Compared with other methods to correct leg length discrepancies and angular deformities, percutaneous epiphysiodesis using transphyseal screws (PETS) has a small incision, short hospital stay, and short operative time.\(^1\) Complications include pain, overcorrection, and screw breakage on removal.\(^4,5,9\)

Screw bending following treatment with PETS is rare. The authors report 3 cases of screw bending following PETS. To the authors’ knowledge, these are the first reported cases of implant bending following transphyseal placement for correction of leg length discrepancy or angular deformity.

Abstract

Percutaneous epiphysiodesis using transphyseal screws is a common method for treatment of limb length discrepancy and angular deformity. The authors report 3 cases of a previously unreported complication following treatment with percutaneous epiphysiodesis using transphyseal screws: bending of the transphyseal screw. In each case, this rare complication was associated with difficult removal of the screw. This retrospective case report accessed the medical records of 3 children, 2 boys and 1 girl, 9 to 14 years old. All of the children had 4.0-mm cannulated stainless steel screws ranging from 40 to 50 mm in length. Two of the patients had partially threaded and 1 had fully threaded screws with bending noted a minimum of 6 months following implantation. Additionally, each of the screws bent near the physes of the bone, which was not located at the center of the screw in every case or at the transition from threaded to nonthreaded portions in each partially threaded screw. To the authors’ knowledge, these are the first reported cases of cannulated screw bending following transphyseal tibial or femoral placement for the correction of leg length or angular deformity in a pediatric population. Although the true incidence rate is unknown, screw bending following percutaneous epiphysiodesis presents complications in the hardware removal process. Further biomechanical tests should be conducted to determine the best screw design to minimize bending of transphyseal screws from physiologic growth. [Orthopedics. 2017; 40(4):e717-e720.]

Case Reports

Patient 1

An 11-year-old boy presented to the orthopedic clinic for evaluation of flat feet, ankles turning while walking, and foot pain while running. Physical examination showed a well-developed boy with pes planus and an associated ankle valgus deformity, full ankle and subtalar range...
of motion, and flexible mid- and forefoot bilaterally. Radiographs indicated pes planus with subluxation of the tarsonavicular joints that was worse on the left (Figure 1A). He also had approximately 9° of ankle valgus bilaterally, based on distal tibia anatomic axis, and associated hindfoot valgus. Knee alignment on standing hips to ankles was within normal limits, with no genu varum. His ankle valgus was subsequently indicated for bilateral medial malleolar PETS. Percutaneous epiphysiodesis using a single partially threaded 4.0×45-mm cannulated stainless steel screw across the medial malleolus physis was used to achieve correction of his deformity bilaterally (Figure 1B). Intraoperatively, there were no complications and screw placement was confirmed via fluoroscopy. The patient was discharged home the same day and allowed to bear weight as tolerated immediately.

At his 6-week follow-up, he presented with full, painless range of motion in his ankles and improved ankle valgus of 7° bilaterally with a stable appearance of his implants. However, 14 months postoperatively, he presented with overcorrection of ankle valgus to 4° on the right and 1° on the left with bending of the screw in the right tibia (Figure 1C). The patient returned to the operating room 3 days later for hardware removal. This was complicated by the screw being difficult to remove from the bone because of its angular deformity, which required increasing the incision length, curettage and trephine reaming of bone around the screw up to the level of the physis, and longer surgical time.

**Patient 2**

A 9-year-old girl with tuberous sclerosis, persistent seizure disorder with right hemiparesis, and leg length discrepancy was referred to the orthopedic clinic for evaluation of knee pain and follow-up for an abnormal result on gait analysis. Physi- cal examination showed a right lower extremity popliteal angle of -20°, a 5° knee flexion contracture, and full ankle range of motion. Her left lower extremity had full knee extension and ankle range of motion. Gait analysis showed decreased knee extension in stance with hip flexion and ankle dorsiflexion, consistent with crouched gait. Radiographs showed an 8-mm leg length discrepancy, with the left leg being longer (Figure 2A).

Anterior distal femur PETS was chosen to treat the right knee flexion contracture causing her crouched gait. One 4.0×40-mm and one 4.0×50-mm partially threaded, cannulated stainless steel cancellous screw were placed across the physis of her medial and lateral distal femurs, respectively (Figure 2A). She was discharged home the same day and allowed to bear weight as tolerated.

Radiographs obtained 2 weeks postoperatively showed no evidence of hardware failure, loosening, or bending (Figure 2B). Six months postoperatively, she presented with occasional pain in her right knee. Physical examination revealed full extension of the right knee and mild genu varum. Radiographs showed a leg length discrepancy of 6 mm, with the left leg being longer (Figure 2C), and interval deformation of both screws (Figure 2D). Because her clinical deformity had corrected, the implants were removed 2 weeks later. This removal was complicated by 1 implant shearing at the screw head–shaft junction, which caused the head to become unattached from the body of the screw. Reaming via trephine, increased bone removal nearing the immature physis, and increased operative time were required to fully remove the screw.

