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CASE REPORT

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Concomitant multiple closed contiguous physeal injuries in a limb with an undescribed 'distractional-separation' type with vascular compromise: a report of two cases

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Abstract *Introduction*: Though physeal injuries are common in children, concomitant multiple closed contiguous physeal injuries in a limb along with vascular compromise are rare. An associated distractional-separation type of physeal injury is being documented for the first time. We present here two such cases. *Materials and methods*: Two children, aged 6 months and 3 years, respectively, suffered a roadside high velocity trauma and thus form the part of this case report. *Results*: Because of the delay in seeking treatment and, or, the nature of injuries, it was associated with a tragic complication—an amputation in both cases. *Conclusion*: Although, the limb in our cases could not be salvaged, these reports describe these unusual injury patterns for the first time and re-emphasize the awareness of urgent recognition of the associated vascular insult.

Keywords Physeal injury · Distractional-separation · Contiguous · Knee injury · Vascular injury

Introduction

Though physeal injuries are common in children, a combination of multiple closed contiguous physeal injury in a limb is rather unusual. Associated vascular injury makes it rarer. We report here two such cases. These also consisted of a longitudinal 'distractional-separation' type of physeal injury, which has never been reported before. The probable mechanism of injury, the associated complications and the course of events are discussed here. These case reports emphasize the importance of recognition of these injuries and the associated vascular compromise.

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Case report

Case one

A 6-month-old female was involved in a high velocity roadside accident. She was sitting on the lap of her pillion-riding mother, when their two-wheeler hit a pole and the child was thrown out. She reported to our tertiary level care center about 15 h later. On examination, the right leg looked cyanosed, swollen and appeared lengthened (Fig. 1). It was also cold, pulseless, anesthetized and paralyzed. The knee was subluxatable. There were associated perineal and gluteal lacerated wounds (Fig. 1). After primary trauma assessment, secondary survey and X-rays showed a distractional injury to both the upper fibular physis and to the lower tibial physis, with gaps between the epiphysis and the metaphysis in both regions (Fig. 2). A concomitant Salter–Harris type 1 injury to the lower end of femur was also noticed later, which was reducible but unstable (giving the impression of subluxatable knee). A color doppler revealed normal flow in the popliteal artery with poor flow distally in the ankle and foot. During exploration, almost 17 h after the injury, the stretched periosteal sleeve was intact at the lower tibial epiphyseal separation with a palpable gap between the epiphysis and the metaphysis (Fig. 3). The ankle mortice was maintained. However, the fibular periosteal sleeve was ruptured and whole of the fibular metaphysis and diaphysis was practically bare and free beneath the skin with minimal tissue coverage (Fig. 4). All the

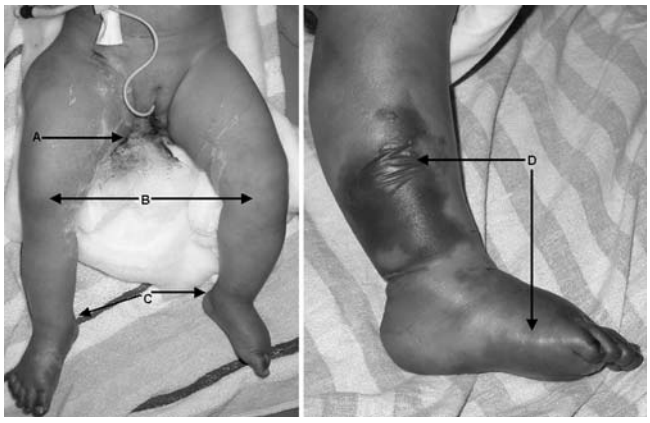

Fig. 1 Clinical photographs showing the perineal and gluteal wounds *A*, and acute limb lengthening on right side (compare the knee *B* and the ankle levels *C*). The ischaemic changes are evident *D*

compartments of the leg were necrosed with shredded neurovascular bundle. A below knee guillotine amputation was done at the demarcation site, which was secondarily closed. Closed reduction of the lower end of femur was done along with percutaneous crossed K-wires fixation. Debridements of the perineal and gluteal wounds were done along with a diversion colostomy. These wounds healed eventually after split thickness skin grafting.

