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Metaphyseal fractures mimicking abuse during treatment for clubfoot

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Abstract *Background.* Metaphyseal injuries resembling the classic metaphyseal lesion (CML) of abuse may occur as the result of serial casting during treatment of clubfoot deformity. Mentioned in the orthopedic literature in 1972, this iatrogenic fracture has not been described in the radiologic literature nor has the similarity to injuries occurring with abuse been previously recognized.

Objective. To describe the mechanism and radiographic appearance of metaphyseal injury observed during serial casting of clubfoot. Note similarities to the CML of abuse.

Materials and methods. Eight children ranging in age from 1 to 4 months underwent casting for clubfoot. Five orthopedic surgeons from three different institutions performed the casting. Two patients had spina bifida and one, arthrogyposis. A complete skeletal survey

was performed on one child who was abused; there was no suspicion of abuse in the remaining seven.

Results. All children manifest injury with periosteal new bone. One child had clear evidence of abuse with 24 rib fractures. X-rays of lower extremities in short leg casts revealed bilateral tibial metaphyseal fractures. Four other children had metaphyseal fractures resembling the CML of abuse, and three developed an area of sclerosis within the metaphysis.

Conclusion. In the setting of serial casting for equinovarus deformity, metaphyseal injury even the CML of abuse may be noted. Since inflicted injuries are almost always unobserved and explanations rarely offered, the fact that the CML occurs as a result of orthopedic manipulation may offer some further insight concerning the pathogenesis of this well-described abuse injury.

Introduction

The classic metaphyseal lesion (CML) of child abuse, also referred to as corner or buckethandle fracture, has been studied extensively by Kleinman et al. [1]. CML occurs as a result of indirect forces when the extremity is pulled, pushed, twisted or when the infant is shaken [2]. With serial casting the clubfoot is pushed and twisted into forced eversion and dorsiflexion to correct the equinovarus deformity and then casted. Techniques for non-surgical treatment of clubfoot differ; however, all involve stretching with manipulation to correct all com-

ponents of the clubfoot deformity, hindfoot varus, forefoot adductus and equinus, followed by serial casting of the foot and ankle, beginning within the first several days following birth. Manipulation to correct the heel varus and forefoot adductus lasts 5–10 min with each cast change and should be performed weekly for 4–6 weeks, and then biweekly. Dorsiflexion and stretching of the tendocalcaneus and calf muscle group to correct the equinus is only begun following correction of the hindfoot varus and forefoot adductus, usually no sooner than after four cast changes [3–5]. Underlying neuromuscular abnormality such as spina bifida or ar-

Table 1 Patient group. Sex, age at initiation of manipulation and serial casting, age at diagnosis of injury, associated abnormalities, clubfoot (unilateral or bilateral), and location of injury

No.	Case	Sex	Age radiotherapy begun	Age at diagnosis (months)	Associated abnormality	Clubfoot	Injury
1	JL	M	5 days	3.5	24 rib fractures	Bilateral	Bilateral
2	ZW	M	15 days	1.5	–	Bilateral	Bilateral
3	BK	F	7 days	1	Spina bifida	Bilateral	Bilateral
4	BG	F	6 days	1.5	Arthrogyrposis	Bilateral	Bilateral
5	IL	M	1 day	4	–	Bilateral	Bilateral
6	TL	M	6 days	1.5	–	Left	Left
7	CG	M	6 days	2	Spina bifida	Bilateral	Left
8	TG	F	4 days	1	–	Bilateral	Bilateral

**Fig. 1** Case 1. AP X-ray of right lower leg (a) and AP X-ray of left lower leg (b), both in short leg Fiberglas cast. Angular deformities at the distal metadiaphysis of tibias and fibulas with associated periosteal new bone on this 3.5-month-old male infant subsequently found to have 24 rib fractures

throgyrposis results in a more rigid or teratologic clubfoot and may further predispose to injury [5–7].

It is not surprising that on occasion a metaphyseal injury may result during manipulation and serial casting. However, there has been no report of this injury in the radiologic literature and only one article describing metaphyseal fracture as a complication of clubfoot treatment in the orthopedic literature in 1972 [8]. We present eight infants undergoing serial casting treatment for clubfoot deformity who developed radiographic evidence of metaphyseal injury, including the CML of abuse.

Materials and methods

Eight infants with clubfoot deformity, 5 males and 3 females, ranging in age from 1 to 4 months at time of diagnosis of injury were identified between 1993 and 2000 (Table 1). Seven of the eight infants had bilateral clubfoot deformity and one infant had unilateral clubfoot. All were treated with serial casting by five different orthopedic surgeons at three hospitals. With the exception of case 1, injuries were identified incidentally on radiographs obtained during routine monitoring of treatment with serial casting. All of the infants ultimately underwent final surgical correction for clubfoot at the M. S. Hershey Medical Center, Penn State University. On average, 50 new patients with clubfoot are referred to our medical center each year and 60% of those will be treated with manipulation and serial casting.

