Trampoline Associated Non-Contact Fractures of the Proximal Tibial Metaphysis in Children: A Systematic Review

Brad Bergin, MD[1]; Taylor Woolnough, MD[1]; Gwendolyn Lovsted Barch[1]; Devin Peterson, MD, FRCSC[2]; Waleed Kishta MD, FRCSC[2]; Darren de SA, MD, FRCSC[2]

[1]Michael G. DeGroote School of Medicine, McMaster University. 1280 Main St W, Hamilton, Ontario, Canada L8S 4L8.

[2]Division of Orthopaedic Surgery, Department of Surgery, McMaster University. 1200 Main Street W, Hamilton, Ontario, Canada L8P 1H1.

Corresponding Author Brad Bergin, MD. Michael G DeGroote School of Medicine, McMaster University. 1280 Main St W, Hamilton, ON L8S 4L8 (email: brad.bergin@medportal.ca).

Funding The authors received no financial support for the research, authorship, or publication of this article.

Conflict of Interest The authors report no conflicts of interest.

Preferred Subspecialty of Reviewers Pediatrics, Knee and/or Trauma.

ABSTRACT

Background: Pediatric injuries of the proximal tibial metaphysis associated with trampoline use are concerning, as they have been reported to spontaneously progress into valgus deformity. The aim of this study was to perform a systematic review of outcomes following fractures of the proximal tibial metaphysis that occur as the result of jumping, particularly on trampolines or inflatable structures, and to assess the incidence of progression to valgus deformity of the proximal tibia. It is hypothesized that this specific mechanism of injury does not result in any future deformity of the tibia.

Methods: A duplicate, independent, and systematic search of Embase, MEDLINE, and Web of Science databases was conducted according to Revised Assessment of Multiple Systematic Reviews (R-AMSTAR) guidelines and reported according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Results: Seven studies met inclusion criteria, which totaled 87 patients with an age range of 2.0 years to 6.0 years, and a follow-up period ranging from 7.7 months to 36 months. In all studies, fractures occurred while bouncing with other individuals. Fractures were transverse and non-displaced in 71.0% to 100.0% and 86.0% to 100.0% of patients, respectively. Tubercle notch scooping and anterior tilting of the proximal tibial epiphyseal plate were common radiographic findings, observed in 49.0% to 100.0% of patients. No initial coronal deformity was reported. All patients were treated with above-knee cast immobilization with satisfactory fracture healing. No patients went on to develop leg-length discrepancy or tibial deformity in coronal or sagittal planes at final follow-up.

Conclusions: Trampoline fractures most commonly occur in patients 2 years to 6 years of age, and are typically the result of two or more individuals using a trampoline simultaneously. Fractures are transverse, non-displaced, without medial gapping and can be identified by tubercle notch scooping and/or anterior tilting of the epiphyseal plate. Diagnosis can be made without the need for advanced imaging techniques. There has been no documented case of progression into valgus deformity or leg-length discrepancy in patients with characteristic trampoline fractures.

Keywords: Tibia; Knee; Child; Pediatric; Fracture; Trampoline

INTRODUCTION

Childhood use of trampolines, particularly at trampoline parks, has increased more than six-fold from 2011 to 2016.[1] Accordingly, trampoline-related injuries are becoming more prevalent.[2] When a trampoline-related fracture of the proximal tibial metaphysis is sustained without an obvious fall or direct tibial blow, it is often described as a "trampoline fracture."[3,4] Fractures of this nature account for 10.0% to 36.0% of all fractures sustained during trampoline use.[1,2,5] A trampoline fracture likely occurs when two or more children are jumping in tandem; as a recoiling mat propels a heavier child upwards, energy is transferred from contracting springs to the descending lighter child, imparting a sudden axial load on the lighter child's tibia.[3,6] Since it is soft, immature bone is less resistant to axial loading, and a trampoline fracture may occur. (Figure 1).[6] Trampoline fracture presentations can often be radiographically subtle with nearly 25.0% of these injuries missed on initial presentation.[6]