Case two

A tractor hit a 3-year-old-pedestrian female. She was presented in a state of shock to our tertiary level care

Fig. 2 X-ray AP and lateral views showing the distractional injuries to the upper fibular physis *C* and the lower tibial physis *D* along with a Salter–Harris type 1 injury to the lower end of femur *A*. The proximal tibio-fibular *B* and the ankle *E* joints are maintained. The left normal side is for comparison

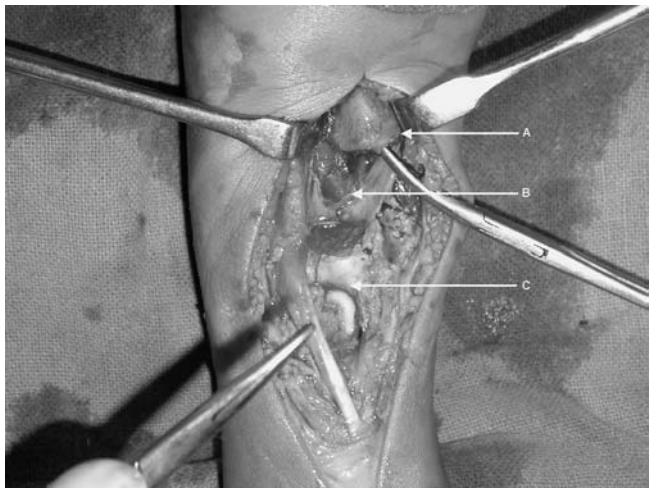

Fig. 3 Clinical peroperative photograph showing the separated lower tibial metaphysis *A* and the empty but intact periosteum (*B*, which has been incised now) with visible gap between the tibial metaphysis and the epiphysis, the latter begin part of intact ankle mortice *C*

center about 10 h later. She had been attended primarily by an osteopath. The left leg looked cyanosed, swollen and appeared lengthened. It was cold, tense, pulseless, anesthetized and paralyzed below the knee with a few superficial abrasions. After primary trauma assessment, secondary survey and X-rays showed a Salter–Harris type 2 separations of the proximal tibial physis. There was an associated longitudinal 'distractional-separation' of the ipsilateral distal tibial and proximal fibular physis with a gap of about 3 cms between their metaphysis and epiphysis. The ipsilateral distal femoral physis also suffered a Salter–Harris type 1 injury (Figs. 5, 6). A color doppler revealed a block in the popliteal artery prior to its division with no distal flow.

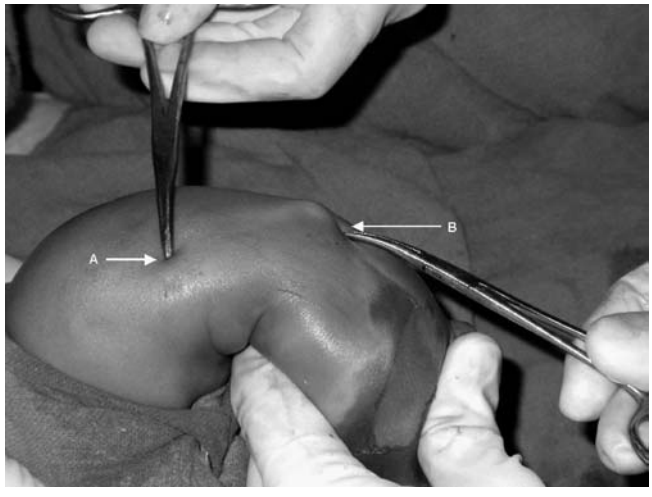

Fig. 4 Clinical photograph showing the free mobile distracted fibular metaphyseal and diaphyseal fragment *B*. Note the increased distance from the knee joint *A*

