Cukurova Medical Journal
ÇUKUROVA ÜNİVERSİTESİ TIP FAKÜLTESİ

Cukurova Med J 2026;51(2):540-549
DOI: 10.17826/cumj.1909209

RESEARCH

Late surgical management of residual limb and ischemic contracture complications in pediatric earthquake survivors

Depremden sağ kalan çocuklarda rezidüel ekstremite sorunları ve iskemik kontraktürlerin geç dönem cerrahi tedavisi

Buğra Kundakçı[1], Aylin Sarıyıldız[1], Ömer Sunkar Biçer[1], Ezgi Nur Sayıcı[1], Kaan Ali Dalkır[1], Sibel Başaran[1]

[1]Cukurova University, Adana, Türkiye

Abstract

Purpose: This study aimed to evaluate late extremity complications and the surgical management strategies used in pediatric patients who developed residual limb problems or ischemic contractures following the February 6, 2023 Kahramanmaraş earthquake.

Materials and Methods: This retrospective observational study included pediatric patients who underwent surgical treatment for amputation stump complications or ischemic contractures secondary to compartment syndrome. Demographic characteristics, complication types, surgical procedures, number of operations, and infection rates were analyzed.

Results: A total of 18 pediatric patients were included, with a mean age of 14.28±5.42 years. The most common late complications were soft tissue insufficiency (33.3%), pressure ulcers (27.8%), and osseous overgrowth (22.2%). Patients with stump-related complications were significantly younger than those with ischemic contractures (12.25±5.34 vs. 18.33±2.73 years). Stump complications were primarily managed with revision procedures, whereas ischemic contractures more frequently required reconstructive procedures, including tendon release, tendon transfer, and metatarsal extension osteotomies.

Conclusion: Late extremity complications in pediatric earthquake survivors show distinct clinical patterns depending on the initial injury and treatment strategy. Amputation stump complications often require revision surgery, whereas ischemic contractures are more commonly managed with reconstructive procedures aimed at restoring functional alignment and improving weight distribution.

Keywords: Earthquake, amputation, traumatic, child, contracture, ischemic, compartment syndrome

Öz

Amaç: Bu çalışmanın amacı, 6 Şubat 2023 Kahramanmaraş depremi sonrasında rezidüel ekstremite sorunları veya iskemik kontraktür gelişen pediatrik hastalarda görülen geç dönem ekstremite komplikasyonlarını ve uygulanan cerrahi tedavi stratejilerini değerlendirmektir.

Gereç ve Yöntem: Bu retrospektif gözlemsel çalışmaya, amputasyon güdüğü komplikasyonları veya kompartman sendromuna sekonder gelişen iskemik kontraktürler nedeniyle cerrahi tedavi uygulanan pediatrik hastalar dahil edildi. Hastaların demografik özellikleri, komplikasyon tipleri, uygulanan cerrahi işlemler, operasyon sayıları ve enfeksiyon oranları analiz edildi.

Bulgular: Toplam 18 pediatrik hasta çalışmaya dahil edildi ve ortalama yaş 14.28±5.42 yıl idi. En sık görülen geç dönem komplikasyonlar yumuşak doku yetersizliği (%33.3), bası yarası (%27.8) ve kemik aşırı büyümesi (%22.2) idi. Güdük ile ilişkili komplikasyonları olan hastalar, iskemik kontraktürü olan hastalara göre anlamlı derecede daha gençti (12.25±5.34 vs. 18.33±2.73 yıl). Güdük komplikasyonları çoğunlukla revizyon cerrahileri ile tedavi edilirken, iskemik kontraktürlerde daha sık olarak tendon gevşetme, tendon transferi ve metatarsal uzatma osteotomileri gibi rekonstrüktif cerrahiler uygulandı.

Sonuç: Depremden etkilenen pediatrik hastalarda görülen geç dönem ekstremite komplikasyonları, başlangıç yaralanmasının tipi ve uygulanan tedavi stratejisine bağlı olarak farklı klinik özellikler göstermektedir. Amputasyon güdüğü komplikasyonları sıklıkla revizyon cerrahisi gerektirirken, iskemik kontraktürler daha çok fonksiyonel dizilimi düzeltmeye ve yük dağılımını iyileştirmeye yönelik rekonstrüktif cerrahilerle tedavi edilmektedir.