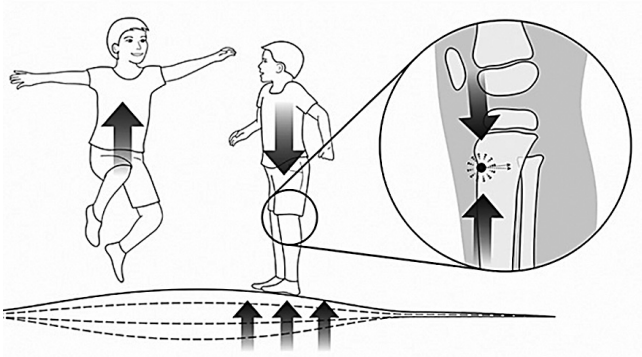

Figure 1. *Force diagram of proposed trampoline fracture mechanism. Upward force produced by recoiling trampoline springs as larger child travels upwards. Downward arrow represents force of gravity on smaller child. Note the mild knee hyperextension producing failure primarily at the anterior cortex.*

Fractures of the proximal tibial metaphysis are concerning, because up to half spontaneously progress into significant valgus deformity, coined 'Cozen's phenomenon.'[7,8] This deformity may arise despite adequate initial alignment.[9] Eventual remodeling has been documented in many cases of post-traumatic tibial valgus deformity. Although to achieve this, operative management has been described by several authors.[10-12] This deformity can be highly distressing to both patients and parents, and can lead to leg-length discrepancy and earlier onset knee arthritis.[13-16] Despite a described risk of spontaneous post-traumatic tibial valgus deformity as high as 50.0%, there exists no consensus in the literature regarding trampoline use and the risk of developing this complication.[17] Therefore, the purpose of this systematic review was to: (1) describe how "trampoline fractures" typically present; (2) identify typical radiographic findings associated with injury and discuss the role for advanced imaging; (3) identify the risk of post-traumatic deformity or leg-length discrepancy in this population. It is hypothesized that this specific mechanism of injury does not result in any future deformity of the tibia.

METHODS

Search Strategy

This review was conducted and reported according to Assessing the Methodological Quality of Systematic Reviews (AMSTAR) and PRISMA guidelines, respectively.[18,19] Three indexes, Embase, MEDLINE, and Web of Science, were searched from database inception to April 2022. In addition, the references of included studies were hand-searched. The search strategy for trampoline-related fractures of the proximal tibial metaphysis included the following keywords: "pediatric," "tibia," "fracture," "deformity," and "Cozen." All studies that described patients with Cozen's phenomenon were included in full-text review for thoroughness. The research question, inclusion criteria, and data extraction tables were established *a priori.*