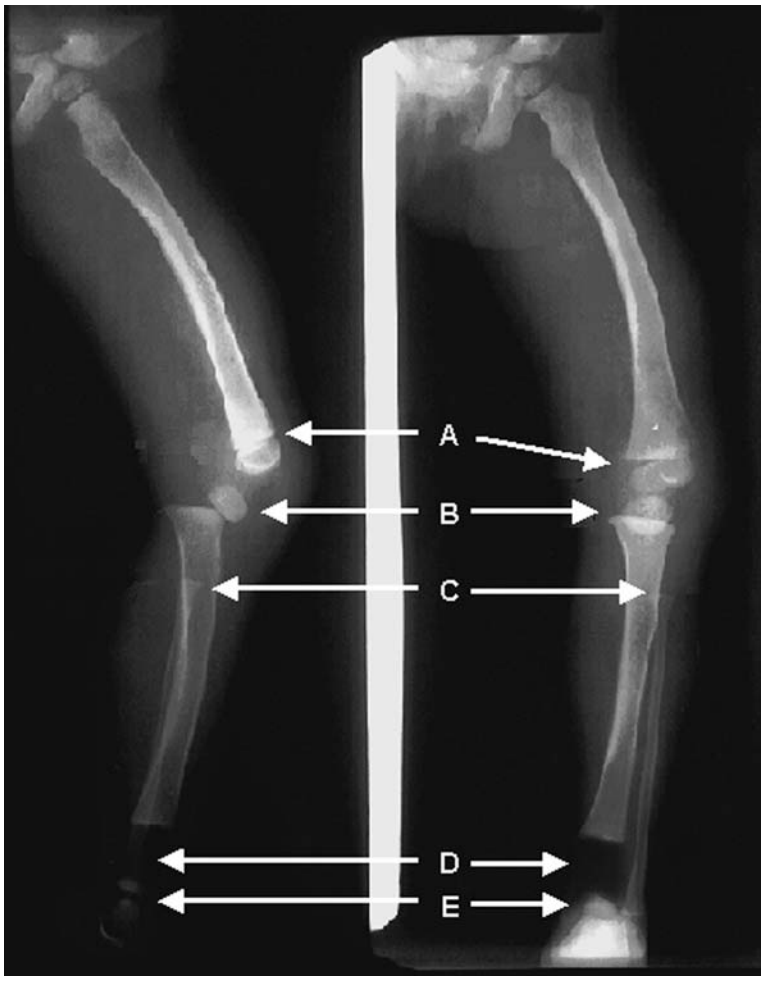

Fig. 5 X-ray AP and lateral views: *A* Salter–Harris type 1 injury to lower femoral physis, *B* Salter–Harris type 2 injury to upper tibial physis with rupture of popliteal vessels, *C* distractional-separation type of injury to upper fibular physis (the proximal tibio-fibular joint is intact), *D* distractional-separation type of injury to lower tibial physis, (note the gap between the lower tibial epiphysis and the metaphysis), and *E* the distal tibial and fibular epiphysis maintaining the normal ankle mortice

After initial resuscitation, the patient was taken for an urgent open reduction of the fractures and exploration of the neurovascular bundle after approximately 13 h after the injury. The popliteal fossa was explored through a posterior incision. Large quantity of blood clot was evacuated. The separated tibial metaphyseal fragment had indented the neurovascular structures. The posterior tibial and common peroneal nerves were in continuity, though stretched and contused. The popliteal artery was shredded proximal to its bifurcation. Both the ends were ragged and thrombosed, lying with a gap of around 5–6 cm between them. On further exploration by a separate anterior incision, the stretched periosteal sleeve was intact at the lower tibial epiphyseal separation with a palpable gap between the epiphysis and the metaphysis. Similarly, there was a distractional injury at the upper fibular physis. The epiphysis was attached to the tibia, whereas the metaphysis had been pulled down along with the distal tibio-fibular syndesmosis. All the compartments of the leg were found to be grossly necrosed. In view of the unsalvageable vascular reconstruction, a consensual decision of a primary amputation was taken considering the general and

