries in the pediatric population.[1] Moreover, pediatric ankle fractures account for approximately 18% of all physeal injuries.[2] These fractures are observed twice as frequently in boys compared to girls. The highest incidence occurs between the ages of 8 and 15, with the majority being associated with sports-related activities.[3] The primary objective of treatment is to restore joint congruency and functional alignment in order to prevent the development of osteoarthritis in the long term. Another critical goal is to avoid limb length discrepancies, given that the distal tibial physis contributes to approximately 45% of the overall length of the ankle.[4]

Fractures that have been anatomically reduced are managed with immobilization using a hanging cast and monitored for six weeks with non-weight-bearing mobilization.[4] Non-reduced and rotationally unstable fractures are treated surgically. Medial malleolar fractures, bimalleolar and trimalleolar fractures, distal tibial fractures are treated surgically with a combination of K-wire, cannulated screws, and plates, taking age into account.[5]

Given the high incidence rates observed in adult populations and the increasing costs associated with surgical interventions, a study conducted in the United States has reported that the annual economic burden of ankle fracture treatment amounts to approximately 11 billion USD. Of this, nearly 1.2 billion USD is attributed to direct healthcare costs, including physician fees, surgical supplies, and operating room time.[6] It has been suggested that by understanding the economic implications

Corresponding Author: Okan Ateş, atesokan@msn.com

of different treatment strategies and diagnostic approaches, it may be possible to optimize resource allocation, minimize unnecessary expenditures, and ultimately enhance patient outcomes.[7]

The aim of this study is to evaluate the impact of fracture type and the implant used on functional outcomes, time to bone union, length of hospital stay, and treatment cost in pediatric patients (ages 0-16) with fractures around the ankle region of the lower extremity.

METHODS

Ethical Approval and Study Design

Approval was obtained from the institution and researchers prior to the study. Ethical approval was granted by the Diyarbakır Gazi Yaşargil Training and Research Hospital Non-interventional Clinical Researches Ethics Committee where all imaging and patient procedures were conducted as a single-center study (Date: 25.10.2024, Decision No: 105). The study did not receive any financial support. All procedures were performed in accordance with ethical guidelines and the principles of the Declaration of Helsinki.

Patient Selection and Study Population

This study retrospectively evaluated pediatric patients aged 0-16 years who underwent surgery due to ankle region fractures of the lower extremity between January 2017 and January 2023 at a level 1 trauma center. Patients older than 16 years, those with tibial shaft or foot fractures, patients lost to follow-up, or those without regular radiographic monitoring were excluded. Of the 76 patients who presented to the emergency department during the study period, 14 were excluded due to irregular follow-up, and an additional 4 patients were excluded due to lack of regular radiographic imaging. Ultimately, 58 patients were included. Four patients with soft tissue defects underwent two-stage external fixation treatment, while the remaining received single-stage treatment. Demographic data, length of hospital stay, fracture location, time to union, surgical methods, post-union functional scores, and treatment costs were recorded.

Grouping and Treatment Protocol

Patients were classified into four diagnostic groups: Group 1 included isolated malleolar fractures (**Figure 1**) (n: 16); group 2 comprised bimalleolar or trimalleolar fractures (**Figure 2**) (n: 14); group 3 consisted of distal tibial fractures (**Figure 3**) (n: 19); and group 4 included patients with lateral malleolus fractures combined with distal tibial fractures (n: 9). According to the implants used, patients were divided into five groups: K-wire (**Figure 1c, d**), cannulated screw, plate-screw (**Figure 2 c, d**), cannulated screw with plate-screw, and cannulated screw with plate-screw plus external fixator. Preoperative and postoperative radiological evaluations were performed for all patients. Postoperative immobilization with a cast was applied for one month except for patients with isolated K-wire and cannulated screws. Fracture union was monitored via anteroposterior (AP) and lateral radiographs taken biweekly during the first three months post-discharge, followed by monthly radiographs thereafter. Radiological and

Figure 1. Preoperative and postoperative radiographs of medial malleolus fracture

Figure 2. Preoperative and postoperative radiographs of bimalleoler fracture

Figure 3. Preoperative and postoperative radiographs of distal tibia fracture

clinical signs of union were defined as the absence of pain or tenderness upon palpation of the fracture line, ability to bear weight painlessly, formation of a hard callus around the fracture line on radiographs, and union of at least three out of four cortices. The American Orthopaedic Foot and Ankle Society (AOFAS)[8] score was assessed after fracture union. Implant costs were evaluated in US dollars according to the exchange rate at the time of treatment and categorized as <100, 100-300, and >300 dollars.