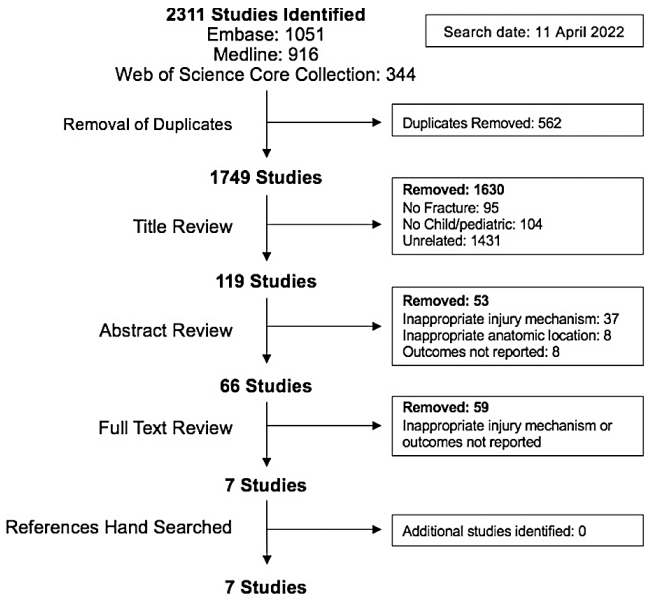

Figure 2. *PRISMA diagram of screening process.*

The following inclusion criteria were used: (1) any level of evidence; (2) studies published in English; (3) including patients with fractures of the proximal tibial metaphysis directly resulting from jumping or trampoline/inflatable-bouncer use; (4) studies reporting outcomes following fracture healing. Patients were excluded if their injury resulted from direct trauma (e.g. impact to the tibia from another individual or trampoline frame), a fall from height (e.g. off of trampoline), or if the mechanism of injury was not adequately described. Studies were excluded if they did not report outcomes related to presentation, radiographic outcomes, or clinical outcomes (i.e. satisfactory fracture healing or lack thereof).

Study Screening

Two reviewers independently screened titles, abstracts, and the full text of all studies (Figure 2). Disagreements during the title and abstract review were resolved by automatic inclusion, while disagreements during full text review were resolved by consultation with a senior reviewer.

Assessment of Quality of Included Studies

Quality of included studies was assessed using the Methodological Index for Non-Randomized Studies (MINORS) Criteria.[20] MINORS is a reliable, validated tool used to assess methodology in studies that use both comparative and non-comparative designs. Each criterion is assigned a score of 2, 1, or 0; the maximum value for non-comparative and comparative studies is 16 and 24, respectively.

Data Abstraction and Statistical Analysis

Relevant information, including author and year of publication, sample size, study design, patient demographics (age, sex, etc.), radiographic fracture features, and follow-up outcomes was abstracted in duplicate and recorded in a Microsoft Excel spreadsheet

Table 1. Minors criteria total score for included studies

MINORS Criteria	Arkink	Boyer	Bruyeer	Kakel	Klimek	Stranzinger	Jeong
Total	5.5	4.5	5.5	7.5	6	17.5	14

Table 2. Patient Demographics

Author	Level of Evidence	N	Female (%)	Patient Age (mean; years)	Jumping with other(s) at time of injury (%)	Follow-up (mean; months)
Arkink et al.[21]	IV	1	100	6	1 (100)	12
Boyer et al.[3]	IV	7	NR	3.9	7 (100)	36
Bruyeer et al.[4]	IV	3	0	2.5	NR	NR
Jeong et al.[22]	III	40	62.5	3.33	40 (100)	18
Kakel et al.[23]	IV	6	NR	4.33	6 (100)	7.71
Klimek et al.[2]	IV	5	NR	2-5	5 (100)	NR
Stranzinger et al.[24]	III	25	64	2-5	NR	NR

NR; not reported. N; number of patients with trampoline fractures. Percentages are reported in brackets. Arkink et al. reported a case of bilateral fractures. Kakel et al. describes six patients with seven fractures.

designed *a priori.* Where appropriate, descriptive statistics are presented. Data are presented as ranges to avoid pooling of low-quality evidence. Meta-analysis was not performed.

RESULTS

Study Characteristics and Reviewer Agreement

The initial search yielded 1,749 studies across the three databases after duplicate removal, seven of which met criteria for inclusion herein: one case report, three case series, one cross-sectional study, and two retrospective cohort studies.[2-4,21-24] The average MINORS score for included studies was 4.8 out of 16 for the five non-comparative studies and 15.75 out of 24 for the two comparative studies (Table 1).

Clinical Findings

Eighty-seven patients with 89 total fractures have been reported. Mean patient age at the time of fracture ranged from 2.0 years to 6.0 years, and follow-up ranged between 7.7 months to 36 months (Table 2). Three studies representing 33 patients did not specify follow-up duration beyond a qualitative description of normal clinical follow-up. In the largest included study, (n=40) 62.5% of patients were female. In six of the seven studies, and confirmed in all but one patient in the seventh study, fractures occurred as the result of trampoline use with no fall from height or direct trauma. All patients experienced this characteristic fracture while bouncing with one or more additional individuals on the trampoline. The presentation in every child was knee pain during the trampoline session and difficulty or refusal to weight bear immediately thereafter and upon arrival to hospital.