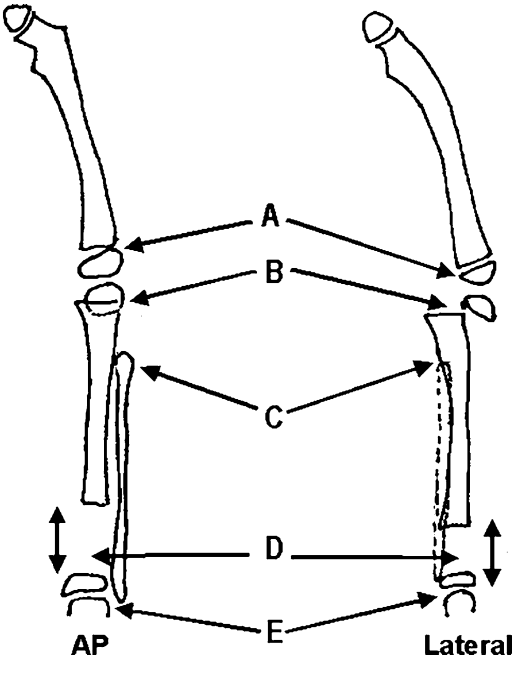

Fig. 6 Pictoral representation of the Fig. 5

local condition of the child. This had to be later converted to a disarticulation at knee after 2 days.

Discussion

Physeal injuries account for 15–30% of all the injuries in children [1]. Injuries to proximal tibial epiphysis are rare, constituting only 0.6–2% of all the physeal injuries [1, 2, 7, 11]. This immunity is due to its paucity of ligamentous attachments and because of the associated supporting structures [1, 2, 7, 11]. Thus the various stresses to the knee are transmitted to the metaphyseal region of the tibia, instead to the epiphysis. The incidence of injury to distal tibial physis varies from 11 to 18%, whereas, in the distal femur it varies from 1 to 6% [7, 11]. However, simultaneous injury to both the proximal and distal tibial physis (bifocal physeal injury as in case 2) is extremely rare and has been reported only twice before [2, 4]. Concomitant closed injuries to multiple adjoining physis are even rarer (distal femur, proximal tibia and fibula, and distal tibia in case 2; and distal femur, proximal fibula and distal tibia in case 1)! Moreover, this longitudinal 'distractional-separation' type of physeal injury (distal tibia and proximal fibula in both the cases) has never been reported before in the English literature.

Foucher evolved the first apparent classification scheme for physeal injuries in 1863 [11]. Since then a number of classifications have been proposed by various authors [1, 11, 12]. While the classification scheme given by Salter and Harris has proved to be of clinical significance, certain patterns of injuries do not fit in any of the described groups and more inclusive schemes have been developed by many authors [11]. Our case of longitudinal 'distractional-separation' type of physeal injury with acute limb lengthening causing vascular compromise, thus, also could not fit into any of the classifications or descriptions proposed so far. Though in any epiphyseal injury, no rule always applies to the severity of the injury to the growth plate increases with the grades in all the classification. All of them rest chiefly on the risk of shortening or deformity due to retardation of growth. None of them recognizes the potential complication of a vascular injury, which can be limb or even life threatening.