Anahtar kelimeler: Depremler, travmatik amputasyon, çocuk, iskemik kontraktür, kompartman sendromu

Address for Correspondence: Buğra Kundakci, Faculty of Medicine, Cukurova University, Department of Orthopaedics nd Traumatology, Adana, Türkiye Email: bugrakundakci@hotmail.com
Received: 13.03.2026 Accepted: 28.05.2026

INTRODUCTION

Major earthquakes are among the most devastating natural disasters, especially for vulnerable populations, such as children. Victims of these disasters are frequently admitted to emergency departments with severe musculoskeletal injuries requiring urgent surgical intervention, including open fractures, crush injuries associated with crush syndrome, penetrating soft tissue injuries, and compartment syndrome presenting with paralysis, paresthesia, and pulselessness. Management may involve a wide spectrum of orthopedic procedures, ranging from limb-salvage interventions such as fasciotomy, debridement, and fracture fixation to more radical procedures, including amputation. As a result, survivors often experience complex long-term musculoskeletal sequelae requiring prolonged reconstructive treatment and rehabilitation[1]. The devastating earthquake that struck southeastern Turkey on February 6, 2023, increased the number of pediatric patients presenting with crush injuries and led to permanent limb deformities, ischemic contractures, and amputations[2]. Studies have shown that stump-related complications following lower extremity amputations are important factors that negatively affect prosthetic fitting and functional outcomes in amputee patients[3]. Beyond conventional stump issues such as soft tissue imbalance and volume fluctuation, pediatric amputees frequently develop additional chronic complications, including bony overgrowth, skin irritation, pressure ulceration, and contractures that interfere with socket fit and prosthetic tolerance. Among these complications, osseous overgrowth is considered the most common long-term problem in skeletally immature patients. These complications are particularly pronounced in cases involving ischemic injury or prolonged soft tissue trauma[3,4].

Beyond conventional stump issues such as soft tissue imbalance and volume fluctuation, pediatric amputees frequently develop additional chronic complications, including bony overgrowth, skin irritation, pressure ulceration, and contractures that interfere with socket fit and prosthetic tolerance. These complications are particularly pronounced in cases involving ischemic injury or prolonged soft tissue trauma[5].

The management of ischemic contractures is complex, and functional outcomes are often unsatisfactory. While most studies on this subject have primarily focused on upper extremity ischemic contractures, data regarding lower extremity involvement remain limited. Ischemic contractures of the lower extremity are commonly associated with plantar sensory loss, chronic pain, and restricted ankle motion[6]. Contractures and insensate limbs may result in chronic ulceration, pain, and abnormal gait mechanics. In such cases, surgical interventions such as tenotomies, soft tissue releases, local or regional flap reconstructions, and corrective osteotomies are often necessary to optimize limb geometry and load distribution. These interventions aim not only to restore function but also to enhance the child's ability to participate in daily activities and rehabilitation programs effectively[7].

Despite the growing literature on earthquake related extremity injuries, data regarding the late-stage surgical management of survivors remain limited. Most previous studies have primarily focused on acute treatment and early outcomes, whereas late complications requiring revision or reconstructive procedures have been insufficiently described. In particular, comparative data regarding stump-related complications and ischemic contracture related sequelae in pediatric earthquake survivors are scarce. Therefore, this study aimed to evaluate the patterns of late extremity complications and the surgical strategies used in pediatric earthquake survivors. We hypothesized that pediatric patients with amputation stump related complications and those with ischemic contractures would demonstrate distinct patterns of late complications and require different reconstructive and surgical management strategies.

MATERIALS AND METHODS

Study design and setting

This retrospective observational study was conducted at the Child Wellness Practice and Research Center (Çocuk İyilik Uygulama ve Araştırma Merkezi, ÇOİM) of Çukurova University Faculty of Medicine, a tertiary referral center located in Adana, Türkiye. The center actively participated in the multidisciplinary care of pediatric patients affected by the February 6, 2023 Kahramanmaraş earthquake. The study was conducted by a multidisciplinary team consisting of orthopedic surgeons specialized in trauma and reconstructive surgery, physical medicine and rehabilitation specialists experienced in the

functional management and rehabilitation of pediatric patients, and a prosthetics-orthotics technician. Treatment decisions were made through a multidisciplinary approach involving orthopedic surgeons, physical medicine and rehabilitation specialists, and prosthetics-orthotics professionals. All surgical procedures included in the study were performed at Çukurova University Faculty of Medicine Hospital by a single orthopedic trauma surgeon. The study protocol was approved by the Ethics Committee of Çukurova University Faculty of Medicine (Approval Date: February 6, 2026; Meeting No: 163; Decision No: 33) and was conducted in accordance with the Declaration of Helsinki.

Patient selection

Children younger than 18 years of age at the time of the earthquake who underwent surgical treatment between July 2023 and December 2025 due to amputation stump complications or ischemic contractures secondary to compartment syndrome were included in the study. Patients were younger than 18 years at the time of the earthquake; however, some patients were older than 18 years at the time of surgical intervention due to delayed presentation of late-stage complications. The mean follow-up duration for osseous overgrowth assessment was 2.5 years. Patients treated for acute earthquake-related injuries during the immediate post-disaster period were not included, as the present study specifically focused on late sequelae requiring revision or reconstructive procedures. Late-stage surgical management of these complications began approximately 6 months after the earthquake. Patients who underwent surgery after the ethics committee approval date were not included in order to maintain a stable and predefined study cohort. No patients were excluded because of missing clinical data. Age and sex were recorded as baseline demographic variables to characterize the study population and to evaluate potential differences between groups. Due to the rarity and highly specific nature of the study population, all eligible pediatric patients meeting the inclusion criteria during the study period were included in the study. To evaluate the adequacy of the sample size, a post-hoc power analysis was performed using G*Power software.