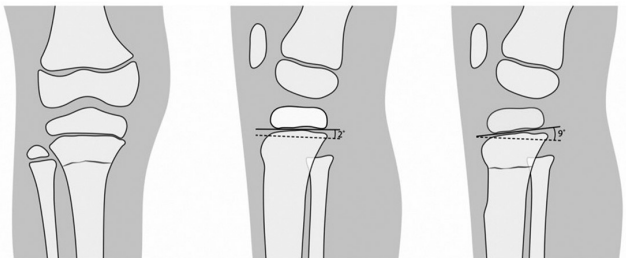

Figure 3. *Diagrammatic representation of common radiographic features of trampoline fractures: (left) anteroposterior radiograph depicting a non-displaced transverse fracture without varus or valgus angulation; (middle) normal lateral radiograph; (right) anterior tilting of physis with tubercle notch scooping.*

All of the included patients were assessed with anteroposterior and lateral view radiographs. Trampoline fractures were transverse and non-displaced in 71.0% to 100.0% and 86.0% to 100.0% of patients, respectively (Figure 3). Overt extension deformity was demonstrated in 0.0% to 14.0% of patients, and was the only angular deformity present in any study. Abnormal tubercle notch scooping and anterior tilting of the proximal tibial epiphyseal plate were seen on lateral radiographs in 49.0% to 100.0% of patients with trampoline fractures (Table 3). Of note, one patient demonstrated a disruption of the posterior proximal tibial cortex.[21] In one study, the injury was missed on initial radiographs in 25.0% of patients. There were no described cases requiring advanced imaging techniques for diagnosis.

No trampoline fracture was associated with an ipsilateral fibula fracture. None of the included

Table 3. Reported radiographic characteristics of trampoline fractures

Author	N	Transverse	Non-displaced	Mild extension deformity	Tubercle notch scooping	Anterior epiphyseal tilt	Anterior Cortical Buckling
Arkink et al.[21]	2	2 (100)	2 (100)	0 (0)	NR	NR	2 (100)
Boyer et al.[3]	7	5 (71)	6 (86)	1 (14)	NR	NR	1 (14)
Bruyeer et al.[4]	3	NR	3 (100)	0 (0)	2 (67)	2 (67)	3 (100)
Jeong et al.[22]	40	NR	NR	NR	19 (49)	NR	18 (46)
Kakel et al.[23]	7	7 (100)	6 (86)	1 (14)	7 (100)	NR	NR
Klimek et al.[2]	5	NR	"Most patients"	NR	NR	"Most patients"	"Most patients"
Stranzinger et al.[24]	25	NR	25 (100)	1 (4)	22 (88)	25 (100)	23 (92)

NR; not reported. N; number of patients with trampoline fractures. Percentages are reported in brackets. One study did not report numerical values and thus direct quotations regarding the characteristic are reported in quotations. Arkink et al. reported a case of bilateral fractures. Kakel et al. describes six patients with seven fractures.

patients experienced associated fractures of the upper extremities, skull, or spine. Only one patient experienced an associated injury of the lower extremity—an ipsilateral cortical buckle fracture of the lateral distal femoral metaphysis.[4] All patients were treated with above-knee cast immobilization for 3 weeks to 4 weeks and went on to achieve satisfactory fracture healing at approximately 1-year post-injury. However, duration of casting was only reported in two studies.[21,22] No patients developed a leg-length discrepancy, recurvatum deformity, or a transient or persistent valgus deformity. All studies qualitatively reported satisfactory patient function at final follow-up, although patient function was not assessed.