Though this combination pattern of injury has never been described before, the closest analogy may be assumed from the acute dislocations of the knee. Pure acute dislocations of the knee are extremely rare in children because the forces required to produce dislocations are more likely to fracture the distal femoral or proximal tibial epiphysis. Thus, most information has been obtained from the reports of knee dislocation in adults [14]. The most dreaded complication of these injuries is a vascular compromise. These vessels may easily be lacerated directly by the displaced or distracted fragment, or occluded by internal swelling, or even by external immobilization [4, 10]. Stress roentgenograms and ultrasound have been suggested to diagnose the dislocation and displacement in cases where there is a suspicion of such epiphyseal injury, because a complete or partial reduction may occur before initial examination (the distal femoral physis in case 1) and vascular injury may be missed [2]. The politeal artery is fixed to the femur at the adductor hiatus and near its bifurcation to the proximal tibia by the fibrous arch of soleus. Also the portion between the middle and lateral inferior genicular branches is relatively immobile. Just after its division, the anterior tibial artery penetrates the interosseous membrane and add further fixity. The popliteal vessels are often at risk due to their above anatomy and have been associated with a variable prognosis despite the improving techniques of arterial repair [3, 14]. The collateral circulation about the knee, unlike that of elbow, is relatively poor. The collateral geniculate branches are not well protected by soft tissues and are frequently injured or unable to compensate for sudden interruption of flow through the main channel. Thus, the collaterals are usually insufficient to maintain viability of the extremity distal to the knee [9, 14].

The incidence of vascular injury with knee dislocation has been estimated to be 10% in children and 32% (range 7–80%) in adults [5, 6, 10, 13–15]. Regardless of the exact percentage, the risk of arterial damage is high and should always be considered, even in low velocity trauma. The mechanism of arterial damage varies with the type of dislocation. When anterior dislocation injures the artery, it is usually by traction, resulting in an intimal tear. On the other hand, vascular injuries associated with posterior dislocations are frequently complete arterial tears [4, 13]. Posterior capsule rupture has been shown to occur at 30° of hyperextension with significant damage to the popliteal vessels at 50° of hyperextension [5, 8]. The most appropriate course with patients who present with these findings is meticulous and frequent clinical examinations and immediate diagnostic intervention. Misdiagnosis of the vascular status leads to delay in the arterial repair and subsequent complications. It is unacceptable to suggest spasm as a cause of ischaemic signs in an attempt to justify observation. If arterial insufficiency is present, there is a vascular injury. However, as pulse deficit is seen in upto 84%, whereas indications of ischaemia are in upto 60% of the cases, normal distal physical examination do not completely rule out the possibility of an impending vascular compromise [6]. Thus vigilant observation upto 48–72 h should be done [6, 13]. Though arteriography, with its limitations, remains the gold standard of evaluation, noninvasive studies like doppler ultrasonography are frequently being used with an accuracy of 96–100% [6, 13]. This may further be augmented with a sphygmomanometer cuff to observe the pressure changes in comparison to the uninjured limb [6]. Nevertheless, no diagnostic modality should delay the treatment if there is an obvious vascular injury, where an intraoperative arteriogram is preferable. Among the nerves, the peroneal nerve is at the greatest risk for injury in a

knee dislocation (14–35%). It is usually a traction injury and when disruption occurs, repair is usually precluded. Stocking type of paresthesia should raise the suspicion of a compartment syndrome, rather than just a simple neuropraxia [13].

Reports have shown that there is a maximum permissible delay between injury and repair; beyond which this irreversible tissue loss is to be expected, despite successful reestablishment of the blood flow. Though corrective measures should not be delayed beyond 6–8 h, possibly no more than 12 h following injury, successful repairs with variable tissue salvage have been carried out after longer intervals for proximal lesions [3, 8, 10]. If blood supply is not restored within this period, the nerves are the first to die, followed by muscles, skin and then bone. If, however, there is a delay then nerves and muscles will die leaving a limb with only skin and bone. At the best, muscles will undergo fibrosis and at the worst, they die. With further damage, the skin dies and gangrene follows, when amputation becomes inevitable [8]. Upto 90% of these cases land up in amputation and upto two-third of the remaining develop variable ischaemic changes, if the blood supply is not restored within 6–8 h [5, 15]. This time interval is a relative factor, being dependent upon the degree of arterial occlusion, the age of the patient, the extent of collateralization, the premorbid limb condition, the amount of local tissue loss, the level of lesion and the therapeutic priorities of any concomitant injuries [8]. Similarly penetrating injuries have shown to have a better limb salvage prognosis (85%) than to blunt trauma (29%) [8]. Inadequate wound coverage due to the radical debridement or inadequate debridement leading to infection always remain a dilemma and are thus the important reasons for failure of primary repair.

