Epiphyseal growth plate fractures pdf

Growth plate (physeal) fractures are usually believed to occur by the zone of preliminary calcification, but can traverse different zones depending on the type of external load application. For example, applying compression-type loads, the histological zone of failure is usually the preliminary calcification portion of the hypertrophic zone. Shear forces can also cause failure in the hypertrophic zone. Tension forces lead to failure of the proliferative zone. Growth plate injury can also be iatrogenic. A common concern is repair of the anterior cruciate ligament (ACL) in the skeletal cord. Wall et al. reported an all-epiphyseal anterior cruciate ligament reconstruction to prevent transfixation or drilling over active open growth plates. [5] Although there were no growth arrests, three patients had knee overgrowth, with two requiring further surgery. The ACL reconstructions had excellent functional results despite high rates of complications (48%) and secondary procedures (37%). The incidence of graft failure was similar to that seen with other ACL techniques. Growth plate lesions were first classified by Poland in 1898; its four-part classification system progressed from a simple epifyseal separation to an epifyseal separation in which it is split in two. Many other classification systems followed, including a system proposed by Petersen in 1994. This system was built on the basis of a population-based epidemiological study and was suitable to progress the physios least involved in the injury that posed the greatest threat to the physio. Of the various classification systems used around the world, the Salter-Harris (SH) classification, initially proposed in 1963 by Robert Salter and W Robert Harris of Toronto, [6, 7] is generally preferred and is the accepted standard in North America to facilitate communication between healthcare professionals. [8, 9] The SH system categorized the different fracture patterns into five types (then expanded to six). Salter-Harris type I A SH I fracture usually traverses through the hypertrophic zone of cartilage-like physiosis, splitting and separating the epiphysis from the metaphyse. When these fractures are not placed, they may not be easily apparent on X-rays due to the lack of bony involvement. In many cases, only mild to moderate swelling of soft tissue is radioly noticed. Clinical findings can be more impressive than imaging (see the first image below); however, subsequent X-rays may show physeal widening or new bone growth along the physeal margins, indicating the presence of a healing fracture (see second image below). In general, the forecast for this type of Excellent. Usually only closed reduction is needed for displaced fractures; however, an open reduction and internal fixation (ORIF) may be necessary if a stable satisfactory reduction cannot be maintained. Growth plate (physeal) fractures. Clinical Clinical of the patient's knee with minimally displaced Salter-Harris I fracture of distal femur. Impressive swelling was noted next to the joint, but no evidence of intra-articular swelling was present. Patient was clearly tender to palpation about distal femoral physics. Growth plate (physeal) fractures. Anteroposterior radiographer of knee of patient in previous picture. Note subtle physeal widening, confirming the diagnosis of Salter-Harris I fracture of distal femur. Salter-Harris type II A SH II fracture partially splits through the physis and contains a variable-sized triangular bone fragment of metafyse (see image below). This fragment is often referred to as the fragment of Thurstan Holland in honour of the British radiologist Charles Thurstan Holland, who in 1929 drew attention to his existence. Growth plate (physeal) fractures. Anteroposterior single X-ray shows impressively displaced Salter-Harris II fracture of distal tibial epiphysis (along with comminuted fracture of distal fibulular diaphysis). Periosteum on the side of the thurstan Holland fragment often remains intact, facilitating reduction. This particular fracture pattern occurs in an estimated 75% of all physeal fractures, and it is the most common physical fracture. The image below illustrates a SH II fracture of the distal femur. Growth plate (physeal) fractures. Displaced Salter-Harris II fracture of distal femur. Large Thurstan Holland (metafyseal) fragment can serve as an important fixation point for steinmann pin or lag screw. Salter-Harris type III A SH III fracture pattern combines physeal injury with joint discontinuity. This fracture partially covers the physis and then extends through the epiphysis in the joint. It has the potential to disturb the joint surface. This injury is less common and often requires ORIF to ensure a good anatomical rearrangement of both the physiosis and the joint surface. . The image below shows a common SH III fracture of the distal tibia, a Tillaux fracture, on computed