Statistical Analysis

Data analyses were performed using NCSS (Number Cruncher Statistical System) 2007 Statistical Software (Utah, USA). Descriptive statistics such as mean, standard deviation, median, and interquartile range were calculated. Between-group normality of distribution was assessed using the Shapiro-Wilk test. For normally distributed variables, comparisons between groups over time were made using one-way ANOVA, followed by Tukey's post-hoc test for subgroup analyses. Variables with non-normal distribution (those with heterogeneity between groups) were compared using the Kruskal-Wallis test and Dunn's multiple comparison test for subgroup analyses. Categorical data between groups were analyzed using the chi-square test. A p value of less than 0.05 was considered statistically significant.

RESULTS

The demographic characteristics, hospital stay duration, time to fracture union, AOFAS scores, and costs of patients grouped according to diagnosis and implant type are presented separately in Table 1, 2. When grouped into four diagnostic categories, no significant differences were observed between groups in terms of age and gender distribution (Table 1). Regarding the general treatment approach, patients operated on for isolated malleolar fractures were primarily treated with K-wires or cannulated screws, whereas bimalleolar and trimalleolar fractures were treated with cannulated screws and plate-screw fixation, and distal tibial fractures with plate-screw fixation; this distribution showed a statistically significant difference (p=0.002). Analysis of hospital stay duration revealed that patients with isolated malleolar fractures had significantly shorter hospital stays compared to other groups (p=0.042), while no significant differences were noted among the other groups (Table 1, 3, and Figure 4).

Table 1. Outcomes according to fracture diagnosis

		Isolated malleolar n: 16		Bimalleoler-trimalleoler n: 14		Distal Tibia fracture n: 19		Lateral malleolar+ distal tibial n: 9		p
Age (year)	Mean±SD	13.64±2.81		13±3.43		12±2.83		11.38±3.98		0.277*
Gender	Male	9	56.25%	10	71.43%	13	68.42%	4	44.44%	0.519+
	Female	7	43.75%	4	28.57%	6	31.58%	5	55.56%	
Implant type	K-wire	8	50.00%	7	50.00%	4	21.05%	4	44.44%	0.002+
	Cannulated screw	4	25.00%	1	7.14%	0	0.00%	0	0.00%	
	Plate-screw	2	12.50%	1	7.14%	14	73.68%	4	44.44%	
	Cannulated+plate-screw	2	12.50%	3	21.43%	0	0.00%	0	0.00%	
	Cannulated+plate-screw+fixator	0	0.00%	2	14.29%	1	5.26%	1	11.11%	
Hospital stay (days)	mean±SD	2±1.46		6.64±11.29		3.47±1.71		2.67±1.87		0.042‡
	Median (IQR)	2 (1-2)		2 (1-7.5)		3 (2-4)		2 (1.5-3.5)		
Time to union (months)		3.44±0.51		4.36±1.55		5.05±1.35		4.89±0.93		0.001*
Implant cost	<100$	8	50.00%	8	57.14%	4	21.05%	4	44.44%	0.001+
	100-200$	8	50.00%	4	28.57%	2	10.53%	1	11.11%	
	>300$	0	0.00%	2	14.29%	13	68.42%	4	44.44%	
AOFAS score after recovery	Mean±SD	87.88±3.16		81.21±9.07		79.26±6.12		81.33±5.83		0.002*

*One-way analysis of variance, ‡Kruskal-Wallis test, +Chi-square test, SD: Standard deviation, IQR: Interquartile range, AOFAS: American Orthopaedic Foot and Ankle Society