Data collection

Patient data were retrospectively collected from institutional electronic medical records and surgical databases. The following variables were recorded for each patient: age at the time of surgery, sex, date of surgery, number of surgical procedures, type of late complication leading to surgical indication, diagnosis, affected extremity and side, presence of preoperative and postoperative infection, and the surgical procedures performed. In cases with multiple complications, the major complication leading to surgical intervention was recorded.

Surgical procedures

Patients were divided into two groups: those with amputation stump complications and those with ischemic contractures secondary to compartment syndrome. In patients with ischemic contractures who underwent limb-preserving surgery, procedures included debridement, tenotomy, tenoplasty, tendon transfer, and osteotomy. In patients with amputation stump complications, surgical interventions included excision of bone spurs and heterotopic ossification, revision with elevation of the amputation level when required, debridement, fibular excision, and webplasty procedures. When fibular excision was performed, the lateral collateral ligament and biceps femoris tendon were tenodesed to the proximal tibia using titanium suture anchors.

Statistical analysis

Statistical analyses were performed using IBM SPSS Statistics for Mac, version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation or median (minimum–maximum), whereas categorical variables were presented as frequency and percentage. The Mann–Whitney U test was used to compare continuous variables between groups because of the small sample size and non-normal data distribution. Fisher's exact test was preferred for categorical variables due to the low expected cell counts. Binary logistic regression analysis was performed to identify factors independently associated with group allocation. Variables included in the regression model were selected based on their clinical relevance and the results of univariate group comparisons, including age, sex, number of surgical procedures, and preoperative infection status. Due to the rarity and highly specific nature of the study population, all eligible pediatric patients meeting the inclusion criteria during the study period were included in the study. To evaluate the adequacy of the sample size, a post-hoc power analysis was performed using

G*Power software version 3.1.9.7 (Heinrich Heine University, Düsseldorf, Germany). A p-value < 0.05 was considered statistically significant.

RESULTS

A total of 18 pediatric patients who underwent surgical treatment for late complications following the 6 February 2023 Kahramanmaraş earthquake were included in the study. The mean age of the patients was 14.28±5.42 years (range, 2–22). Ten patients (55.6%) were male and eight (44.4%) were female.

When late complications were evaluated, the most common problem was soft tissue insufficiency (n=6, 33.3%), followed by pressure ulcers (n=5, 27.8%) and bone spur formation (n=4, 22.2%). Short stump, infected implant, and inadequate grasp were each observed in one patient (5.6%). These three most common complications accounted for 83.3% of all cases (Table 1).

Table 1. Distribution of the major complications (n=18)

Major complication	n	%
Soft tissue insufficiency	6	33.3
Pressure ulcer	5	27.8
Bone spur	4	22.2
Short stump	1	5.6
Infected implant	1	5.6
Inadequate grasp	1	5.6

Regarding surgical management, stump revision alone was performed in 33.3% of patients, while bone resection procedures (bone spur or heterotopic ossification excision) were performed in 16.7% of cases. Debridement alone was performed in 16.7%, whereas combined surgical procedures were required in 33.3% of patients. In cases requiring combined surgery, procedures generally included both soft tissue reconstruction and corrective osteotomies.

The mean number of surgeries per patient was 1.28 (range, 1–3). While 77.8% of patients were treated with a single surgical procedure, 22.2% required two or more surgical interventions. The preoperative infection rate was 50%, whereas the postoperative infection rate was 11.1%.

Patients were divided into two groups: those with amputation stump complications and those with ischemic contracture–related complications with limb preservation. Of the patients, 66.6% had stump-related complications, while 33.3% had ischemic contracture–related complications.

According to the comparative analysis, the mean age of the amputation subgroup was 12.25 ± 5.34 years, whereas the mean age of the ischemic contracture group was 18.33 ± 2.73 years. Patients with stump-related complications were significantly younger than those with ischemic contractures ($p < 0.05$).

Patients with stump-related complications underwent a higher number of surgical procedures compared with those with ischemic contractures (mean 1.42 ± 0.67 surgeries per patient vs. 1 surgery per patient, respectively). However, this difference was not statistically significant (Mann–Whitney U test, $p = 0.138$). Similarly, preoperative ($p = 1.00$) and postoperative infection rates ($p = 0.53$) did not differ significantly between the two groups (Fisher's exact test).

Surgical treatment in the stump complication group mainly consisted of stump revision procedures, whereas patients with ischemic contractures more frequently required reconstructive procedures, including debridement, tendon release, tendon transfer, and metatarsal extension osteotomies aimed at correcting deformities and improving weight distribution (Figure 1).