tomography (CT). Growth plate (physeal) fractures. Multiple data processed tomography (CT) scans show salter-harris III's displaced fracture of distal anterolateral tibial epifysis (i.e. Tillaux fracture). Salter-Harris type IV A SH IV fracture runs obliquely through the metaphysis, crosses the physiosis and epiphysis and enters the joint. The Thurstan Holland sign (i.e., a Thurstan Holland fragment) is also seen with this fracture pattern. The image below illustrates such a fracture of the proximal tibia. Growth plate (physeal) fractures. Displaced Salter-Harris IV fracture of proximal tibia. The side part of the epifyse (with fragment Thurstan Holland) and medial portion of the epifyse are independently shifted (i.e., each is free-floating fragment). type V A SH V lesion involves compression or crush injuries to the physio and is often impossible to definitively diagnose at the time of injury. Knowledge of the injury mechanism simply makes a lake or suspicious of this injury. There are no fault lines visible on the first X-rays, but they can be associated with diaphyseal or metafyseal fractures. (See the images below.) Growth plate (physeal) fractures. Salter-Harris V fracture pattern should be strongly suspected when mechanism of injury includes significant compressional forces. This is the first injury radiography of the child's ankle that was subjected to significant pressure and inversion forces. It shows minimally displaced fractures of tibia and fibula with apparent maintenance of distal tibial physeal architecture. Growth plate (physeal) fractures. Follow-up X-ray of single of child in previous image. This X-ray shows growth arrest secondary to Salter-Harris V nature of the damage. Note clearly asymmetric Park-Harris growth recovery line, indicating that lateral portion of the growth plate continues to function and medial portion does not. SH V fractures are generally very rare; However, family members should be warned of the potential disruption of growth and should be aware that if growth disruption occurs, treatment is still available (depending on the age of the child and the remaining growth potential). Salter-Harris type VI An additional classification of physeal fractures that was not included in the original SH classification, but has now been incorporated occasionally, is SH VI, which describes an injury to the peripheral part of the physics and can result in a peripheral angular bridge formation that can cause significant angular deformity by tethering the intact physies. [10] (See the images below.) Growth plate (physeal) fractures. Mortise X-ray showing somewhat subtle physeal injury to distal tibia. Salter-Harris VI pattern can be suspected based on history and physical examination. In this case, the X-ray indicates that it is highly likely that a small part of the peripheral medial physiosis (as well as a small amount of adjacent epiphyseal and metafyseal bone) is avulsed. Growth plate (physeal) fractures. Clinical photo of patient above with displaced Salter-Harris II fracture of distal femur. Mechanism of injury and physical examination findings correspond to Salter-Harris VI physeal injury pattern. Some may also refer to this injury type as Kessel's fracture. This injury was presented by Lipmann Kessel, who described it as follows: A rare growth plate injury results from damage to the periosteum or perichondral ring ... after burns or a blow to the surface of the limb, for example a run over injury. [11] FREDERIC SHAPIRO, in Pediatric Orthopedic Malformations, 2001 Episeal growth plate fracture separations account for about 15-20% of large long bone fractures in children. They are about twice as common in men as in women and three times as often in the upper extremity as in the lower extremity. In those studies that accurately document all physeal fractures, it is those of the hand and in particular phapm ducts of the fingers that are the most common. In the main long bones, the fracture of the distal radial epifysis is most common in all series, with injuries of the distal tibia epifyse and desal humeral epifyse following in frequency. The age in preventing records peaked incidences of female fractures about 1.5 years earlier than those in men. The vast majority of epifyseal growth plate fractures occur between 10 and 15 years old, although fracture patterns in specific epiphyses tend to have characteristic age ranges. Joel Clingenpeel MD, MPH, MS. MEdL, ... Bryan Greenfield MD, in Urgent Care Medicine Secrets, 20181.The Salter-Harris classification describes growth plate fractures and has five levels (I-V) leading to acute management and general prognosis.2.Fractures related to NAT include femur and spiral extremity fractures in preamble children, multiple fractures in various stages of healing, fractures of the metaphyse and fractures in the bucket handle.3.Torus, greenstick and bow fractures are often collectively referred to as plastic