Table 2. Multiple comparison tests based on diagnosis

Multiple comparison test	Dunn's	Tukey	
	Hospital stay	Time to union	AOFAS
Isolated vs bimalleolar-trimalleolar	0.048	0.156	0.029
Isolated vs distal tibial	0.033	0.001	0.001
Isolated malleolus fracture/lateral malleolus fracture+distal tibia fracture	0.245	0.023	0.075
Bimalleolar-trimalleolar/distal tibia fracture	0.631	0.346	0.818
Bimalleolar-trimalleolar/lateral malleolus fracture+distal tibia fracture	0.649	0.717	0.999
Distal tibia fracture/lateral malleolus fracture+distal tibia fracture	0.145	0.986	0.850

AOFAS: American Orthopaedic Foot and Ankle Society

Table 3. Outcomes according to implant type

		K-wire n: 23	Cannulated screw n: 5	Plate-screw n: 21	Cannulated+ plate-screw n: 5	Cannulated+plate-screw+fixator n: 4	p
Age (year)	Mean±SD	10.61±2.87	13.9±3	13.31±2.61	16.18±1.61	14.15±3.39	0.0001*
Gender	Male	12 52.17%	4 80.00%	14 66.67%	4 80.00%	2 50.00%	0.599+
	Female	11 47.83%	1 20.00%	7 33.33%	1 20.00%	2 50.00%	
Diagnosis	Isolated malleolar	8 34.78%	4 80.00%	2 9.52%	2 40.00%	0 0.00%	0.002+
	Bimalleoler-trimalleoler	7 30.43%	1 20.00%	1 4.76%	3 60.00%	2 50.00%	
	Distal tibia fracture	4 17.39%	0 0.00%	14 66.67%	0 0.00%	1 25.00%	
	Lateral malleolar+distal tibial	4 17.39%	0 0.00%	4 19.05%	0 0.00%	1 25.00%	
Hospital stay (days)	Mean±SD	4.61±9.02	1.80±0.45	3.43±1.66	3.20±3.35	3.00±2.16	0.104‡
	Median (IQR)	2 (1-3)	2 (1.5-2)	3 (2-4)	3 (1-6)	2.5 (1.25-5.25)	
Time to union (months)		3.74±0.69	3.2±0.45	5.10±1.26	4.00±0.71	6.75±1.26	0.0001*
Implant cost	<100$	23 100.00%	1 20.00%	0 0.00%	0 0.00%	0 0.00%	0.0001+
	100-200$	0 0.00%	4 80.00%	6 28.57%	5 100.00%	0 0.00%	
	>300$	0 0.00%	0 0.00%	15 71.43%	0 0.00%	4 100.00%	
AOFAS score after recovery	Mean±SD	85.91±7.29	84.8±3.11	79.71±4.79	81.6±9.32	74.75±6.99	0.004*

*One-way analysis of variance, ‡Kruskal-Wallis test, +Chi Square test, SD: Standard deviation, IQR: Interquartile range

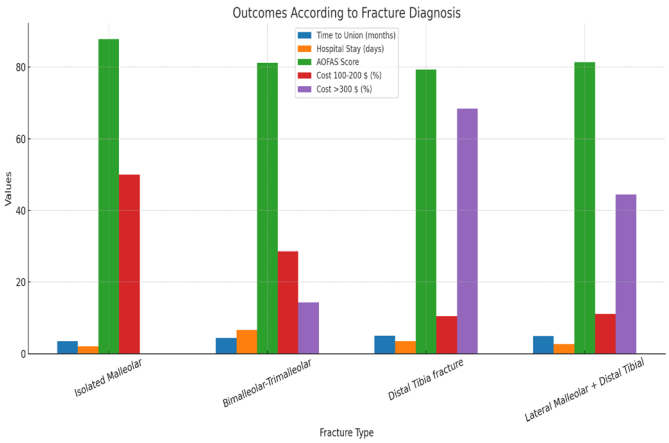

Figure 4. Outcomes and cost by diagnosis

Similarly, time to fracture union was significantly shorter in the isolated malleolar fracture group compared to others (p=0.023) (Table 3, Figure 4). Cost analysis based on diagnosis showed a higher prevalence of costs in the range of $100-300 for isolated malleolar fractures, while distal tibial fractures were associated with costs exceeding $300 (p=0.001). Post-union AOFAS scores were significantly higher in the isolated malleolar fracture group compared to the bimalleolar-trimalleolar and distal tibial fracture groups (p=0.001) (Table 3, Figure 5), with no statistically significant differences observed among the other groups (p>0.05).