DISCUSSION

One of the more common trampoline-related fractures is of the proximal tibial metaphysis, termed "trampoline fracture."[2,5] Pediatric fractures of the proximal tibial metaphysis are of particular risk of spontaneous progression to valgus deformity despite adequate reduction, coined Cozen's phenomenon.[9] A recently published retrospective chart review concluded that 14.3% of patients develop a post-traumatic valgus angulation during follow-up after a fracture of the proximal tibial metaphysis, and that 54.5% of these fractures that show a medial gap go on to develop a valgus deformity > 4 degrees.[7] Other studies report the rate of developing valgus deformity at 50.0% to 90.0% following a fracture of the proximal tibial metaphysis.[8,17] Therefore, it is important to understand the presentation and progression of this specific fracture type. We found that almost all trampoline-related fractures of the proximal tibial metaphysis are transverse, lack significant angulation, and demonstrate cortical buckling and/or tubercle notch scooping. Furthermore, this systematic review confirmed the initial hypothesis, as there have been no reported cases of trampoline-related fractures of the proximal tibial metaphysis progressing to valgus deformity.

Trampoline fractures were only identified in younger children aged 2 years to 6 years old.[2-4,21-24] It is plausible that soft, immature bone predisposes patients to this type of injury.[6] These children typically present with an inability to weight bear, decreased knee range of motion, and pain around the proximal tibia, particularly with knee hyperextension.[3,4,25] Interestingly, initial hyperextension, in addition to axial loading, may contribute to the characteristic radiographic appearance of notch scooping and epiphyseal tilting.[2,4] In addition, none of the patients experienced associated fractures of the ipsilateral tibia and all trampoline fractures were a result of jumping with one or more other individuals without any direct trauma or fall from the trampoline. It is important to note that plain radiography is interpreted as normal in up to 24.0% of cases; therefore, a thorough history and physical examination are of critical importance in the diagnosis of trampoline fractures, because the narrative is consistent among patients.[24]

Despite the potential inadequacies of radiography, trampoline fractures demonstrate consistent radiographic findings such as a transverse fracture of the metaphysis, minimal angulation and cortical buckling, and/or tubercle notch scooping. However, if x-rays appear normal but clinical suspicion remains high, immobilization with above-knee casting is prudent until radiographs are repeated in 7 days to 10 days. A delayed diagnosis can be made by identifying the periosteal reaction of an occult fracture.[2] In the included studies, standard radiographs were the only imaging modality used for diagnosis. However, magnetic resonance imaging (MRI) and bone scans have successfully been used to diagnose this fracture, particularly when osteomyelitis is part of the differential diagnosis at presentation.[26,27] Routine use

of either modality for children with normal x-rays is likely resource-prohibitive and is not recommended. Ultrasound may also be viable for detection of radiographically subtle pediatric tibia fractures, however literature supporting this application is limited.[28,29] Overall, the literature does not support the requirement of advanced imaging for accurate diagnosis, particularly considering the characteristic radiographic features.

None of the included studies reported progression to valgus deformity after adequate follow-up, although it is worth mentioning three studies that were excluded from our systematic review. In 2019, Yang et al.[7] published a retrospective chart review, reporting that 13 of 58 patients (22.4%) with a trampoline-related fracture of the proximal tibial metaphysis eventually developed a valgus deformity. However, Yang and colleagues did not confirm the mechanism of injury and thus, the study was ineligible for inclusion. Their definition of "trampoline fracture" significantly deviated from the classic one used in this paper. The fracture pattern described by Yang et al.[7] included medial cortical gapping and obvious displacement, which is more consistent with a direct blow to the tibia or falling from the trampoline. Another recent study published in 2019 by Yoo et al.[30] confirmed the results of this systematic review and found that trampoline-related fractures of the proximal tibial metaphysis did not progress to valgus deformity or leg-length discrepancy after a minimum of 1-year follow-up. Despite showing similar fracture patterns to the classic trampoline fracture, this study was excluded because the data was mixed with crush injuries of the tibia. Furthermore, Burton et al.[8] reported that two bounce house injuries of the proximal tibial metaphysis did not result in valgus deformity after sufficient follow-up, but the study was excluded because the mechanism of injury was not stated.

