Bone Impaction Grafting of the Lateral Femoral Condyle in a Pediatric Patient

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Abstract

Avascular necrosis of the femoral condyle is an uncommon but serious sequela in patients who have received chemotherapy or corticosteroid treatment. The optimal treatment of avascular necrosis of the femoral condyles in pediatric patients is not well established. Nonoperative management has had limited long-term success, and many of the surgical procedures available for adults, including core decompression, osteotomy, and femur resurfacing, are undesirable in skeletally immature patients with open physes.

This article describes a case of a 7-year-old girl with acute lymphocytic leukemia who developed avascular necrosis of the lateral femoral condyle that was treated with bone impaction grafting. The patient experienced right knee pain and swelling shortly after the initiation of chemotherapy. The radiological studies obtained showed subchondral collapse of the lateral femoral condyle. After a course of nonoperative management failed to improve symptoms, she underwent bone impaction allografting of the lateral femoral condyle using a physis-sparing approach. More than 5 years postoperatively, she has achieved excellent clinical results. Postoperative imaging of the knee has also confirmed good integration of the bone graft, an open physis, and preservation of the articular surface. This technique is a relatively less invasive surgical procedure for the treatment of avascular necrosis of the femoral condyle in a pediatric patient.

Figure: T2-weighted coronal magnetic resonance image 2 years postoperatively (A). Anteroposterior radiograph 5 years postoperatively (B).
Avascular necrosis of the femoral condyle is an uncommon but serious sequela in patients who have received chemotherapy or corticosteroid treatment. No current consensus exists on the optimal treatment of avascular necrosis in the femoral condyles of pediatric patients. Conservative treatment options, including analgesics, restricted weight bearing, and physical therapy, have resulted in limited long-term success. Surgical options in adult patients include core decompression, osteotomy, resurfacing of the femur with osteoarticular allografts, knee arthroplasty, and bone grafting. However, many of these procedures are undesirable in skeletally immature patients with open physes because the distal femoral physis would be violated.

This article describes a case of a 7-year-old girl who developed avascular necrosis of the lateral femoral condyle after undergoing chemotherapy and corticosteroid therapy for acute lymphocytic leukemia. Her lateral femoral condyle defect was treated with bone impaction allograft using a physis-sparing approach, and excellent clinical and radiographical results were achieved after a 5-year follow-up.

**CASE REPORT**

A 7-year-old girl with a medical history of Down syndrome presented with right knee pain and swelling after sustaining a fall onto her right knee. She had been diagnosed with acute lymphocytic leukemia 14 months previously. She had completed the induction phase of chemotherapy and was on maintenance chemotherapy with vincristine, methotrexate, leucovorin, and dexamethasone. On physical examination, she had gross swelling of the right knee and pain with range of motion. Her bilateral knees were in gross neutral alignment. A radiograph (Figure 1A) and magnetic resonance imaging scan (Figure 1B) of the right knee demonstrated an extensive area of avascular necrosis and subchondral collapse of the lateral femoral condyle.

After aspiration of the knee ruled out infection, the patient was initially treated nonoperatively with a nonweight-bearing long-leg cast for 6 weeks. Corticosteroids were discontinued by the pediatric oncologist after a diagnosis of avascular necrosis was established, but chemotherapeutic agents were continued to completion for an additional 13 months. However, despite compliance with conservative management, the pain persisted, and effusion reappeared when she returned to weight-bearing status. A repeat radiograph (Figure 1C) and magnetic resonance imaging scan (Figure 1D) 3 months after initial presentation showed increased lucency, raising concerns of advanced collapse of the lateral femoral condyle. Because nonoperative measures failed, the family consented to surgery with debridement of the lateral femoral condyle and impaction bone grafting.

**Surgical Technique**

In the supine position, general anesthesia was administered and a deflated tourniquet was applied to the right thigh. Initial arthroscopic evaluation of the knee demonstrated an intact, stable chondral surface of the lateral femoral condyle.

Following tourniquet inflation, a standard lateral approach to the knee was performed. Under fluoroscopic guidance, the lateral cortex of the lateral femoral condyle was identified, and a trap-door entry was developed through the cortical bone with a small osteotome. The inner surface of the condyle was largely devoid of cancellous bone. Through this opening, all remaining necrotic bone was debrided with a curette. A K-wire was used to drill into the healthy epiphyseal bone in the lateral femoral condyle to promote blood flow. The defect was tightly filled with allograft bone impacted with a bone tamp, and the cortical trapdoor was then closed.