fractures and are unique to children due to the pliability of the pediatric skelet.4.De fractures Toddler's subtle radiographic fractures and involve the distal third of the tibia in ambulatory kleuterkinderen.5.De Ottawa ankle rules recommend ankle resographers if there is bony pain at the medial or sideways malleolus along with an inability to carry weight after an ankle injury. Alvin H. Crawford, ... Shital N. Parikh, in Green's Skeletal Trauma in Children (Fifth Edition), 2015This is the only mechanism considered to result in a displaced growth plate fracture of the distal tibia without any associated fibulular fracture. The tibial Thurston-Holland fragment is variable in size, but is mainly rear in location. It is clear from several published series that this plantar inflection injury is the least common of pediatric ankle injury patterns.3,15,135 Displacement is also typically subtle, and the lateral X-ray is the most likely widening of the tibia physe (Fig. 17-14). No special studies are required for this damage because diagnosis is quite simple. At least three cases of rotational displacement of the lower tibia epifyse secondary to trauma have been reported. The injury is of the supination-plantar flexion variety with a Salter-Harris type I distal tibial fracture and an intact fibula. In this rare injury to the distal shin growth plate, the distal tibial epifyse undergoes real rotational displacement with posterior displacement of the fibula but without fracture of the fibula.8,87,108 The fibula in these cases seems to be plastic enough to rotate without breaking. Reduction is achieved with an audible click, probably caused by the fibula back in the metaphysical portion of the incisura calfbularis and have retained its normal relationship and annexes to the displaced persons epifyse. No permanent damage to the growth plate was noted with these injuries. Despite displacement that usually ranges from subtle to meeting virtually all orthopedic definition of uninplaced, growth arrest after the supination-plantar flexion mechanism is not rare. Unlike the other ankle fracture mechanisms already discussed, contemporary literature does not offer a specific estimate of the rate of this growth disorder. Therefore, the decision-making of the treating orthopaedic surgeon should be guided by an assessment of the amount of physical displacement and estimation of the amount of growth remaining. It is clear that there is little need to reduce mild residual physical displacement aimed at reducing the likelihood of growth arrest in a patient with very little residual growth. If it is determined that significant growth persists and the surgeon opts for surgical treatment, it should be ensured that each interposed periosteum is extracted, as it is quite common in this injury pattern. After anatomical reduction, internal fixation can often be achieved with a single masonry screw and washing machine. Non-weight-bearing cast immobilization has been indicated for several weeks after surgery in order to provide pain relief and promote undisturbed fracture healing. James R. Kasser, Paul J. Moroz, in The Pediatric and Adolescent Knee, 2006The Salter-Harris-type classification of physeal fractures has been used for more than 40 years to describe children's long bone growth plate fractures, and despite other classification systems described,27–29, the Salter-Harris system is considered the standard in the literature.23 This classification system is based on the radiographic appearance of the fracture (Figure 19-3) and indicates the degree of involvement of the joint , the epiphysis, and the physio. The higher the classification, the greater the chance of joint incongruent or growth disruption. Its popularity as a pediatric fracture classification system lies in its simplicity and overall usefulness (i.e., its ability to reasonably predict forecast the physical damage). However, the knee area of the growing child may be the only exception to the remarkable prognostic ability of the Salter-Harris system. For example, even salter-Harris type II fractures of the distal femur can be seen in up to 40% of cases, with the rates usually seen for fractures of type III and IV.29 In most other lung-bone epiphyseal fractures seen elsewhere in the body, type II fractures do not have the same extent of growth problems as the knee area.30 .31Exermentably these restrictions, the Salter-Harris classification system is widely recognized and will be used in this chapter to describe individual fracture types. H. Kozin MD, in Fractures and Injuries of the Distal Radius and Carpus, 2009Growth plate closure occurs in 4% to 5% of all Salter-Harris distal radius fractures.20,21 Alle groeiplaatfracturen vereisen een röntgenfoto van 3 tot 6 maanden maanden healing to ensure further growth. Failure to recognize a growth plate arrest can quickly lead to deformity (Fig. 15-9 and 15-10). The deformity varies depending