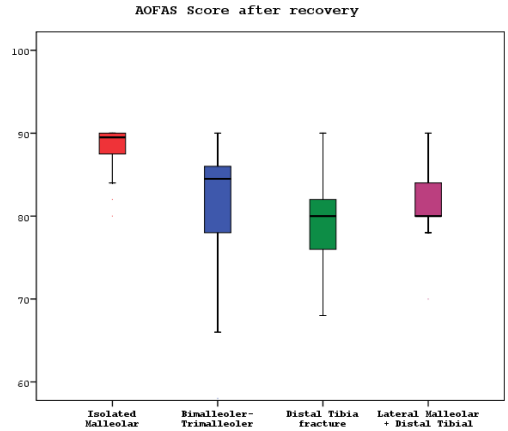

Figure 5. AOFAS score after recovert by diagnosis

AOFAS: American Orthopaedic Foot and Ankle Society

When patients were classified into five groups according to implant type, those treated with K-wires were significantly younger than patients treated with other implants (p=0.0001) (Table 2, Figure 6). No statistically significant difference was found in mean hospital stay duration across implant groups (p=0.104). The mean time to union was significantly longer in the cannulated screw and plate-screw plus external fixator group compared to the K-wire, cannulated screw, plate-screw, and cannulated screw plus plate-screw groups (p=0.0001) (Figure 6). Additionally, the mean union time in the plate-screw group was significantly longer than in the K-wire and cannulated screw groups (p=0.002, p=0.0001, Table 2, 4), no significant differences observed other than the comparisons in previous sentence (p>0.05) (Table 4).

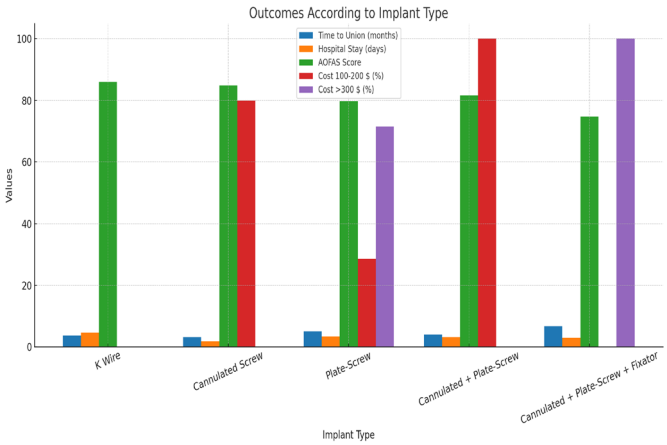

Figure 6. Outcomes and cost by implant type

Table 4. Tukey multiple comparison test based on implant type

Tukey multiple comparison test	Age	Time to union	AOFAS
K-wire/cannulated screw	0.123	0.791	0.997
K-wire/plate screw	0.095	0.0001	0.018
K-wire/cannulated screw and plate screw	0.001	0.982	0.650
K-wire/cannulated screw and plate screw+fixator	0.016	0.0001	0.018
Cannulated screw/plate screw	0.993	0.002	0.504
Cannulated screw/cannulated screw and plate screw	0.682	0.689	0.932
Cannulated screw/cannulated screw and plate screw+fixator	0.999	0.0001	0.147
Plate screw/cannulated screw and plate screw	0.233	0.171	0.975
Plate screw/cannulated screw and plate screw+ fixator	0.981	0.023	0.615
Cannulated screw and plate screw/cannulated screw and plate screw+fixator	0.801	0.001	0.505

AOFAS: American Orthopaedic Foot and Ankle Society

Statistically significant differences were found in post-union AOFAS scores among the implant groups (p=0.0001). The K-wire group demonstrated significantly higher post-union AOFAS scores compared to the plate-screw and cannulated screw plus plate-screw plus external fixator groups (p=0.018), while no significant differences were observed among other groups (p>0.05) (Table 4, Figure 7).