These findings highlight the importance of consistent fracture description and documentation of injury mechanism, particularly when using eponyms. Some authors use "trampoline fracture" to describe any pediatric proximal tibial metaphysis fracture resulting from trampoline use, regardless of radiographic appearance or history of a direct blow or fall from a trampoline. Other authors use the eponym to describe a particular radiographic appearance—transverse, minimally-displaced fractures, with tubercle notch scooping and/or anterior epiphyseal tilting—which often results from "normal" trampoline use in the presence of heavier individuals.[3,4,31] In this second description, a greater emphasis is placed on fracture morphology, an important distinction because these injuries may occur during other activities such as inflatable bouncer use.[24,32,33] Beyond generation of axial loading, the significance of trampoline use is unclear.[6] Accordingly, we advocate for use of a fracture morphology-focused definition as used in this review, limiting application of the "trampoline fracture" eponym to the specific fracture morphology mentioned previously. Doing so also acknowledges that these fractures may occur on trampolines, inflatable structures, or other bouncing surfaces. Alternatively, the previously proposed "Toddler II fracture" description may also be appropriate.[25]

The results of this review suggest that immediate or delayed operations are not required to treat trampoline fractures. Above-knee cast immobilization is appropriate to achieve satisfactory outcomes. Furthermore, contrary to current management strategies for many proximal tibial fractures, trampoline fractures are unlikely to require close follow-up after radiographic evidence of sufficient healing has been established, as this review suggests a low risk for any future complications such as angular deformities or leg-length discrepancies.[34,35] Physicians can be confident that patients presenting with a classic history for a trampoline fracture will typically experience satisfactory outcomes if the following conservative management algorithm is followed. Above-knee cast immobilization for 3 weeks to 4 weeks with x-rays at 7 days to 10 days to confirm fracture (if not initially seen), and repeat radiographs prior to cast removal. Weight bearing can then be initiated and the patient can be followed for approximately 1 year to ensure satisfactory healing. Furthermore, physicians should promote pediatric guidelines that recommend restricting trampoline use to children greater than 6 years of age and to limit use to only one jumper at a time.[36]

STUDY LIMITATIONS

This review is limited by the small number of patients and low quality of evidence, with associated inherent risks of bias. As a result, the data was unable to be pooled and a quantitative analysis could not be performed to assess for the impact of potential confounding variables such as age and sex. The second limitation of this study is that half of the included papers did not explicitly report the duration of follow-up. The studies in question stated that no angulation developed after an adequate follow-up period. So, although unlikely, it is impossible to exclude progression into valgus deformity following study completion.

CONCLUSION

Trampoline fractures most commonly occur in patients 2 years to 6 years of age and are typically the result of two or more individuals using a trampoline simultaneously. Fractures are transverse, non-displaced, without medial gapping and can be identified by tubercle notch scooping and/or anterior tilting of the epiphyseal plate. Diagnosis can be made without advanced imaging techniques. To date, there has been no documented case of progression into valgus deformity or leg-length discrepancy in patients with characteristic trampoline fractures.