Two of the infants had spina bifida (cases 3 and 7), and one was diagnosed with arthrogyrposis (case 4); all three had bilateral clubfoot deformity. The remaining five infants were normal. A complete skeletal survey was performed on only one of the eight children (case 1); there was no suspicion for abuse in the other seven infants.

Results

The parents of J. L., case 1, brought him to the emergency room for “breathing difficulty” and a chest X-ray revealed 24 rib fractures. Subsequent skeletal survey disclosed angular deformity of both distal tibias and fibulas with periosteal reaction in short leg casts (Fig. 1).

Six of the seven infants with bilateral clubfoot had bilateral metaphyseal injuries, and the remaining one developed an injury on the left. One infant had a unilateral left clubfoot with resultant injury. A total of 14 tibial bony injuries were documented in our patient group. All of the infants demonstrated periosteal reaction at the distal tibia and fibula. Five infants (cases 1, 3, 4, 7, 8) had definite bony fractures on X-ray (Figs. 1–5); 3 of the 5 (cases 3, 4, 7) had an associated neuromuscular abnormality (Figs. 3–5). The extensive periosteal reaction in case 8 (Fig. 2) is suggestive of a Salter Harris II physeal injury rather than a CML in which periosteal reaction is modest and there is no epiphyseal displacement. The remaining three cases (cases 2, 5, 6) manifested injury with focal periosteal reaction at the metadiaphyseal



Fig. 2 Case 8. AP radiograph (a) and lateral (b) of right ankle on a 1-month-old baby girl undergoing serial casting. Metaphyseal fracture at distal tibia, possibly a Salter Harris II, and angular deformity at distal fibula with abundant periosteal reaction. Similar changes were noted at the left ankle

Fig. 3 Case 7. AP X-ray (a) and lateral (b) of left lower leg show fairly classic metaphyseal lesion (CML), bucket handle pattern, at the distal tibia and fibula on this 2-month-old male infant with spina bifida. Healing periosteal reaction at both tibia and fibula. Similar change was noted on the right

Fig. 4 Case 3. AP radiograph of left ankle reveals classic metaphyseal lesion (CML) through distal tibia and probable Salter Harris II fracture at fibula on this 1-month-old with spina bifida. Similar, though less marked changes were noted on the right

Fig. 5 Case 4. Lateral X-ray of left ankle on 1.5-month-old female with arthrogyrosis demonstrates tibial metaphyseal fracture. Offset in anterior physis suggests cartilaginous hypertrophy at fracture site and associated healing periosteal reaction. Note focal sclerosis within metaphysis. Similar changes were noted on the right