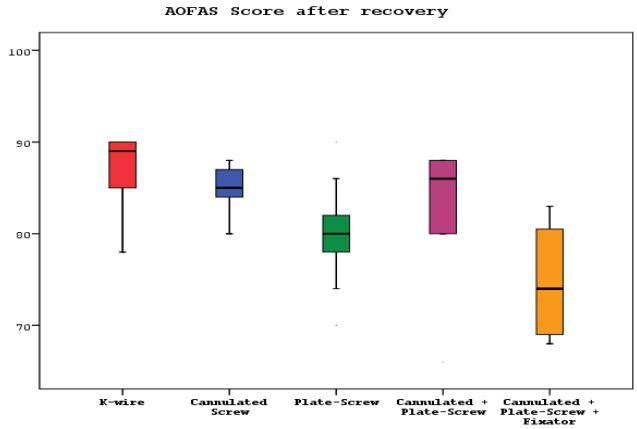

Figure 7. AOFAS score after recovery, grouping the results according to implants

AOFAS: American Orthopaedic Foot and Ankle Society

DISCUSSION

Our study provides valuable insights into the differences in treatment protocols, implant costs, and functional outcomes in operatively treated pediatric ankle fractures, with a focus on diagnostic and therapeutic approaches. Our study offers a different perspective on pediatric ankle fractures by separately evaluating both diagnosis and implants used in the pediatric age group. Consistent with existing literature,[9-12] our findings indicate that patients with isolated malleolar fractures demonstrated superior outcomes in terms of union time, functional results, and length of hospital stay compared to other fracture types. Cost analysis based on implant type showed, as expected, that K-wire fixation was associated with lower costs, and higher AOFAS scores were observed in these patients, likely due to the less invasive nature of both the trauma and the surgical procedure.

Pediatric ankle fractures are frequently encountered and are of particular importance as they often involve the growth plate (epiphysis). Swapnil M. Keny,[13] in his 2024 review of current concepts, emphasized the increasing relevance of modern approaches, including 3D printing and AI (artificial intelligence)-assisted applications in both diagnosis and treatment. In a systematic review by Talaski et al.,[14] the use of CT scans was recommended, particularly in triplane fractures, to assess the need for surgical intervention. Kang et al.[15] reported favorable outcomes in their study involving 46 patients, recommending surgical fixation for fractures with displacements greater than 4 mm. Similarly, Ayas et al.[16] reported positive results in their study of 25 patients, recommending surgery for triplane fractures displaced more than 2 mm. Roberts et al.,[17] in their cohort of 261 patients, emphasized that anatomical reduction was critical for optimal healing and minimizing complications; inadequately reduced fractures were associated with deformity and other issues. In our study, we also observed good outcomes in surgically treated unstable fractures involving the ankle region with displacement greater than 2 mm among 58 patients. Considering the critical role of the epiphyseal region in skeletal development, we recommend detailed evaluation with CT if necessary, and surgical intervention for unstable and displaced fractures.

Ankle region fractures involving the epiphysis are classified as malleolar and metaphyseal fractures based on the Salter-Harris classification.[18] In our study, we categorized patients based on fracture location and implant type. In their guideline on the management of pediatric ankle fractures, Venkatadass et al.[19] recommended K-wires and screws for isolated malleolar fractures, and plate-screw fixation for bimalleolar, trimalleolar, and distal tibia fractures. Their findings are in agreement with ours and with other literature reporting favorable outcomes following closed reduction and percuta neous fixation. Onay et al.,[20] in a study of 39 patients, compared closed reduction with percutaneous fixation, open reduction with screw fixation, and open reduction with plate fixation, and found no significant differences in union or functional outcomes. In our study, K-wires or cannulated screws used for isolated malleolar fractures resulted in better union times and outcomes compared to other fracture types and implant groups. This is likely due to the lower energy of trauma and the relatively smaller anatomical involvement in these cases. No significant differences were found among other fracture types or implant combinations.