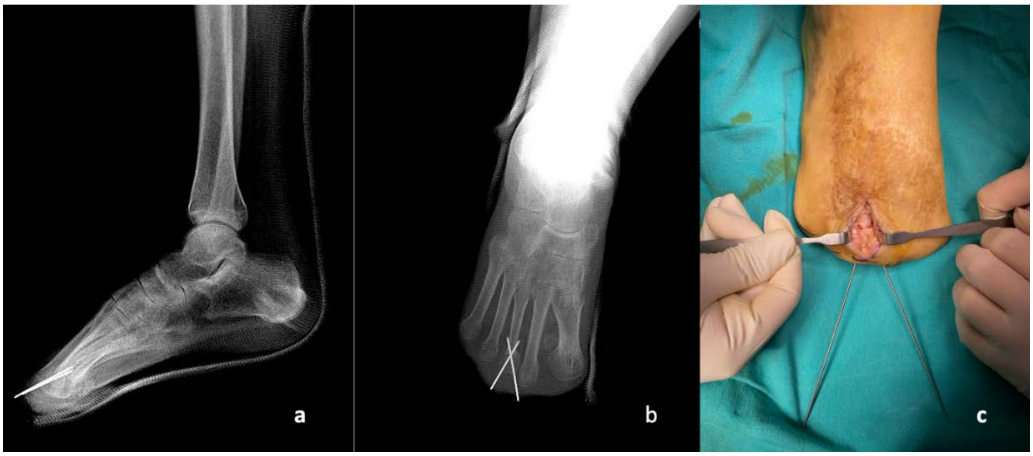


Figure 1. Patient treated with distal metatarsal osteotomy for a pressure ulcer: (a) Postoperative lateral radiograph; (b) Postoperative anteroposterior radiograph; (c) Dorsal view of the foot showing the osteotomy and fixation.

Within the amputation subgroup, preoperative infection was present in 6 patients (50.0%), and 2 patients developed postoperative infection. The most common level of amputation among patients presenting with complications was below-knee amputation (58.3%, n=7), followed by above-knee amputation (16.7%, n=2), knee disarticulation (8.3%, n=1), transhumeral amputation (8.3%, n=1), and metacarpophalangeal level amputation of the hand (8.3%, n=1) (Table 2).

Table 2. Amputation levels prior to stump revision

Stump levels	n	%
Transtibial	7	58.3
Transfemoral	2	16.7
Knee disarticulation	1	8.3
Transhumeral	1	8.3
Hand MCP*	1	8.3

*MCP: Metacarpophalangeal

Table 3. Logistic regression analysis of factors associated with group allocation

Variable	OR*	95% CI†	p value
Age	1.31	1.02–1.69	0.036
Sex (male)	1.17	0.20–6.72	0.86
Number of surgeries	1.92	0.52–7.01	0.32
Preoperative infection	1.00	0.22–4.42	1.00

*OR: odds ratio; †CI: confidence interval.

In the ischemic contracture group, six patients were included, and all were successfully treated with a single surgical session. Preoperative infection was present in 50% of these patients. In one patient who underwent fibular excision due to a short amputation stump (Figure 2), the suture anchor used for tenodesis later became infected and required removal; however, no instability developed thereafter. Binary logistic regression analysis was performed to identify factors associated with group allocation. Age was identified as the only independent factor associated with group allocation (OR = 1.31, 95% CI: 1.02–1.69, p = 0.036) (Table 3). Sex, number of surgical procedures, and preoperative infection were not identified as significant predictors ($p > 0.05$ for all).

