Use of a Core Reamer for the Resection of a Central Distal Femoral Physeal Bone Bridge: A Novel Technique with 3-Year Follow-up

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Take-Home Points

- Central physeal arrest of the distal femur is challenging, but this surgical technique provides an option for treatment.
- Partial bone bridges can be resected, but advanced imaging with MRI or CT, or both, is helpful in preoperative planning.
- Regardless of the type of physeal bar resection that is chosen, it is unlikely that complete, normal bone growth will be restored and closed follow up will be needed.

A physeal bone bridge is an osseous connection that forms across a physis. It may cause partial premature physeal arrest. Angular deformity and limb-length discrepancy are the main complications caused by physeal bone bridges. The indications for the treatment of physeal bridges are well documented. Trauma and infection are common causes of distal femoral physeal bone bridges. Arkader and colleagues showed that among different types of physeal bridges, the Salter-Harris type is significantly associated with complications, among which growth arrest is the most common and occurs in 27.4% of all patients.

The treatment of distal femoral physeal bone bridges is technically difficult and provides variable results. Poor
results are reported in 13% to 40% of patients.\textsuperscript{7-10} Procedure failure has been attributed to incomplete resection with the persistent tethering and dislodgement of the graft.\textsuperscript{11} Methods with improved efficacy for the removal of central physeal bridges will help prevent reformation after treatment. We have used a novel technique that allows the direct resection of a central physeal bone bridge in the distal femur through the use of a fluoroscopically guided core reamer. This technique enables the complete removal of the bone bridge and the direct visual assessment of the remaining physis. The patient’s parents provided written informed consent for print and electronic publication of this case report.

Case

A 3-year-old boy with a history of hemifacial microsomia presented for the evaluation of genu valgum and leg-length discrepancy. His intermalleolar distance at that time was 8 cm. A standing radiograph of his lower extremities demonstrated changes consistent with physiologic genu valgum. He had no history of knee trauma, infection, or pain.

At the age of 5 years and 7 months, the patient returned for a repeat evaluation and was noted to exhibit the progressive valgus deformity of the right leg and a leg-length discrepancy of 3.9 cm (Figure 1). Radiographs also showed the presence of a bone bridge of unknown etiology in the boy’s distal femoral physis. Computed tomography and magnetic resonance imaging (MRI) were used to characterize the size and location of the bone bridge, which was found to involve approximately 30% of the physis (Figures 2A-2C). Using the multiplier method described by Paley and colleagues,\textsuperscript{12} the patient’s projected leg-length discrepancy, assuming complete growth arrest, was approximately 10.2 cm. The risks and benefits of physeal bone bridge resection, including the high rate of recurrence, were discussed with the patient’s family, who wished to proceed with resection.

Operative Technique

With the patient supine on the operating table and after the administration of general anesthesia, 3-dimensional (3-D) fluoroscopy was used to localize the bone bridge, which confirmed the fluoroscopic location that was previously visualized through preoperative 3-D imaging. The leg was elevated, and a tourniquet was applied and inflated. A lateral parapatellar approach was used to isolate the distal femoral physis anteriorly because the bone bridge was centered just lateral to the central portion of the distal femoral physis. A Kirschner wire was placed in the center of the bridge under anteroposterior and lateral fluoroscopic imaging (Figures 3A-3E). A series of core reamers were then introduced, starting at 10 mm diameter and increasing to 18 mm diameter before complete resection was accomplished. Irrigation was used to prevent the thermal necrosis of the physis during reaming, and lateral fluoroscopic imaging was used to prevent injury to the posterior neurovascular structures. Each time a reaming was completed, the physeal bone bed was inspected to confirm complete bone bridge resection (Figure 3C). Once 18 mm of the physis had been removed, direct visual inspection confirmed normal physis was present on all sides of the bone that remained following physeal bar resection (Figures 3D and 4A, 4B). The defect was irrigated with normal saline and filled with cranioplast (Figure 3E). Cranioplast (the methyl ester of methacrylic acid that easily polymerizes into polymethyl methacrylate) was chosen because the amount of adipose tissue was insufficient for harvesting for interposition given the patient’s lean body habitus. Moreover, the use of the cranioplast prevented the occurrence of exothermic reactions during curing and provided hemostasis because the cranioplast occupied the entire cavity and was strong enough to provide structural support.\textsuperscript{13} When partially set into a putty-like state to allow molding, the cranioplast was carefully contoured within the femoral trochlea. To protect the resection site from pathologic fracture, the patient was placed in a long-leg cast, and only protected weight-bearing with the use of a walker was allowed for 6 weeks.
Outcome

The patient healed uneventfully, and early range-of-motion exercises were started 6 weeks postoperatively. At 6-month follow-up, his leg-length discrepancy was 2.7 cm, and the bone bridge did not recur. At 3-year follow-up, his leg-length discrepancy was 3.0 cm, and the bone bridge did not recur. Over the 3 years postoperatively, the patient exhibited 9.8 cm of growth on his operative side and 9.5 cm on his nonoperative side (Figure 5). The patient has returned to full function and has had no pain, patellofemoral complaints, or complications associated with the cranioplast. He currently is being followed for his leg-length discrepancy. A contralateral epiphysiodesis is planned to equalize his leg-length discrepancy.