on the location and size of the physical rod. Peripheral rods lead to angular deformity when uneven growth occurs. Small central beams, on the other hand, cause tents of the joint surface and larger beams prevent longitudinal growth, resulting in shortening of the radius relative to the ulna. Advanced imaging studies can better delineate the size and location of the physical rod (fig. 15-11). Management depends on the location of the bar, the size of the bar, and the amount of growth remaining. Radioulnar discrepancy of less than 1 cm is well tolerated in long-term follow-up.21 Options include bar resection, formal epiphyphysiodes, corrective osteotomy, and osteogenesis distraction. In addition, the ulna can be tackled by epiphysiation and/or shortening (fig. 15-12). Malunion after distal radius fractures is common, but remodeling with growth results in gradual correction. Angulation will grow below 20 degrees in 2 years; greater angulation requires additional growth. If the patient is close to skeletal maturity, little remodeling can be expected. Corrective osteotomy with bone transplantation is indicated in patients with pain or limited movement. The goal is to restore alignment to relieve pain, improve movement, correct midcarpal instability or prevent degenerative arthritis.22 The operation should correct both sagittal and coronal alignment (fig. 15-13). A distal radius corrective osteotomy can be addressed from a dorsal or volar approach. Similar to adults, the volar approach and volar locking systems have gained popularity to avoid prominent hardware. Trans-FCR exposure is performed. The malunion site has been identified. The distal part of a fixed corner plate is contoured and applied in parallel to the physies and the joint surface (fig. 15-14). Mini-fluoroscopy is used to prevent the physio. The plate protrudes from the proximal radius, but acts as a guide for correction. The beam is cut parallel to the physe and articular surface at the level of malunion. The osteotomy is opened using a laminar spreader, and the plate is used as a guide for correction. The proximal plate is applied to the beam using a bone reduction clamp. Correction is assessed via mini-fluoroscopy, and adjustments accordingly. The plate is then firmly attached to the beam using bicortical schroeffixation (fig. 15-15). Cancellous bone transplantation is placed in the osteotomy site. The graft can be harvested from the ulna or iliac comb, depending on the size of the defect. I no bone transplant replacements because there is sufficient autologous bone available. X-rays are taken to verify correction of coronal and sagittal alignment (fig. 15-16). Intra-articular malunion may occur after a Salter-Harris III or IV fracture. Fortunately, this malunion is unusual because the treatment is very difficult. The surgeon the risk-benefit ratio between intra-articular osteotomy and malunion acceptance. An advanced imaging study, preferably a CT scan, can delineate the size of the incongruens and is essential in the decision-making process. A missed Galeazzi fracture dislocation is a formidable problem. The ulna is subluxated and forearm rotation is limited. Treatment depends on the time of the injury and the status of the DRUJ. Early recognition can be treated with corrective osteotomy of the radius and reduction of the DRUJ. Subsequent recognition requires assessment of the articular surfaces of the distal ulna and sigmoid notch. Articular degeneration is a contraindication for reduction. In these cases, a salvage procedure, such as a Darrach or Sauvé-Kapandji, is required (fig. 15-17). Fortunately, this injury occurs in children who are close to skeletal maturity, and progressive ulnar-negative variance is not a concern, as ulnar-negative variance up to 1 cm is usually asymptomatic.21 However, in the young child, the length of the ulna should be addressed by distraction sorose. Persistent pain after distal radius fracture may be related to an associated chondrale injury, triangular fibrock (TFC) tear, or scapholunate ligament injury. These injuries are rare in children. Most TFC and scapholunate ligament tears are partial and can be treated by arthroscopic inspection and débridement. Arthroscopic treatment can lead to long-term improvement.23,24 In the case of peripheral TFC cracks, open or arthroscopic repair is warranted.24Volar fixation with plate and screws can result in prominent hardware along the dorsum of the distal forearm and wrist area. The child presents himself with extensor tenosynovitis of the irritated tendons. This finding is a warning of future problems, including tendon rupture. Treatment requires plate and screw removal, which can be difficult with titanium implants. Another option is dorsal exposure and burring the prominent screw head (s). Scott H. Kozin MD, in Principles and Practice of Wrist Surgery, 2010Growth plate closure occurs in approximately 4% to 5% of all