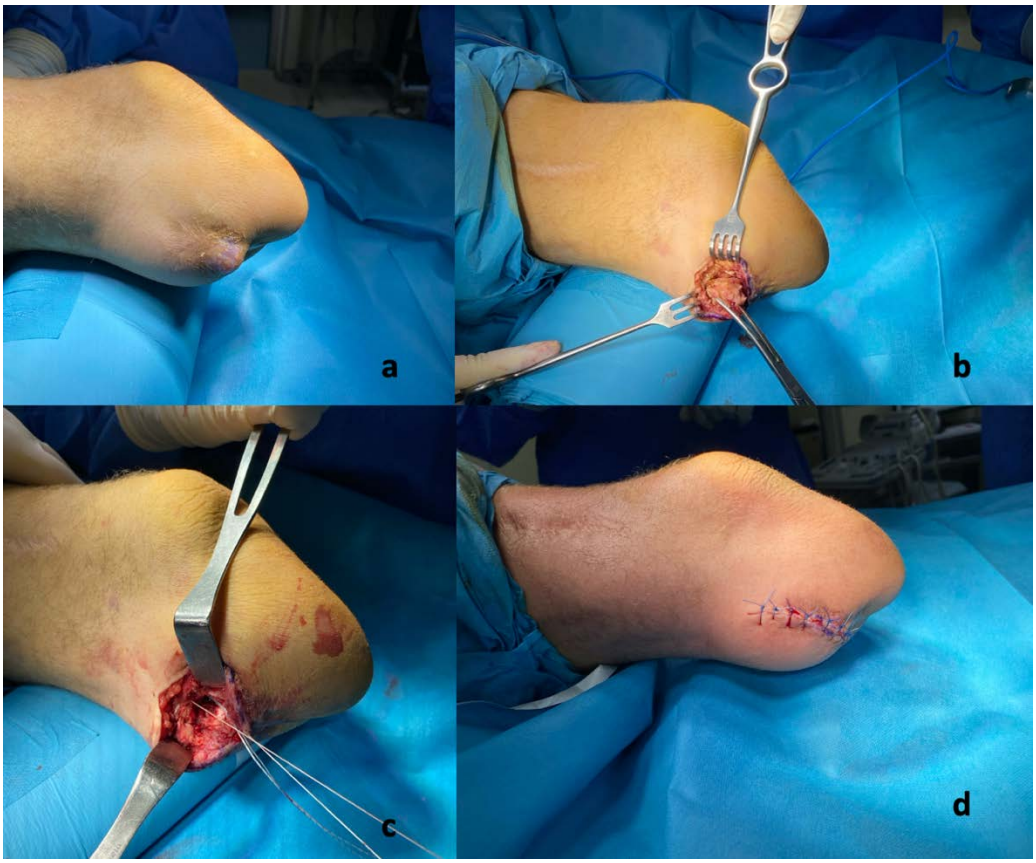


Figure 2. (a) Skin irritation caused by fibular stump prominence; (b) Fibular excision; (c) Tenodesis of the lateral collateral ligament (LCL) and biceps femoris tendon to the tibia; (d) Postoperative appearance.

DISCUSSION

This study presents the clinical profile and surgical management of late extremity sequelae in pediatric patients following the February 6, 2023 Kahramanmaraş earthquake. Our findings indicate that the most common problems in patients with amputation stump complications were soft tissue insufficiency and bone prominence, and that surgical intervention in this group tended to occur at younger ages and often required revision procedures. In contrast, patients with ischemic contractures most commonly presented with pressure-related wounds and were generally managed successfully with single-session reconstructive procedures. These findings highlight the importance of long-term follow-up and reconstructive planning to achieve optimal prosthetic or orthotic function and maximize patient mobility after disaster-related extremity injuries.

Early revision rates following amputations performed under disaster conditions have been reported to exceed 50% [2,8,9]. This is largely attributed to the challenging circumstances under which life-saving amputations are performed, often under severe time constraints and limited resources. In addition, surgeons may attempt to preserve maximal limb length and function, occasionally stretching the limits of standard surgical indications. Although these strategies may be life-saving during the acute phase, they may later result in suboptimal stump morphology and the need for revision surgery.

Even when the amputation procedure is technically adequate, complications remain common in pediatric patients. The most frequently reported complication

in pediatric amputees is osseous overgrowth at the stump [10]. This condition is characterized by swelling, tenderness, and distal bone prominence, often accompanied by the formation of an adventitious bursa over the bone. In advanced cases, the bone may protrude through the skin. Radiographically, tapering of the distal bone is commonly observed and supports the diagnosis [11]. Mechanical mismatch between the prosthetic socket and the stump may also contribute to local soft tissue inflammation and bursitis [12].

Management of osseous overgrowth remains challenging and frequently requires repeated revision procedures [11]. Numerous techniques have been proposed to address this problem; however, none has achieved universal acceptance [13]. Although cartilage capping techniques have been suggested to reduce overgrowth, limited success has been reported with iliac crest apophyseal transfer, and the risk of donor-site morbidity limits its routine use [10]. In our experience, periosteal capping did not consistently prevent recurrent osseous overgrowth, possibly due to the persistent growth potential in pediatric patients and the limited capacity of periosteal coverage to effectively suppress longitudinal bone growth. Recurrent bone overgrowth remains a persistent clinical problem in pediatric amputees. In our study, the mean follow-up duration for osseous overgrowth was 2.5 years, with postoperative follow-up ranging from 6 months to 2.5 years. Although this duration provides mid-term insight, continued growth potential in pediatric patients suggests that longer follow-up may be necessary to fully assess recurrence risk.

In our study, stump-related complications were observed in a younger patient group compared to ischemic contracture–related complications. Osseous overgrowth is a well-recognized complication in skeletally immature patients and has been reported to occur more frequently in younger children, while it is rarely observed after the age of 12 [10,14] The increased biological growth potential in this population likely contributes to recurrent bone prominence and a higher need for revision procedures.

