Management of traumatic physeal growth arrest

Benjamin G Escott

Simon P Kelley

Abstract

Physeal fractures account for approximately one third of all childhood fractures. Growth arrest is a serious complication of these injuries which, if not managed correctly, can lead to angular deformity, limb length discrepancy, or both. This in turn may cause pain, loss of function and disability. The article reviews the evaluation of a child with suspected traumatic physeal growth arrest including patient history, physical examination and imaging strategies for the early detection of physeal growth arrest and measurement of limb length discrepancy. Various anatomical classifications of physeal growth arrest are also presented. Finally, we discuss an approach to the management of a child with confirmed traumatic physeal growth arrest depending on the nature of the arrest and limb deformity.

Keywords fractures, bone; growth arrest; growth plate; paediatrics

Introduction

Childhood fracture is a common event with half of boys and one third of girls experiencing at least one fracture during childhood.[1,2] Fractures involving the physis accounts for between 18%[3] and 30%[4] of these injuries with an estimated incidence of 2.8 per 1000 person years.[5] Peak age for fracture of the growth plate is 11–12 years for girls and 13–14 years for boys, being rare in children under the age of 5 years. While physeal growth arrest is estimated to occur in only 5–10% of all physeal fractures, reported rates vary widely depending on the anatomical region and mechanism of injury. Fractures of the distal femur are most prone to physeal growth arrest with some estimates exceeding 50% of all distal femur physeal fractures.

Physeal growth arrest is a potentially serious complication after traumatic injury that can lead to limb length discrepancy, angular deformity, or both. This in turn may cause pain, loss of joint function and disability. Routine surveillance and early detection of physeal arrest provides the best opportunity to prevent these complications. In cases where significant deformity arises, numerous surgical options exist to help correct deformity and restore function. Regardless of the aetiology, the management principles remain the same. The basic science and acute management of physeal fractures has been the subject of previous review[6] so it will not be covered in depth in this article.

Physeal fracture classification

Many classification systems for physeal injuries have been proposed in recent decades but the most commonly used remains that of Salter and Harris[7] (Figure 1). Their classification is anatomical, easy to remember and provides some insight into the management and prognosis of these fractures. Type I fractures run transversely through the physis alone. Type II fracture run through the physis but exit through the metaphysis forming a triangular 'Thurston-Holland' metaphyseal fragment. Type III fractures extend partially through the physis but breach through the epiphysis to the articular surface. Type IV fractures cross all zones of the physis vertically with the fracture line passing through both the metaphysis and epiphysis. Finally, Type V

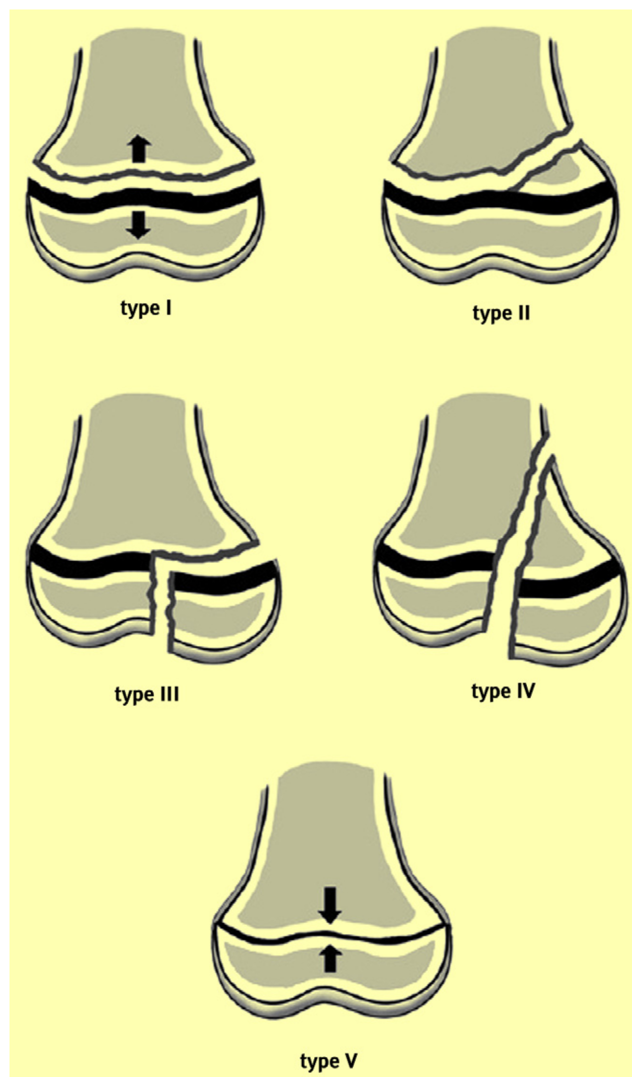

Figure 1 The Salter–Harris classification of growth plate fractures (Reprinted from Orthopaedics and Trauma, 24(1), Kelley S., The Response of Children to Trauma, pages 29–41, Copyright 2010, with permission from Elsevier).