Salter-Harris distal radius fractures.21.22 Therefore, all growth plate fractures mandate a follow-up x-ray 3 to 6 months after healing to ensure further growth. Failure to recognize a growth plate arrest can quickly lead to deformity (Fig. 66-18 and 66-19). The resulting deformity varies depending on the location and size of the physical rod. Peripheral rods lead to angular deformity secondary to uneven growth of the physio. Small central beams, on the other hand, cause tents of the joint surface and larger beams prevent longitudinal growth, resulting in the shortening of the radius relative to the ulna. Advanced can better delineate the size and location of the physical rod (fig. 66-20A and B). The management must be individualized and depends on the location of the bar, the size of the bar and the amount of growth remaining. Options are resection resection the bar with fat interposition, formal epiphyphysiodes to prevent persistent angular deformity, corrective osteotomy and extension or shortening of the radius or ulna. Extension can be achieved by bone transplantation or derivation osteogenesis. In addition, a long ulna can be tackled by epiphysiation and/or shortening (fig. 66-21A and B). Wan-Ju Li, ... Rocky S. Tuan, in Principles of Reerative Medicine, 2008A wide range of patients with significant bone abnormalities who need amputation in the past now benefit from various orthopedic strategies. Congenital abnormalities of bone, growth plate fractures and defects, fractures resulting in malunion or non-union, the genetic disorder osteogenesis imperfecta (brittle bone disease), and bone loss from tumor resection (primary bone tumors or tumors spread to bone) are only a handful of movement problems that can be addressed by regenerative medicine. Currently, the use of orthopaedic prosthetics is a serious but highly functional option. Distraction osteogenesis, a surgical procedure for bone reconstruction and extension, was developed in the 1950s by Ilizarov and is still used today. Bone autografting is a therapeutic option developed in the 19th century and considered the current gold standard, but has limitations, especially in the size of the defect to be grafted. Autografts contain the patient's own OB and osteocytes, but require a second surgical site for harvesting the bone, usually the iliac crest of the pelvis. This increases the morbidity of patients, such as postoperative pain and the risk of infection. Allograft bone from bone banks or cadavers avoids the pitfalls of autograft bone, but does not possess the strength or cellularity of autograft bone. As the number of operations requiring bone transplantation continues to increase, the development of functional tissue bone grafts becomes increasingly important. Four critical factors to successful bone tissue engineering are osteoconducty, osteoproduction, osteoinduction, osteoinduction, and mechanical stimulation. Osteoconductie refers to the integration of the scaffolding or graft material into the site and the final renovation and replacement of it. Osteoproduction is the production of bone material by cells, and osteoinduction is the use of growth factors that attract additional osteogenic cells to the site. For both in vivo and ex vivo bone tissue, mechanical stimulation seems to be a critical factor in the development of biologically and mechanically optimal bone tissue. Bone tissue engineering should take into account the enormous mechanical strength and elasticity of the bone. For long bones such as the femur, mechanical stability of the construction is crucial, while for finer tissues such as fingers or craniofacial applications plasticity takes on greater significance. Tissue passing through tissue used for clinical applications must meet both biological and mechanical requirements. Several scaffolding strategies have been used for MSC-based MSC-based tissue engineering. Matching bone strength is a major concern, and many strategies have been used. Fully or partially demineralized bone matrix (DBM) of processed allograftbot contains collagen, growth factors and other proteins and is sown with MSCs to create promising engineered constructs. DBM shares many structural and functional similarities with autologous bone and, as expected, supported osteogenic function of MSCs (Mauney et al., 2004). Coral, composed mainly of calcium carbonate and with a similar structure to bone, is sown with periosteum as a therapeutic strategy (Vacanti et al., 2001). Porous ceramics, such as those of tricalcium phosphate and hydroxyapatite, have been used in combination with MSCs to successfully produce bone replacement tissues in patients who have not performed traditional therapies (Quarto et al., 2001). Optimization of the scaffolding strategy requires understanding the mechanism of action. Ceramics offers good osteoconductivity and proper integration into the defect site by attaching to tissues without rejection or