The older age observed in the ischemic contracture group may be explained by differences in tissue characteristics and treatment response across age groups. However, there is limited direct evidence in the literature supporting this association. In pediatric patients, musculoskeletal tissues exhibit greater elasticity and responsiveness to manipulation, which allows deformities to be managed more effectively with conservative measures at younger ages. This principle is clearly demonstrated in conditions such as congenital talipes equinovarus, where early treatment with serial casting and manipulation yields excellent outcomes, whereas older children more frequently require corrective surgical procedures such as osteotomies or arthrodesis [15,16]. Therefore, the greater flexibility and rehabilitation potential in younger children may reduce the severity of long-term contracture sequelae, while older patients may present with more rigid deformities requiring surgical intervention.

The importance of preserving an active knee joint for functional ambulation and energy efficiency in amputees is well recognized [17]. However, extremely short transtibial stumps reduce the lever arm available for prosthetic function and limit the surface area for load transmission. Although successful prosthetic use has been reported in transtibial amputations with tibial segments as short as 5 cm, such cases present considerable challenges for prosthetists and may be associated with higher failure rates [18]. Earlier studies recommended fibular excision in transtibial amputations with tibial lengths shorter than 8,75 cm to facilitate prosthetic fitting [19]. More recent studies have suggested that even patients with tibial segments longer than 10 cm may benefit from fibular excision when prosthetic fit is compromised [20]. However, these studies were primarily conducted in adult populations. In pediatric amputees, stump length varies considerably with growth, and therefore prosthetic socket compatibility rather than absolute stump length should guide surgical decision-making.

It is well established that a cylindrical stump shape provides better prosthetic fit than a conical one [18]. In short stumps, fibular excision may help achieve a cylindrical stump configuration and reduce pressure caused by the fibula. Although this procedure requires tenodesis of the lateral collateral ligament and biceps femoris tendon, instability has rarely been reported [20]. In our series, fibular excision with tenodesis was performed in one patient with a short stump. Although postoperative infection developed and the tenodesis anchors were removed, no instability or functional deterioration occurred, and prosthetic use improved. Based on this experience, fibular excision may be considered a useful alternative before proceeding to higher-level amputation in patients with prosthetic fitting difficulties due to short transtibial stumps.

Soft tissue insufficiency represents an even more challenging scenario than short stumps. This problem is frequently observed in earthquake survivors who previously underwent fasciotomy and repeated debridement of the leg, followed by transtibial amputation due to infection or soft tissue necrosis. Surgical decision-making in these patients is often a complex process. The first step is to evaluate whether bone shortening can provide additional soft tissue coverage [18]. If stump shortening is not feasible, two main options remain. The first is to perform disarticulation rather than transosseous amputation, as recommended by Krajbich for pediatric amputations [13]. Although this approach may improve prosthetic fitting in some cases, it results in the loss of a functional joint and is therefore often not preferred by patients and their families [18]. The second option is soft tissue augmentation using free tissue transfer. Various flaps have been described for this purpose, including the anterolateral thigh flap, scapular free flap, latissimus dorsi musculocutaneous flap, and groin flap [21–23]. These procedures are technically demanding and require expertise in microsurgical reconstruction. In pediatric patients, microsurgical anastomosis may be even more challenging due to smaller vessel size, and donor-site morbidity must also be considered. In our practice, limited bone shortening has been performed in selected patients with short stumps and soft tissue insufficiency; however, recurrence of soft tissue problems may still occur due to the limited amount of bone that can be safely resected.

Most studies investigating earthquake-related complications focus primarily on amputation stump problems, whereas literature addressing ischemic contractures remains limited. These contractures typically develop as sequelae of compartment syndrome, either following fasciotomy or in untreated cases. Although fasciotomy performed after crush injuries may salvage the limb, evidence regarding preservation of long-term function remains limited. Furthermore, delayed fasciotomy may worsen outcomes due to the risk of infection and the need for repeated debridement [24]. As a result of muscle necrosis, fibrosis, and associated peripheral nerve injury, patients may develop contractures affecting the ankle, foot, and toes, particularly following damage to the anterior, lateral, and posterior compartments of the leg [24,25]. Nerve injury at the level of the leg or foot frequently leads to intrinsic muscle paralysis, resulting in deformities such as claw toe. The treatment strategy for these contractures depends on the severity of the deformity, the relative involvement of intrinsic and extrinsic muscle groups, and the degree of paralysis [26]. The peroneal nerve is commonly affected in these injuries [27], which may result in equinovarus deformity, often requiring tendon transfer procedures [25]. Persistent deformities may require surgical correction, including soft tissue release, tendon lengthening, tendon transfer, osteotomy, or arthrodesis, to improve function or restore a more favorable limb position [26]. In our series, flexor tenotomies were performed in two patients with toe flexion contractures, and in one patient, this procedure was combined with Achilles tendon lengthening and tibialis anterior tendon transfer. Although these soft tissue procedures are often successful, achieving the appropriate balance between muscle groups remains surgically challenging.