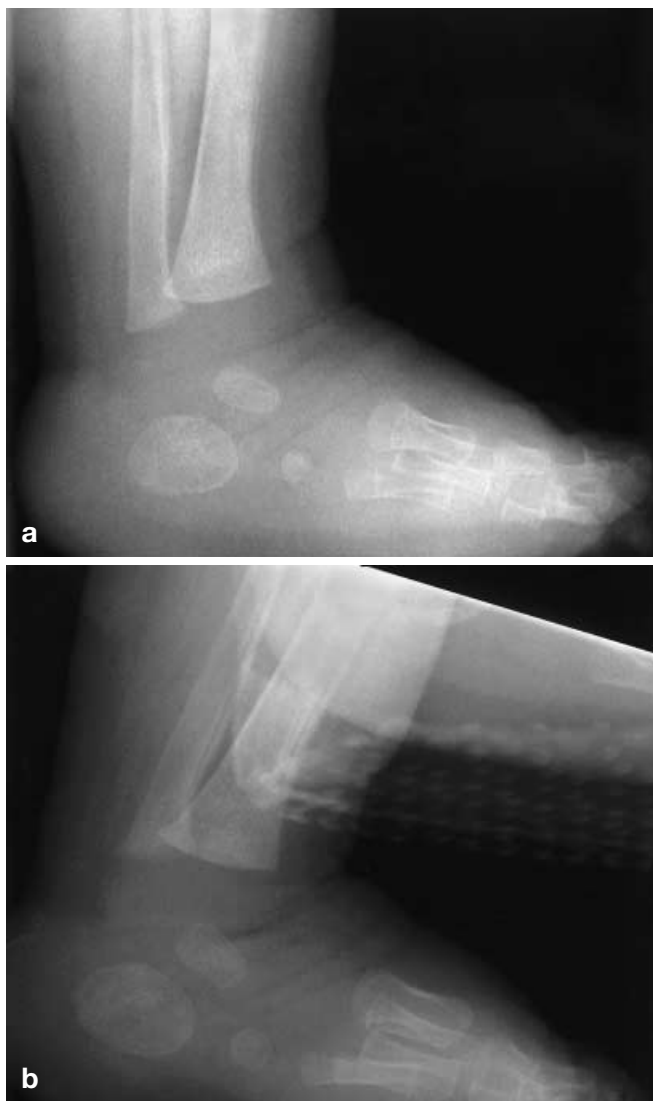


Fig. 6 Case 6. Lateral radiograph (a) of left foot at 1.5-months of age showing minor periosteal reaction and linear sclerosis within distal tibial metaphysis. Follow-up lateral X-ray (b) 1 month later with added periosteal healing bone at tibia and fibula and resolving sclerosis

region. One of the three (case 6) demonstrated an area of sclerosis at the tibial metaphysis (Fig. 6), as did two infants with more marked metaphyseal deformity (Figs. 2, 5). All of our patients healed completely without sequelae and most went on to posteromedial release for repair of clubfoot deformity.

Discussion

The classic metaphyseal lesion (CML) is considered highly specific for abuse, and the distal tibia is recog-

nized as a high risk site, as are the knee and shoulder. The fracture involves the primary spongiosa of the metaphysis, which may be more vulnerable because of rapid growth [1, 2]. It is not surprising that three of the eight infants had an underlying neuromuscular abnormality (two with spina bifida and one arthrogryposis), as lack of normal muscle function probably results in a greater vulnerability to the fragile chondroosseous junction during the orthopedic maneuvers necessary with serial casting [5–7]. Radiographically, a step-off or discrete fracture can be identified between the subperiosteal bone collar and metaphyseal cortex. The preservation of the thicker collar of bone at the periphery of the fracture explains the classic “bucket handle” or “corner” appearance of the metaphyseal fracture [2] (Figs. 2–5). Histologically, there is cartilaginous hypertrophy at the fracture site with an increasing zone of radiolucency (Fig. 5). Both the acute and healing CML are similar in appearance radiographically [9]. Sclerosis and subperiosteal new bone are other indicators of healing, previously described in the CML occurring at the distal tibia [10]. The injury may be accompanied by subperiosteal hemorrhage because of avulsion of the periosteum manifest by subperiosteal new bone formation usually adjacent to the metaphyseal injury [11]. Whereas symmetric diaphyseal periosteal reaction is a common finding in infants between 1 and 6 months of age and has been referred to as physiologic new bone, the pattern and thickness (> 2 mm) aid in distinguishing post-traumatic periosteal reaction from physiologic new bone formation [11, 12].

While the CML is often thought of as pathognomonic for child abuse, it is important to realize that a differential diagnosis exists. Rarely, the metaphyseal lesion can be secondary to a true accidental injury or birth trauma [11]. Skeletal dysplasia and metabolic abnormalities may at times mimic the CML, but are usually distinguishable on the basis of clinical, laboratory, and radiographic findings. There are several normal metaphyseal variants that need to be recognized, including step-offs, beaks, proximal tibial cortical irregularity and spurs, all of which occur at the knee, but have not been described at the distal tibia and fibula [13].

Rib fractures are the most common site of injury in the abused infant. The presence of unexplained rib fractures has been shown to have a significant correlation with abuse [11, 14]. Case 1 was abused, as evidenced by the 24 rib fractures; however, the symmetric fractures at the distal tibiae and fibulae were likely the result of serial casting. The only prior reference to fracture as a complication of treatment of clubfoot appears in the orthopedic literature in 1972 [8]. In this article Weseley quotes R.A. Dunham: “in the infant, hard tissues (bone and cartilage) should be regarded as soft, and soft tissues, (tendon and ligament) as hard.” Weseley

describes surgical and nonsurgical complications observed in more than 300 congenital clubfeet but provides no illustrations of the injuries. Included in the nonsurgical complications attributed to forced eversion and dorsiflexion are: (1) posteromedial tibiofibular bowing, (2) distal tibial and fibular compression fractures (4 cases), (3) distal tibial metaphyseal spur, (4) torus of fractures of distal tibial metaphysis, and (5) fracture of distal fibula. All fractures healed without residual deformity.

While the CML remains highly specific for abuse, in the setting of serial casting for treatment of equinovarus deformity, metaphyseal injury, Salter Harris physal fracture, and even a classic CML radiographic appearance may be noted. Since inflicted injuries are rarely witnessed and explanations as to how the injuries occurred are only occasionally offered by the perpetrator, the fact that the CML occurs as a result of orthopedic manipulation may offer some further insight into the pathogenesis of this well-described abuse injury.

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