The arthroscope was reintroduced to confirm smooth contour of the distal femur without free-floating cancellous bone chips or evidence of articular cartilage damage. The patient was placed in a long-leg cast, and a postoperative radiograph demonstrated decreased lucency of the lateral femoral condyle (Figure 2A).
The patient was followed serially. A 6-month follow-up radiograph (Figure 2B), 2-year postoperative magnetic resonance image (Figure 2C), and 5-year postoperative radiograph (Figure 2D) confirmed excellent radiographical integration of the bone graft, an open phys, and preservation of the articular surface. Clinically, the patient has full range of motion with no pain or effusion. She walks with no limp and has equal leg lengths. She has developed a slight valgus deformity of bilateral knees, which has been successfully treated with bilateral hemiepiphysiodesis.

**DISCUSSION**

The etiology of avascular necrosis in children with acute lymphocytic leukemia is likely multifactorial and may include the disease process of cancer, chemotherapy, glucocorticoid therapy, poor nutrition, and mineral abnormalities.\(^1\)\(^2\) Although symptoms occur in 4% to 13% of patients with acute lymphocytic leukemia after the onset of chemotherapy,\(^3\)-\(^5\) the prevalence of avascular necrosis based on magnetic resonance imaging findings in patients with acute lymphocytic leukemia may be as high as 38%.\(^6\) No current consensus exists on the ideal treatment of avascular necrosis of the distal femur.

Mont et al reported that nonoperative management of corticosteroid induced avascular necrosis in adults resulted in satisfactory outcome of 18% at 6-year follow-up in 1 study\(^6\) and 20% success rate in symptomatic knees at a mean of 8 years in a subsequent study.\(^7\) After failed nonoperative management, surgical core decompression was then attempted to reduce the intraosseous pressure and improve microcirculation in the bone. Good results were reported in 73% of adult patients after 11 years.\(^7\) Similarly, Jacobs et al\(^8\) reported good results in all 7 patients with early-stage avascular necrosis (Ficat I and II) at 4.5 years, but found 52% acceptable results for patients with late-stage avascular necrosis (Ficat III and IV). Other operative methods, such as a high tibial osteotomy, have been described in adults to treat avascular necrosis of the distal femur by transferring the mechanical load away from the affected compartment. Aglietti et al\(^9\) reported satisfactory results in 87% of patients (age range, 43-70 years) with a mean follow-up of 6.2 years, and Koshino\(^10\) reported clinical improvement in 94% of patients (age range, 38-85 years) with a follow-up range of 2 to 8 years. Rozing et al\(^11\) reported that postoperative knee scores were higher in patients who received a high tibial osteotomy compared with those who only had drilling of the osteonecrotic areas of the knee.

Allografts are another common option used to restore large distal femur defects in adults with avascular necrosis. Flynn et al\(^12\) reported a 70% success rate at a mean of 4.2 years in 17 patients treated with frozen osteochondral allografts, and Görtz et al\(^13\) reported an 82% acceptable outcome at 5.5 years with distal femurs treated with fresh osteochondral allografts. Although successful, neither study included patients younger than 16 years. Fukui et al\(^14\) incorporated osteoperiosteal iliac bone grafts in a series of 10 patients (age range, 17-55 years) and showed successful graft incorporation in 9 patients after a mean follow-up of 6 years. Rijnen et al\(^15\) reported bone impaction grafting of the femoral condyles for corticosteroid associated avascular necrosis in a series of skeletally mature patients (age range, 16-47 years) with clinical success in 6 of 8 knees. However, their technique involves drilling from the metaphys and would violate the distal femoral physis in a pediatric patient.\(^16\)

**CONCLUSION**

The current pediatric patient underwent impaction bone grafting of the lateral femoral condyle with excellent results at a follow-up of 5 years. The authors demonstrated the successful outcome of this surgical technique in a patient with open physis who developed avascular necrosis from steroids and chemotherapy. The current method has limitations and may not be suitable for all pediatric patients with avascular ne-
necrosis of the distal femur. Patients with an extensive depth of necrosis may be more susceptible to physeal damage during impaction grafting. In addition, the applicability of this technique is unknown for patients with avascular necrosis of both femoral condyles. However, for lateral femoral condyle avascular necrosis, this procedure shows promise as a relatively less invasive surgical method that can prevent collapse, preserve the distal femoral physis, and postpone the progression of osteoarthritis.

REFERENCES