Pressure ulcers resulting from peripheral neuropathy, joint stiffness, and deformity are well described in the context of diabetic foot disease [28]. However, literature regarding pressure ulcers secondary to compartment syndrome–related neuropathy remains limited. In other conditions, such as Freiberg disease and transfer metatarsalgia, various osteotomy techniques have been described to relieve plantar pressure and pain by shortening or elevating the metatarsal head or decompressing the metatarsophalangeal joint [29]. In our series, five patients presented with pressure ulcers. In two of these patients, plantar ulcers beneath the metatarsal heads were treated with distal metatarsal dorsal closing wedge osteotomy. This minimally invasive technique, performed through small dorsal incisions, proved to be a simple and effective method that allowed successful wound healing by redistributing plantar pressure.

This study has several limitations. Its retrospective design and relatively small sample size limit the generalizability of the findings and restrict the ability to perform more robust statistical analyses. The relatively low statistical power (68.4%) may increase the risk of Type II error and should be considered when interpreting the findings. Furthermore, the regression analysis should be considered exploratory because of the limited sample size and the highly specific nature of the study population; therefore, the findings should be interpreted with caution. In addition, long-term functional outcomes, patient-reported outcome measures, and quality-of-life

assessments were not available. The lack of standardized functional outcome measures, such as PEDI or prosthesis-related quality-of-life scales, limits the assessment of functional outcomes following surgical treatment. Another limitation is the absence of a control group. However, this study also has notable strengths. The current literature on late surgical management of earthquake-related extremity sequelae in pediatric patients remains limited, and our study provides valuable clinical insight into this underreported field. Furthermore, the study includes a unique and clinically meaningful patient population consisting of pediatric earthquake survivors with complex extremity complications. Future prospective studies incorporating standardized functional and psychosocial outcome measures are needed to better define optimal surgical strategies and rehabilitation pathways for pediatric patients affected by earthquake-related extremity injuries.

Late extremity complications in pediatric earthquake survivors demonstrate distinct clinical patterns depending on the initial injury and treatment strategy. Amputation stump complications tend to occur in younger patients and frequently require revision procedures due to problems such as soft tissue insufficiency and osseous overgrowth. In contrast, ischemic contracture–related complications are more commonly associated with deformity and pressure-related wounds and are generally managed with reconstructive procedures aimed at restoring functional alignment and improving weight distribution. These findings emphasize the importance of long-term multidisciplinary follow-up in pediatric disaster survivors with complex extremity injuries. Recognition and timely management of stump-related complications and ischemic contractures may improve prosthetic or orthotic compatibility, functional mobility, and overall rehabilitation outcomes. Future prospective multicenter studies with larger patient populations and standardized functional outcome measures are needed to better define optimal surgical strategies, rehabilitation protocols, and long-term quality-of-life outcomes in pediatric patients affected by earthquake-related extremity injuries.

Author Contributions: Concept/Design : AS, BK; Data acquisition: ENS, BK; Data analysis and interpretation: SB, KAD, BK; Drafting manuscript: BK; Critical revision of manuscript: AS, SB, KAD; Final approval and accountability: BK, AS, ÖSB, ENS, KAD, SB; Technical or material support: ENS; Supervision: ÖSB; Securing funding (if available): n/a.
Ethical Approval: The study protocol was approved by the Ethics Committee of Cukurova University Faculty of Medicine (Approval Date: February 6, 2026; Meeting No: 163; Decision No: 33).
Peer-review: Externally peer-reviewed.
Conflict of Interest: The authors declare that there is no conflict of interest regarding the publication of this article.
Financial Disclosure: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.
Acknowledgements: The authors would like to thank all healthcare professionals and staff of the Child Wellness Practice and Research Center (ÇOİM), Çukurova University, for their dedicated care and support of children affected by the 6 February 2023 Kahramanmaraş earthquake. We also sincerely acknowledge the individuals and organizations who supported the center's activities, and the children and families who became part of the ÇOİM community for their resilience and trust.