Benjamin G Escott *MBBS Orthopaedic Resident, The Hospital for Sick Children, University of Toronto, Toronto, ON, Canada.*

Simon P Kelley *MBChB FRCS (Tr and Orth) Paediatric Orthopaedic Surgeon, Department of Orthopaedic Surgery, The Hospital for Sick Children, Assistant Professor, Department of Surgery, University of Toronto, Toronto, ON, Canada.*

fractures represent a crush injury of the physis which may appear radiographically similar to a Type I fracture but is distinguished by a history of a high-energy mechanism, typically an axial load.

Fracture types I through IV of the Salter—Harris classification have traditionally been associated with an increasing risk of physeal growth disturbance, though not in a strictly linear fashion. Type I Salter—Harris fractures occur most commonly in younger children and usually carry a favourable prognosis, except fractures of the proximal or distal femur or high-energy injuries. Type II fractures are the most common physeal fracture accounting for more than half of all physeal fractures[5] and also carry a favourable prognosis except for certain locations including fractures of the distal femur which carry a 50% risk of physeal growth disturbance.[8] Type III fractures are more common in older children and carry a less favourable prognosis depending on the vascularity of the physis and injury to the germinal layer. Anatomical reduction of the articular surface is of critical importance after Type III fractures. Type IV fractures also carry a less favourable prognosis despite a relatively smaller cross-section of physeal involvement due to the inevitable damage to the germinal layer. Fixation of these fractures must include not only anatomical reduction of the articular surface but also reduction of the physis to reduce the risk of physeal growth disturbance. Finally, growth arrest is common after Type V fractures due to a crushing injury of the germinal physeal layer. Crush injury of part of the physis may also be present in combination with the other Salter—Harris fracture types. Broadly speaking, the higher Salter—Harris fracture types (III—V) are associated with a greater risk of physeal growth disturbance compared to the lower types (I and II).

Evaluation

History

Clinical evaluation for post-traumatic physeal arrest is not complete without a detailed history, physical examination and relevant imaging. A thorough history including birth history, family history of musculoskeletal disorders, history of trauma and onset of deformity should be sought. Any functional disability from limb deformity or limb length discrepancy should be recorded, along with descriptions of pain or instability. Numerous factors have been found to be associated with physeal growth arrest after fracture and should specifically be sought during history-taking. Clinical factors associated with a higher risk of physeal growth arrest include a high-energy mechanism of injury, certain Salter—Harris fracture types (e.g. Type III or IV), fractures of the distal femur and distal tibia, greater initial displacement, higher number of reduction attempts, operative intervention and poor-quality final reduction.[9] Many of these factors — initial displacement, number of reduction attempts and necessity for operative intervention — represent the consequences of a high-energy mechanism resulting in more significant bone and soft-tissue disruption. Patient factors such as younger age at the time of injury, while associated with an increased risk of physeal growth arrest, are likely to have less to do with the incidence of physeal arrest and more to do with the risk of developing a clinically significant growth arrest due to greater growth remaining. The referring physician may be a useful reference for clinical factors such as the number of reduction attempts, something that the patient or family may not be able to provide.

Physical examination

Physical examination of the limb after post-traumatic physeal growth arrest should include a comprehensive assessment of the appearance and function of the limb including limb alignment and limb length, range of motion, neurological examination, vascular examination and gait.

Physical examination should begin with both the child's affected and unaffected limbs adequately exposed for comparison with the child standing. This allows observation and quantification of coronal (varus or valgus) malalignment, sagittal malalignment (procurvatum, recurvatum or fixed flexion contractures), limb length inequality and rotational malalignment. It is often helpful to ask the child to walk at this stage so that one can assess the impact of the deformity on gait. Observation of the child walking quickly or running may accentuate mild gait asymmetries. Numerous strategies are used by children to maintain a grossly symmetrical gait when a limb length discrepancy exists and should be sought in the clinic setting during gait observation. These include, toe-walking on the shorter limb to reduce trunk sway, and vaulting, circumduction or persistent flexion to improve clearance of the longer limb. Young children are especially able to mask a limb length discrepancy when they are small and nimble but may lose their ability to compensate as they age due to increased height and weight.

The child should next be assessed supine on the examination table. Here one can assess joint range of motion, both active and passive, and identify the presence of any fixed joint contractures. Rotational malalignment can also be further assessed in both the supine and prone positions according to any standard orthopaedic text. Joint stability should also be assessed. Ligamentous instability can arise as a direct result of the initial traumatic event or secondary to mechanical imbalance due to malunion or growth disturbance. Broadly speaking, joint instability should be addressed at the time of initial surgical intervention as a stable joint is essential for early range of motion and rehabilitation of the affected limb. On the examination table one can also look more closely at other features of the injured limb such as the integrity of the soft-tissue envelope. Before performing any bone or joint reconstruction, one must be sure that the overlying soft tissues will allow the desired correction and satisfactory healing. In more severe injuries the opinion of a plastic surgeon may be very useful to assist with incision planning and potential soft-tissue reconstruction techniques. Vascular examination of the distal pulses is essential as injury to one or more vessel supplying the affected limb may complicate future surgical intervention, and should be clearly documented to both anticipate and reduce the risk of ischaemic complications. Vascular studies should be ordered as required when a distal perfusion deficit is suspected. Peripheral neurological examination is performed to assess and document the sensory and motor function of the affected limb. Neurological deficits may complicate the functional rehabilitation after surgical correction. Furthermore, a neurological deficit detected postoperatively can then be classified as pre-existing or iatrogenic and managed accordingly.