inflammatory reactions, but unfortunately lack of tensile strength, limiting applications with torque, sliding tension or bending. Natural coral has been studied for decades as a bone transplant substitute, and is biocompatible, osteoconducting and biodegradable. Improved ex vivo construct production requires combining biomaterial strategies with bioreactors that can produce shear and compressing forces to provide a dynamic culture system. Dynamic culture of cell-seeded scaffolding, for example using spinner flasks, has been shown to result in a more even cell distribution and a 121% increase in cell density (Mauney et al., 2004). Direct cell therapy has also been tested for musculoskeletal applications. Percutaneous autologous bone marrow transplantation, the reintroduction of sucked bone marrow directly at the site of a non-union in the tibia, has been described in human patients with good results (Hernigou et al., 2005). Growth plate (physis) injuries in children can result in shortening or angular deformity with the formation of bony bridges over the growth plate between the epifyse and metafysis. Direct implantation of MSCs in growth plate defects resulted in a significant reduction in growth arrest in rabbittibia (Chen et al., 2003). Gene therapy also holds promise for bone tissue engineering. A number of strategies have been tested for bone repair. Proof of concept was established with improved healing of a critical defect in a rat femur with delivery of rats MSCs transduced with the gene for BMP-2 to the site of the defect (Lieberman et al., 1999). In mice, systemically injected MSCs with IGF-1 were shown to be Bone marrow. The MSCs showed chemotactic ability by responding to the local fracture environment and preferably locating them to the fracture site, where they also accelerated the healing process (Shen et al., 2002). Gene therapy with an MSC-based vehicle is also used to treat a genetic disease. Engineered adeno-associated viral vectors were successfully used to disrupt the expression of mutated collagen type I gene in AMs derived from individuals with osteogenesis imperfecta. Subcutaneous implantation of transducated MSCs in immunodeficient mice produced improved bone matrix (Chamberlain et al., 2004). If host MSCs can be expanded or replaced, future OB could then produce higher quality osteoid. A gene therapy approach has also been developed with muscle-derived mesenchymal precursor cells. These cells act as vehicles that produce osteoinductive proteins and have been shown to cure critically sized bone defects (Young et al., 2002). Mouse primary myoblasts over-express Runx2 via aretroviral system were implanted in combination with collagen scaffolding in the hind legs of mice and resulted in trabecular bone growth (Gersbach et al., 2006). Future improvement of bone tissue engineering depends critically on understanding the biological signals needed for bone induction and optimizing the pharmacokinetics of their delivery. Optimized vascularization is essential, as cell labeling experiments show a significant loss of OB in the first week after transplantation in porous cancellous bone matrices, presumably due to suboptimal initial vascularization (Kneser et al., 2006). Scaffolding containing growth factors, such as vascular endothelial growth factor (VEGF) and endothelial cells, appear to increase vascular formation in structures in vivo, but integration with the host vascular system remains a challenge (Rouwkema et al., 2006). Frederic Shapiro, in The Pediatric and Adolescent Knee, 2006In the developing, skeletal immature joint, the weakest areas are often (though not always) the physical areas such that trauma that ruptures ligaments in the adult in the boy causes growth plate fractures in the youth. It is important to check for injuries to the distal femoral physis or the proximal tibia physis, in which additional ligament fractures are clinically suspected.1 Extensor mechanism injuries often lead to tibia tuberculosis fractures19 instead of ligament fractures, and crosspleation stress injuries often cause anterior tibia spine fractures at the point of cruciate ligament insertion, leaving the ligament intact.20FREDERIC SHAPIRO, in Pediatric Orthopaedic Deformities , 2001Dilating destruction of the function of the growth plate is associated with the formation of localized transphyseal bone bridges (287 , 313). This usually after certain growth plate fracture separations (6, 60, 73, 304, 350, 421, 434, 461, 495), in severe cases of Blount disease (infantile tibia vara), vara), infection (409). The bone bridges slow down the growth in a localized part of the physio and encapsulate a pre-angular deformity and shortening as the remaining physical tissue continues to function. The possibility of removing focal bone bridges was lifted by Ollier (354) more than 100 years ago. He was able to demonstrate the formation of transphyseal bone bridges in laboratory