REFERENCES

1. Choi ES, Jang JH, Woo JH, et al. Pediatric trampoline-related injuries in a nationwide registry in South Korea, 2011 to 2016. Yonsei Med J. 2018;59(8):989-994. doi: 10.3349/ymj.2018.59.8.989.
2. Klimek PM, Juen D, Stranzinger E, et al. Trampoline related injuries in children: risk factors and radiographic findings. World J Pediatr. 2013;9(2):169-174. doi: 10.1007/s12519-013-0416-2.
3. Boyer RS, Jaffe RB, Nixon GW, et al. Trampoline fracture of the proximal tibia in children. AJR Am J Roentgenol. 1986;146(1):83-85. doi: 10.2214/ajr.146.1.83. PMID: 3484416.
4. Bruyeer E, Geusens E, Catry F, et al. 'Trampoline fracture' of the proximal tibia in children: report of 3 cases and review of literature. JBR-BTR. 2012;95(1):10-12. doi: 10.5334/jbr-btr.69.
5. Choi ES, Hong JH, Sim JA. Distinct features of trampoline-related orthopedic injuries in children aged under 6 years. Injury. 2018;49(2):443-446. doi: 10.1016/j.injury.2017.12.017.
6. Menelaws S, Bogacz AR, Drew T, et al. Trampoline-related injuries in children: a preliminary biomechanical model of multiple users. Emerg Med J. 201;28(7):594-598. doi: 10.1136/emj.2009.085803.
7. Yang BW, Shore BJ, Rademacher E, et al. Prevalence of Cozen's phenomenon of the proximal tibia. J Pediatr Orthop. 2019;39(6):e417-e421. doi: 10.1097/BPO.0000000000001354.
8. Burton A, Hennrikus W. Cozen's phenomenon revisited. J Pediatr Orthop B. 2016;25(6):551-555. doi: 10.1097/BPB.0000000000000327.
9. Cozen L. Fracture of the proximal portion of the tibia in children followed by valgus deformity. Surg Gynecol Obstet. 1953;97(2):183-188.
10. Jackson DW, Cozen L. Genu valgum as a complication of proximal tibial metaphyseal fractures in children. J Bone Joint Surg Am. 1971;53(8):1571-1578.
11. Morin M, Klatt J, Stevens PM. Cozen's deformity: resolved by guided growth. Strategies Trauma Limb Reconstr. 2018;13(2):87-93. doi: 10.1007/s11751-018-0309-y.
12. Zionts LE, MacEwen GD. Spontaneous improvement of post-traumatic tibia valga. J Bone Joint Surg Am. 1986;68(5):680-687.
13. Tuten HR, Keeler KA, Gabos PG, et al. Posttraumatic tibia valga in children. A long-term follow-up note. J Bone Joint Surg Am. 1999;81(6):799-810. doi: 10.2106/00004623-199906000-00007.
14. Alghamdi A, Rahmé M, Lavigne M, et al. Tibia valga morphology in osteoarthritic knees: importance of preoperative full limb radiographs in total knee arthroplasty. J Arthroplasty. 2014;29(8):1671-1676. doi: 10.1016/j.arth.2014.03.001.
15. Bassey LO. Valgus deformity following proximal metaphyseal fractures in children: experiences in the African tropics. J Trauma. 1990;30(1):102-107. doi: 10.1097/00005373-199001000-00017.
16. Robert M, Khouri N, Carlioz H, et al. Fractures of the proximal tibial metaphysis in children: review of a series of 25 cases. J Pediatr Orthop. 1987;7(4):444-449. doi: 10.1097/01241398-198707000-00013.
17. Nenopoulos S, Vrettakos A, Chaftikis N, et al. The effect of proximal tibial fractures on the limb axis in children. Acta Orthop Belg. 2007;73(3):345-353.
18. Shea BJ, Grimshaw JM, Wells GA, et al. Development of AMSTAR: a measurement tool to assess the methodological quality of systematic reviews. BMC Med Res Methodol. 2007;7:10. doi: 10.1186/1471-2288-7-10.
19. Moher D, Liberati A, Tetzlaff J, et al. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med. 2009;6(7):e1000097. doi: 10.1371/journal.pmed.1000097.
20. Slim K, Nini E, Forestier D, et al. Methodological index for non-randomized studies (minors): development and validation of a new instrument. ANZ J Surg. 2003;73(9):712-716. doi: 10.1046/j.1445-2197.2003.02748.x.
21. Arkink EB, van der Plas A, Sneep RW, et al. Bilateral trampoline fracture of the proximal tibia in a child. Radiol Case Rep. 2017;12(4):798-800. doi: 10.1016/j.radcr.2017.07.020.
22. Jeong C, Lee SU, Kim HG, et al. Trampoline-related fractures of the proximal tibia in children. J Orthop Surg Res. 2021;16(1):551. doi: 10.1186/s13018-021-02707-9.
23. Kakel R. Trampoline fracture of the proximal tibial metaphysis in children may not progress into valgus: a report of seven cases and a brief review. Orthop Traumatol Surg Res. 2012;98(4):446-449. doi: 10.1016/j.otsr.2012.02.007.
24. Stranzinger E, Leidolt L, Eich G, et al. The anterior tilt angle of the proximal tibia epiphyseal plate: a significant radiological finding in young children with trampoline fractures. Eur J Radiol. 2014;83(8):1433-1436. doi: 10.1016/j.ejrad.2014.05.013.
25. Swischuk LE. Musculoskeletal injury in the right leg of a child who jumped a lot in a birthday party. Emerg Radiol. 2009;16(5):331-333. doi: 10.1007/s10140-009-0803-0.
26. Gauthé M, Mestas D, Canavese F, et al. Differential diagnosis of trampoline fracture from osteomyelitis by bone scan with pinhole collimator. Ann Nucl Med. 2014;28(2):163-166. doi: 10.1007/s12149-013-0770-0.
27. Hauth E, Jaeger H, Luckey P, et al. MR imaging for detection of trampoline injuries in children. BMC Pediatr. 2017;17(1):27. doi: 10.1186/s12887-017-0791-2.