Eight months following hardware removal, her right knee was nontender to palpation and had full range of motion. Radiographs indicated a leg length discrepancy of 4 mm and continued correction of her genu varum (Figure 2E).

**Patient 3**

A 14-year-old boy with methylene-tetrahydrofolate reductase mutation and mild left hemiparesis presented with bilateral ankle valgus, gait abnormalities, and knee pain. Physical examination showed an external thigh foot angle of 25° on the left and 35° on the right. Radiographs showed ankle valgus of 9° on the left and
11° on the right (Figure 3A). Gait analysis indicated bilateral lower extremity rotation abnormalities due to femoral anteversion and external tibial torsion as well as external foot progression averaging 10° on the left and 20° on the right.

Bilateral medial malleolus epiphysiodesis was performed as a part of the patient’s single event, multilevel surgical procedure. Percutaneous epiphysiodesis using a single fully threaded 4.0×45-mm cannulated stainless steel cancellous screw across the medial malleolar physis was employed bilaterally to correct his ankle valgus deformities (Figures 3B-C). Femoral rotation osteotomies stabilized using an interlocked femoral lateral entry intramedullary nail to achieve 15° of external rotation bilaterally and tibial rotation osteotomies stabilized using a stainless steel plate to achieve 20° of tibial internal rotation bilaterally were also performed. He tolerated the procedure without complications and was discharged home on postoperative day 3 with non–weight-bearing instructions.

Three weeks postoperatively, his implants were stable and he was cleared to begin bearing weight. Radiographs obtained 7 weeks postoperatively showed early osteotomy healing without implant failure. Six months postoperatively, he had advanced healing and improvement of ankle valgus to 2° bilaterally.

Eight months postoperatively, physical examination revealed bilateral full knee extension, hip and tibial rotation angles at neutral, and ankle dorsiflexion past neutral. His ankle valgus had corrected and distal tibial implants were removed bilaterally. Intraoperative fluoroscopy showed bending of the left medial malleolus screw (Figure 3D). Removal of the deformed left medial malleolar screw was difficult, requiring increased operative time and use of an additional broken-screw extractor set.

**Discussion**

Percutaneous epiphysiodesis using transphyseal screws is commonly performed to treat leg length discrepancies and angular deformities in the lower extremities. Complications of PETS, including pain, overcorrection, and difficult screw removal, have been reported; however, to the authors’ knowledge, this is the first report of in situ implant bending.2-9

In the current cases, bending was noted a minimum of 6 months following implantation, with each screw bending near the physis of the bone. This is significant because the bending point was not at the transition from threaded to nonthreaded in the partially threaded screws. Because of the length of time in situ before screw bending was observed and the proximity of the bend to the physis, the authors believe that bending resulted from forces acting on the screw from physiologic growth, weight-bearing stress, normal impact during ambulation, or a combination of these factors.2,3
Longitudinal bone growth likely imparted additional, transverse forces across the screw, leading to its deformation. A likely hypothesis is that as the transphyseal screw impeded longitudinal growth on one side of the physis, the unhindered areas of the physis continued to grow. The screw then acted as a pivot as the unhindered side of the physis continued to grow, thus placing increased bending or creep forces on the screw. With enough growth of the unhindered side, the screw began to bend.

This hypothesis could explain all 3 cases of screw bending, including that in patient 2, who had 2 transphyseal screws placed in the anterior distal femur to correct a sagittal deformity. However, the posterior portion of the physis was unimpeded, allowing for growth in that area and thus placing transverse forces on the screws (Figure 2D). The inhibition of growth in the anterior portion of the physis was needed for the desired clinical correction, but the forces appear to have been stronger than the screw over time, thus causing a creep deformity and screw bending in the observed direction.

The hardware removal procedures were more difficult because of the bent screws. This was seen in every case, with longer operative times, special screw removal instruments, and additional techniques with elevated degrees of difficulty required to remove the implants. Furthermore, patient 1 required a longer surgical incision and curettage and trephine reaming of bone around the screw up to the level of the physis. Patient 2 required increased bone removal nearing the open physes with increased risk of physeal damage. Although additional techniques were required for implant removal, there were no observed acute complications of the physis and all screws could be completely removed. However, concern over physeal bar formation with overcorrection of the deformity required close monitoring after the procedure.

Surgeons should consider implant bending after performing PETS. Because removal of a bent implant can be technically challenging and lead to a longer operative time, screws may need to be removed prior to complete correction of an angular deformity if bending is observed. On the basis of these results and experiences, the authors recommend proceeding with implant removal as soon as screw bending is observed radiographically and having a broken screw removal set, bone curettes, and a trephine reaming system available when doing so.

**CONCLUSION**

To date, no published studies exist addressing the mechanical properties of cannulated vs noncannulated and/or fully vs partially threaded screws when placed across a physis for PETS fixation. Given this failure mode, further biomechanical tests should be performed to determine the best screw design to minimize bending of transphyseal screws. A full chart review for similar cases of bent screws at the authors’ institution would be beneficial in determining whether other modes of hardware failure exist. It is also recommended that these complications be consistently documented and that a multicenter prospective study be conducted to examine other screw options or techniques.

**REFERENCES**