animals. Experimental work in rabbits by others at this time also showed partial bone bridge of the physio (434). There was a good clinical awareness in the latter stages of the nineteenth century of bone bridge formation after epiphyseal trauma with its subsequent effect on growth. Ollier himself made efforts to surgically remove bone bridges, but recurrence was common due to not using a suitable interpositional tissue to prevent recurrent bridge formation. The mechanism of bone bridge formation was described extensively in chapter 7.De position of the bone bridge defines not only the type of deformity, but also the surgical approach to removing the bridge and the type of material placed to prevent reformation (fig. 26A). Central bone bridges lead to shortening without angular deformation, while peripheral bone bridges lead to corner deformity and shortening. Bright (72) classified partial growth arrests in three types: type I, peripheral lesion; type II, central lesion; and type III, combined central peripheral lesion. The exact position and size of bone bridges can be demonstrated by tomography, CT scanning and magnetic resonance imaging (fig. 26B). Examples of bone bridges are shown in Fig. 26A. FIGURE 26. (A) Adult transphyseal bone bridges can be seen on ordinary X-rays. (Ai) A central transphyseal bone bridge (arrow) is shown at left in a 7-year-old girl who suffered a distal tibial growth plate arrest after meningococcal from infancy. (Aii) A peripheral bone bridge (arrow) of the proximal media tibia after Blount's disease is seen (right). Varus deformation of the tibia has developed. (B) Magnetic resonance imaging defines the size of the bone bridge (white arrow; bone bridge is black, persistent physics is white). Image is from A, left. MRI is from the coronal (lateral) plane. (C) A series of X-rays shows the operative approach to removing a central bone bridge (Ci, Cii), filling the fat defect, followed by the reintroduction of the bone window (Ciii, Civ), and results after the resumption of growth several months later (Cv). Langenskiold (285-287) refocused attention on the formation of focal bone bridge and developed bridge resection and the implantation of fat for use as a clinical tool. In a series of experiments in his laboratory, many types of interpositional materials were used, but fat was both the easiest and the most effective in preventing the reformation of bone bridges thus maintaining physical function. Fat is a minimally vascularized tissue and generally persists as fat when when growth plate defects, which separate the epifyseal and metaphyseal circulations and allow the rest of the physio to continue growth. Another interpositional material used was cartilage, which had as effective a result in experimental studies as the fat (357). In comment on Langenskiold's first 43 clinical procedures excising local bone bridges and interposing autologous fat grafts, the results overall were good to very good; only 7 showed questionable benefit mainly because the procedure was carried out too close to the end of the growth period (287). The vast majority of the procedures involved the distal femur, proximal tibia, and distal tibia. The etiology of partial closure in 38 growth plates was fracture in 28, osteomyelitis at 8, and tuberculosis and Blount's disease in 1 each. After interposition of the fat graft, the radiolucent area of the fat transplant usually has a rounded or oval shape, while after the subsequent growth the radiolucent area becomes elongated. The fate of the vetimplantates was experimentally studied by making round cavities in the proximal end of the shin growth plates in pigs and filling them with autologous fat. Studies indicated that the volume of adipose tissue implanted in the cavities constantly increased parallel to the growth in bone length. It turned out that the fat was supplemented with fat cells in the metafyse. Langenskiold et al. (288) recalled 3 patients several years after surgery for CT scan assessment of the epifyseal-metaphyseal region. They concluded that the former resection cavities were mainly filled by fatty tissue and that the portion of implanted fat had grown in size corresponding to the growth in length of the bones in the affected ends. Some strands of fibrous tissue were mixed with the fat. A layer of dense bone remained in the periphery of the fat graft. Langenskiold concluded that the free fat grafts implanted at the time of the resection continued to grow and thus filled in the elongated cavities. The fat remained until well after the period of growth termination, and the cavities were not filled with liquid or bone. Examples of central bone bridge resection are shown in Fig. 26C. Other clinical studies have assessed the treatment of partial physeal growth arrest by bridge resection and fat interposition. Vickers (486) reported on 15 patients with good initial results. Williamson and Staheli (506) assessed 