28. Lewis D, Logan P. Sonographic diagnosis of toddler's fracture in the emergency department. J Clin Ultrasound. 2006;34(4):190-194. doi: 10.1002/jcu.20192.
29. Warkentine FH, Horowitz R, Pierce MC. The use of ultrasound to detect occult or unsuspected fractures in child abuse. Pediatr Emerg Care. 2014;30(1):43-46. doi: 10.1097/PEC.0000000000000064.
30. Yoo MJ, Yoo JI, Lee JY, et al. Treatment of typical trampoline fracture of the proximal tibia in children: results of minimum 1 year follow-up. Eur J Trauma Emerg Surg. 2021;47(3):811-816. doi: 10.1007/s00068-019-01266-3.
31. Skak SV, Jensen TT, Poulsen TD. Fracture of the proximal metaphysis of the tibia in children. Injury. 1987;18(3):149-156. doi: 10.1016/0020-1383(87)90127-6.
32. Swischuk LE, John SD, Tschoepe EJ. Upper tibial hyperextension fractures in infants: another occult toddler's fracture. Pediatr Radiol. 1999;29(1):6-9. doi: 10.1007/s002470050523.
33. Saade-Lemus S, Nguyen JC, Francavilla ML, et al. Buckle fracture of the proximal tibia in children and frequency of association with trampoline and inflatable bouncer use. Pediatr Radiol. 2019;49(10):1327-1334. doi: 10.1007/s00247-019-04450-0.
34. Mashru RP, Herman MJ, Pizzutillo PD. Tibial shaft fractures in children and adolescents. J Am Acad Orthop Surg. 2005;13(5):345-352. doi: 10.5435/00124635-200509000-00008.
35. Shannak AO. Tibial fractures in children: follow-up study. J Pediatr Orthop. 1988;8(3):306-310. doi: 10.1097/01241398-198805000-00010.
36. Briskin S, LaBotz M. Council on Sports Medicine and Fitness, American Academy of Pediatrics. Trampoline safety in childhood and adolescence. Pediatrics. 2012;130(4):774-779. doi: 10.1542/peds.2012-2082.