REFERENCES

1. Uluöz M, Gökmen MY. The 2023 Turkey earthquake: management of 627 pediatric musculoskeletal injuries in the first month. Children. 2023;10:1733.
2. Basaran S, Sariyildiz A, Olmez S, Kundakci B, Bicer OS. Prosthesis applications and challenges in children with earthquake-related amputations. Injury. 2024;55:111920.
3. Emsieh S, Terro K, Rabay C, Ibrahim A, Atiyeh B. Surgical burden of traumatic lower limb amputations in the pediatric age group. Ann Burns Fire Disasters. 2023;36:337-46.
4. Khan MA, Javed AA, Rao DJ, Corner JA, Rosenfield P. Pediatric traumatic limb amputation: the principles of management and optimal residual limb lengths. World J Plast Surg. 2016;5:7-14.
5. Griffet J. Amputation and prosthesis fitting in paediatric patients. Orthop Traumatol Surg Res. 2016;102:161-75.
6. Tang H, Zhang SC, Tan ZY, Zhu HW, Zhang QL, Li M. Functional reconstruction of ischemic contracture in the lower limb. Chinese Journal of Traumatology - English Edition. 2011;14:96-9.
7. Horsch A, Gleichauf S, Lehner B, Ghandour M, Koch J, Alimusaj M et al. Lower-limb amputation in children and adolescents-a rare encounter with unique and special challenges. Children (Basel). 2022;9:1004.
8. Heszlein-Lossius HE, Al-Borno Y, Shaqqoura S, Skaik N, Giil LM, Gilbert M. Life after conflict-related amputation trauma: a clinical study from the Gaza Strip. BMC Int Health Hum Rights. 2018;18:34.
9. Yiğit N, Yavuz İA, Aydın T, Güven Ş, Çağlar C, Bozkurt İ et al. Functional outcomes and mortality after multi-limb amputations following the 2023 Türkiye earthquake: a two-year follow-up study from a level I trauma center. J Orthop Surg Res. 2025;20:802.
10. Jahmani R, Robbins C, Paley D. Iliac crest apophysis transfer to treat stump overgrowth after limb amputation in children: case series and literature review. Int Orthop. 2019;43:2601-5.
11. Murphy AD, Atkins SE, Thomas DJ, McCombe D, Coombs CJ. The use of vascularised bone capping to prevent and treat amputation stump spiking in the paediatric population. Microsurgery. 2017;37:589-95.

12. Subedi N, Heire P, Parmer V, Beardmore S, Oh C, Jepson F, Ali SI et al. Multimodality imaging review of the post-amputation stump pain. Br J Radiol. 2016;89:20160572.
13. Krajbich JI. Lower-limb deficiencies and amputations in children. J Am Acad Orthop Surg. 1998;6:358-67.
14. Aitken GT. Surgical amputation in children. J Bone Joint Surg Am. 1963;45:1735-41.
15. Bensahel H, Jehanno P, Delaby JP, Themar-Noël C. Conservative treatment of clubfoot: the functional method and its long-term follow-up. Acta Orthop Traumatol Turc. 2006;40:181-6.
16. Shingade VU, Shingade RV, Ughade SN. Correction of neglected or relapsed clubfoot deformity in an older child by single-stage procedure: early results. Curr Orthop Pract. 2012;23:122-9.
17. McClenaghan BA, Krajbich JI, Pirone AM, Koheil R, Longmuir P. Comparative assessment of gait after limb-salvage procedures. J Bone Joint Surg Am. 1989;7:1178-82.
18. Schnur D, Meier RH. Amputation surgery. Phys Med Rehabil Clin N Am. 2014;25:35-43.
19. Spira E, Steinbach T. Fibulectomy and resection of the peroneal nerve for "short tibia stumps". Acta Orthop Scand. 1973;44:589-96.
20. Harrington CJ, Kaplan SA, Richards JT, Smith DG, Souza JM, Potter BK. Transtibial amputation with fibulectomy and fibular collateral ligament-biceps reconstruction: surgical technique and clinical experience. J Orthop Trauma. 2023;37:299-303.
21. Kadam D. Secondary reconstruction of below knee amputation stump with free anterolateral thigh flap. Indian J Plast Surg. 2010;43:108-10.
22. Shenaq SM, Krouskop T, Stal S, Spira M. Salvage of amputation stumps by secondary reconstruction utilizing microsurgical free-tissue transfer. Plast Reconstr Surg. 1987;79:861-70.
23. Erdmann D, Sundin BM, Yasui K, Wong MS, Levin LS. Microsurgical free flap transfer to amputation sites: indications and results. Ann Plast Surg. 2002;48:167-72.
24. Matsuoka T, Yoshioka T, Tanaka H, Ninomiya N, Oda J, Sugimoto H et al. Long-term physical outcome of patients who suffered crush syndrome after the 1995 Hanshin-Awaji earthquake: prognostic indicators in retrospect. J Trauma. 2002;52:33-9.
25. Altan L. Postoperative rehabilitation of compartment syndrome following fasciotomy. Turk J Phys Med Rehabil. 2023;69:133-9.
26. Santi MD, Botte MJ. Volkmann's ischemic contracture of the foot and ankle: evaluation and treatment of established deformity. Foot Ankle Int. 1995;16:368-77.
27. Yalın M, Gölgelioğlu F. A comparative analysis of fasciotomy results in children and adults affected by crush-induced acute kidney injury following the Kahramanmaraş earthquakes. Medicina (Kaunas). 2023;59:1593.
28. Armstrong DG, Lavery LA. Diabetic foot ulcers: prevention, diagnosis and classification. Am Fam Physician. 1998;57:1325-32.
29. Sorensen MD, Weil L Jr. Lesser metatarsal osteotomy. Clin Podiatr Med Surg. 2015;32:275-90.