29 physeal reseal resections, 22 of which were followed over 2 years. They interpreted their results in the longer-term group as 11 excellent, 5 good, 2 fair and 4 poor. Twenty of the 29 bridges were caused by rupture, 3 by tumors, 3 by tibia traction pins, and 1 by infection. Twenty of the bridges were peripheral, 6 were central, and 3 were combined. The results reversed with bridge size. They were uniformly excellent for bridges less than 25% of the physical volume, bridges between 25 and 50% yielded good to results in 9 out of 12 cases, and the results were generally poor in bridges greater than 50% with only 1 out of 4 yielding a good result. Bright (72) briefly reported on 100 patients who were followed for more than 2 years with silsastic interposition material, with 81% of patients demonstrating some growth after bridge resection and 70% with good to excellent results. Aufaure et al. (29) studied 18 cases of bone bridge resection in childhood and concluded that there were 9 good results and 9 failures. The best results were obtained in cases where the bridge was peripheral, as it was more easily approached and after a traumatic injury in young children. The larger the bone bridge, the greater the chance of failure. Extensive bridges particularly those centrally, therefore, had a poor prognosis and all leg bridges due to osteomyelitis were failures. Most bone bridges were resected on the distal femoral and distal shin growth plates. Resection has been clinically feasible in many cases if a fourth or less of the growth plate is involved and there is still sufficient growth left to justify the removal of the focal force. Interposition of fat, cartilage, silastic, or methyl methacrylate can keep the epifyseal and metaphyseal circulations separate, thereby preventing the formation of further bone bridges and allowing the unaffected growth plate cartilage to continue to grow normally. Each of these methods has proponents; the interposition of fat is the easiest and most commonly used approach clinically. Examples of a bone bridge resection procedure are shown in Fig. 26C. The size of the bone bridge must be determined before a decision is taken to remove the bridge again. Ordinary second-plan economists are inadequate. Tomography has been shown to replace a good percentage estimate of the physical area with the bone bridge, but CT or MR scanning with three-dimensional reconstruction is currently used (96). William C. McGarvey, in Baxter's the Foot and Ankle in Sport (Second Edition), 2008Pediatric ankle fractures form a wide range of patterns and complexity. However, these are often found in the growing population of high school, junior high, and elementary school athletes. Salter-Harris (S-H) fractures where the joint is not consistent with the principles of all generic, pediatric fracture management protocols (fig. 5-12). Closed anatomical reduction is often successful by simply reversing the mechanism of injury. Cast immobilization is usually effective for management, and benevolent remodeling usually compensates for any minor malalignments. Immobilization is usually required for 6 to 8 weeks, at which point gradual weight lower and range of motion can be advanced if tolerated. Any joint incongruent need open management (Fig. 5-13, A and B). The increases in the diagnosis and management of adolescent variants of the Tillaux (S-H III) and triplane (S-H IV) fractures. These usually occur between the ages of 12 and 14 years as the medial tibia physe begins to close, creating an irregular stress distribution and resistance to forces applied over the ankle (Fig. 5-14). Tillaux and triplane fractures are considered adult, and treatment issues should be seen as such (fig. 5-15). The focus of treatment should be based on congruity of articular reduction, because the complications surrounding these injuries are the result of non-anatomical incongruity relationships, leading to early degenerative changes rather than the more popular but incorrect suspicion of growth arrest. Deviations or asymmetry in growth are actually rare and not very consistent in these scenarios. Any issue of joint inregregibility should be resolved by obtaining advanced imaging studies, especially CT scanning, to eliminate the possibility of joint step-off. Separations of more than 2 mm away along the joint surface, regardless of congruity, need to be repaired. No compromise should be accepted at the joint surface for fear of early degenerative changes. Percutaneous techniques using large reduction clamps or devices and gamed shengeusation are acceptable, but the surgeon should be sure of anatomical repair and no interlocutor tissue. If there is any question about the adequacy of the reduction, open treatment is required. As soon as stability is ensured, movement can be introduced; however, weight bearing bearing should be withheld for 6 to 8 weeks until the healing is confirmed. Confirmed.