A continuous tractional force in a hyperextended knee led to injuries to these adjoining epiphysis in these limbs. In children as ligaments are stronger, physeal separation occurred in the distractional mode inside the intact periosteal sleeve, rather than a dislocation. This explains the maintained proximal and distal tibio-fibular syndesmosis, inspite of the physeal separation, the latter the weaker links. In both our cases, no vascular repair was attempted because of the already set irreversible gangrenous changes. This could be due to the delay in seeking treatment, and, or the very nature and severity of injury where acute limb lengthening causes shredding of all the soft tissues (including the vascular tissues) leading to an early unsalvageable damage.

Conclusion

Although, the limb in our cases could not be salvaged, these reports describe these unusual injury patterns for the first time. Neither closed involvement of three contiguous physis nor the closed 'distractional-separation' type of physeal injury has been described before. These reports also re-emphasize the awareness of an urgent recognition of the commonly associated vascular insult.

References

1. Aitken AP, Ingersoll RE (1936) Fractures of the proximal tibial epiphyseal cartilage. J Bone Joint Surg Am 18(4):787–796
2. Burkhart SS, Peterson HA (1979) Fractures of the proximal tibial epiphysis. J Bone Joint Surg Am 61:996–1002
3. Conkle DM, Richie RE, Sawyer JL, Scott W Jr (1975) Surgical treatment of popliteal artery injuries. Arch Surg 110:1351–1354
4. Green NE, Allen BL (1977) Vascular injury associated with dislocation of knee. J Bone Joint Surg Am 59(2):236–239
5. Gupta SP, Agarwal A (2004) Concomitant double physeal injuries of the tibia with vascular comprise: a case report. J Orthop Sci 9:526–528
6. Heppenstall RB, McCombs PR, DeLaurentis DA (2001) Vascular injuries. In: Bucholz RW, Heckman JD (eds) Rockwood and Greens' fractures in adults. 5th edn. Lippincott Williams & Wilkins, Philadelphia, pp 319–331
7. Herring JA (2002) Lower extremity fractures. In: Tachdjian's pediatrics orthopaedics, vol 3, 3rd edn. WB Saunders, Philadelphia, pp 2344–2399
8. MacGowan W (1968) Acute ischaemia complicating limb trauma. J Bone Joint Surg Br 50(3):472–481
9. McCoy GF, Hannon DG, Barr RJ, Templeton J (1987) Vascular injury associated with low velocity dislocations of the knee. J Bone Joint Surg Br 69(2):285–287
10. McGuigan JA, O'Reilly MJG, Nixon JR (1984) Popliteal arterial thrombosis resulting from disruption of the upper tibial epiphysis. Injury 16:49–50
11. Peterson HA (2001) Physeal injuries and growth arrest. In: Beaty JH, Kasser JR (eds) Rockwood & Wilkins' fractures in children. 5th edn. Lippincott Williams & Wilkins, Philadelphia, pp 91–138
12. Salter RB, Harris WR (1963) Injuries involving the epiphyseal plate. J Bone Joint Surg Am 45(3):587–622
13. Schenck RC Jr (2001) Traumatic dislocations of the knee. In: Bucholz RW, Heckman JD (eds) Rockwood and Greens' fractures in adults. 5th edn. Lippincott Williams & Wilkins, Philadelphia, pp 1914–1928
14. Sponseller PD, Stanitski CL (2001) Knee dislocations. In: Beaty JH, Kasser JR (eds) Rockwood & Wilkins' fractures in children. 5th edn. Lippincott Williams & Wilkins, Philadelphia , pp 1057–1059
15. Stannard JP, Sheils TM, Lopez-Ben RR, McGwin G, Robinson JT, Volgas DA (2004) Vascular injuries in knee dislocations: the role of physical examination in determining the need for arteriography. J Bone Joint Surg Am 86(5):910–915