In orthopedic surgery, implant cost constitutes a major component of overall expenses. Understanding the clinical and economic implications of different surgical and diagnostic approaches allows surgeons to adopt more efficient and cost-effective strategies. Stull, et al.[21] reported mean costs of $12,920 for isolated bimalleolar injuries and $18,613 for trimalleolar fractures, emphasizing the importance of cost containment. Rainey et al.,[7] in a systematic review of pediatric ankle fractures, found only 7 eligible studies out of 131 reviewed, none of which directly addressed cost, instead focusing on diagnostic strategies and outcome improvement. This highlights a notable gap in the literature and the need for further research. Barfield et al.[18] found that outpatient procedures involving ankle surgery were less costly when performed via ORIF (open reduction internal fixation) compared to non-orthopedic ankle surgery. Given the high frequency and cost burden of these procedures, effective resource utilization and selection of the most efficient treatment options represent an ethical imperative for orthopedic surgeons.

Pediatric ankle fractures currently hold a significant place in pediatric fractures, but if not treated appropriately, they can lead to future deformities and morbidity. Therefore, patients should undergo a thorough evaluation and, if necessary, consultation with several individuals before deciding on surgical options. It should be remembered that any mistake could result in a person with walking impairment in the future, and due diligence should be exercised, taking into account the costs involved.

Limitations

This study has several limitations. First, it was a retrospective study relying on previously recorded data. Although data entry was conducted prospectively, which may mitigate some recall and collection biases, these cannot be entirely eliminated. Further randomized controlled studies with larger sample sizes are needed to validate our findings. Another limitation is the relatively small sample size, as data were collected from a single trauma center. Surgeries were also performed by different surgeons, introducing procedural variability. In addition, the number of screws used per patient was not standardized, which may have affected cost analyses and outcomes.

CONCLUSION

Surgical treatment of isolated malleolar, bimalleolar, trimalleolar, and distal tibial fractures in the pediatric population yielded favorable results. Isolated malleolar fractures, due to their lower-energy nature, were associated with shorter hospital stays, quicker union times, better functional outcomes, and lower implant costs. Although distal tibial fractures were linked to higher implant costs, However, the comparable clinical results across non-malleolar fracture types suggest that implant costs do not significantly impact overall functional outcomes. These findings support the ethical and clinical necessity for efficient and cost-effective treatment planning in pediatric ankle fractures.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was carried out with the permission of the Diyarbakır Gazi Yaşargil Training and Research Hospital Non-interventional Clinical Researches Ethics Committee (Date: 25.10.2024, Decision No: 105).

Informed Consent

Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

REFERENCES

1. Cruz AI, Raducha JE, Swarup I, Schachne JM, Fabricant PD. Evidence-based update on the surgical treatment of pediatric tibial shaft fractures. *Curr Opin Pediatr*. 2019;31(1):92-102. doi:10.1097/MOP.0000000000000704
2. Su AW, Larson AN. Pediatric ankle fractures: concepts and treatment principles. *Foot Ankle Clin*. 2015;20(4):705-719. doi:10.1016/j.fcl.2015.07.004
3. Cancino B, Sepúlveda M, Birrer E. Ankle fractures in children. *EFORT Open Rev*. 2021;6(7):593-606. doi:10.1302/2058-5241.6.200042
4. Olgun ZD, Maestre S. Management of pediatric ankle fractures. *Curr Rev Musculoskelet Med*. 2018;11(3):475-484. doi:10.1007/s12178-018-9510-3
5. Cancino B, Sepúlveda M, Birrer E. Ankle fractures in children. *EFORT Open Rev*. 2021;6(7):593-606. doi:10.1302/2058-5241.6.200042