Discussion

Given the considerable growth potential of the distal femoral physis, an injury to the distal femoral physis and the formation of a physeal bone bridge can have a profound effect on a young patient in terms of leg-length discrepancy and angular deformity. Fracture from trauma or infection is a common cause of physeal bone bridges. The etiology of our patient’s distal femoral physeal bone bridge is idiopathic, which is considerably less common than other etiologies, and the incidence of idiopathic physeal bone bridge formation is not well established in the literature. Hresko and Kasser identified atraumatic physeal bone bridge formations in 7 patients. Among the 13 patients with physeal bone bridges described by Broughton and colleagues, the cause of bridge formation is unknown in 1.

Physeal bone bridges that form centrally are particularly challenging because they are difficult to visualize through a peripheral approach. A number of methods for resecting central physeal bone bridges have been described. These methods have varying degrees of success. In 1981, Langenskiöld first described the creation of a metaphyseal mirror and the use of a dental mirror for visualization. This technique, however, yielded unfavorable results in 16% of patients. Williamson and Staheli reported poor results in 23% of patients. Loraas and Schmale described the use of an endoscope, termed an osteoscope, for visualization, citing advantages of superior illumination and potential for image magnification and capture. Marsh and Polzhofer also showed this technique to have low morbidity but poor results in 13% of patients, whereas Moreta and colleagues reported poor results in 2 out of 5 patients. The rate of poor results of these methods may be related to the technical difficulty of using dental mirrors and arthroscopes and can be improved by highly efficient direct methods with improved visualization, such as the method described in this article.

Proper imaging is necessary for the accurate quantification of bone bridges to determine resectability and to identify the best surgical approach to resection. MRI with software for the generation of 3-D physeal maps is a reproducible method with good interobserver reliability. Intraoperative computer-assisted imaging also is beneficial for determining the extent and location of the resection to ensure complete bone bridge removal.

To our knowledge, a direct approach through parapatellar arthrotomy for the resection of a centrally located distal femoral physeal bone bridge has not been previously described. This novel technique provided direct access to the physeal bone bridge and was performed without injuring the adjacent physeal cartilage in the medial and lateral columns of the distal femur, which may grow normally in the absence of the bridge. Instead of using a lateral or medial approach with a metaphyseal window, we directly approached this central bar through a parapatellar approach and were able to completely resect it under direct visualization. This obviated the need for an arthroscope or dental mirror. To remove the entire physeal bone bridge, we needed to resect completely from the anterior cortex to the posterior cortex. Although this technique potentially increased the risk of iatrogenic...
fracture, we believed that this risk would not differ greatly from that of disrupting the medial or lateral metaphysis and would be more stable with either axial and torsion load. At 3-year follow-up, the patient exhibited restored normal growth in his operative limb relative to that in his nonoperative limb, had not developed angular deformity, and had maintained his previously developed limb-length discrepancy that could be corrected with the epiphysiodesis of his opposite limb at a later date.

The limitations to this technique include the fact that it may be most effective with small-to moderate-sized central physeal bone bridges, although resection has shown good results with up to 70% physeal involvement. In this patient, the bone bridge was moderately sized (30% of the physis), centrally located, and clearly visible on fluoroscopy. These characteristics increased the technical safety and ease of the procedure. The resection of large, peripheral bridges may destabilize the distal femur. The destabilization of the distal femur, in turn, can lead to fracture. Patellofemoral mechanics may also be affected during the treatment of distal femoral physeal bone bridges. This patient has not experienced any patellofemoral dysfunction or symptoms. Given the patient’s age and significant amount of remaining growth, he will need close monitoring until he reaches skeletal maturity.

This paper will be judged for the Resident Writer’s Award.

Key Info

Figures/Tables

Figures / Tables:

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Figure 1. Standing radiograph of the lower extremities of a boy aged 5 years and 7 months with the valgus deformity of the right leg and a leg-length discrepancy of 3.9 cm.
Figure 2. (A) Sagittal and (B) coronal magnetic resonance imaging, and (C) coronal computed tomography images were used to characterize the size and location of the bony bridge of the distal femoral epiphysis with an unknown etiology. The bone bridge was found to involve approximately 30% of the physis.

Figure 3. Operative technique. (A) Central bone bridge on the coronal section of the distal femur. (B) Under fluoroscopic guidance, a guide pin is placed in the center of the bone bridge. (C) Reamer with an appropriate size is chosen to ensure the complete resection of the bone bridge. (D) Complete resection is completed, leaving intact physis on the medial and lateral walls. (E) Defect is filled with cranioplast.
Figure 4. Direct visual inspection confirmed normal physis circumference in the resection site. (A) Intraoperative clinical photo demonstrates resected bone bridge. (B) Intraoperative radiograph reveals complete resection of the bone bridge.

Figure 5. Postoperative leg growth. The patient's leg-length discrepancy was 2.7 cm at 6-month follow-up and 3.0 cm at 3-year follow-up. Over 3 years, the patient exhibited 9.8 cm of growth on his operative side and 8.5 cm on his nonoperative side. Open square, operative leg; closed square, normal leg.
References


Multimedia

Product Guide
- STRATAFIX™ Symmetric PDS™ Plus Knotless Tissue Control Device
- STRATAFIX™ Spiral Knotless Tissue Control Device
- BioComposite SwiveLock Anchor
- BioComposite SwiveLock C, with White/Black TigerTape™ Loop

Citation

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