6. Belatti DA, Phisitkul P. Economic burden of foot and ankle surgery in the US Medicare population. *Foot Ankle Int*. 2014;35(4):334-340. doi:10.1177/1071100713519777
7. Rainey M, Ramirez C, Dayoub E, Sanchez D, Childs B, Bacak C. The economic ramifications of pediatric distal tibial physeal fractures. *J Orthopaed Business*. 2025;5:1.
8. Madeley NJ, Wing KJ, Topliss C, Penner MJ, Glazebrook MA, Younger AS. Responsiveness and validity of the SF-36, Ankle Osteoarthritis Scale, AOFAS ankle hindfoot score, and Foot Function Index in end stage ankle arthritis. *Foot Ankle Int*. 2012;33(1):57-63. doi:10.3113/FAI.2012.0057
9. Verhage SM, Schipper IB, Hoogendoorn JM. Long-term functional and radiographic outcomes in 243 operated ankle fractures. *J Foot Ankle Res*. 2015;8(1):45. doi:10.1186/s13047-015-0098-1
10. Pina G, Fonseca F, Vaz A, Carvalho A, Borralho N. Unstable malleolar ankle fractures: evaluation of prognostic factors and sports return. *Arch Orthop Trauma Surg*. 2021;141(1):99-104. doi:10.1007/s00402-020-03650-w
11. Broos PLO, Bisschop APG. Operative treatment of ankle fractures in adults: correlation between types of fracture and final results. *Injury*. 1991;22(5):403-406. doi:10.1016/0020-1383(91)90106-O
12. Tejwani NC, McLaurin TM, Walsh M, Bhadsavle S, Koval KJ, Egol KA. Are outcomes of bimalleolar fractures poorer than those of lateral malleolar fractures with medial ligamentous injury? *J Bone Joint Surg*. 2007;89(7):1438-1441. doi:10.2106/JBJS.F.01006
13. Keny SM. Pediatric and adolescent ankle fractures: current concepts and advances in management. *J Clin Orthopaed*. 2024;9(2):44-46. doi:10.13107/jcorth.2024.v09i02.660
14. Talaski GM, Sleem B, Luo EJ, et al. Diagnosis, treatment, and potential complications of triplane ankle fractures in pediatric patients: a systematic review. *J Clin Med*. 2025;14(5):1578. doi:10.3390/jcm14051578
15. Kang H, Kang T, Lim C. The incidence and treatment outcome of atypical triplane fractures in adolescents. *Indian J Orthop*. 2022;56(12):2133-2140. doi:10.1007/s43465-022-00679-4
16. Ayas MS, Kalkışım M, Turgut MC, et al. Analysis of clinical outcomes in pediatric distal tibia triplanar fractures treated surgically and conservatively. *Cureus*. 2021;13(12):e20723. doi:10.7759/cureus.20723
17. Roberts V, Mason LW, Harrison E, Molloy AP, Mangwani J. Does functional outcome depend on the quality of the fracture fixation? Mid to long term outcomes of ankle fractures at two university teaching hospitals. *Foot Ankle Surg*. 2019;25(4):538-541. doi:10.1016/j.fas.2018.04.008
18. Dias LS, Tachdjian MO. Physeal injuries of the ankle in children: classification. *Clin Orthop Relat Res*. 1978;(136):230-233.
19. Venkatadass K, Sangeet G, Prasad VD, Rajasekaran S. Paediatric ankle fractures: guidelines to management. *Indian J Orthop*. 2021;55(1):35-46. doi:10.1007/s43465-020-00270-9
20. Onay T, Çelen ZE, Bayhan M, Kandemir İ, Kiliç NC, Kayaalp ME. A more conservative approach in the surgical management of pediatric physeal ankle fractures should be preferred: mid to long-term functional outcomes of three different surgical techniques for salter-harris type II and triplane distal tibial fractures. *J Pediatr Orthop*. 2023;43(9):e734-e741. doi:10.1097/BPO.0000000000002471
21. Stull JD, Bhat SB, Kane JM, Raikin SM. Economic burden of ınpatient admission of ankle fractures. *Foot Ankle Int*. 2017;38(9):997-1004. doi:10.1177/1071100717709576