Chapter 22

Concurrent Techniques for the Treatment of Unicompartmental Arthritis

Meniscus Allograft Transplantation, Cartilage Repair, and Osteotomy

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INTRODUCTION

Unicompartmental arthritis is a common outcome in patients after total or subtotal menisectomy, with a relative risk of up to 14 times when compared to matched controls.[1-3] Worse outcomes are associated with young age, chondral damage at the time of menisectomy, ligamentous instability, and malalignment of the lower extremity.[4,5] The treatment of degenerative arthritis in the knee with unicompartmental or total knee replacement has yielded excellent results. However, young and active patients are less accepting of joint replacement due to associated activity restrictions.[6] Therefore, younger patients have traditionally been treated with joint preserving procedures such as osteotomies to alter the load-bearing axis of the knee joint and decrease stress in the affected compartment.[7-9] In this patient population, good to excellent results have been reported in up to 70% of patients at 10 years after high tibial osteotomy.[10] However, to obtain good results, large correction angles are required,[11] which are thought to be poorly tolerated in young patients wishing to remain active. In addition, while pain relief may be afforded in some following osteotomy, many patients continue to have activity-related pain and effusions due to persistent intra-articular pathology. More recently, meniscal allograft transplantation (MAT) has been popularized for the treatment of the symptomatic menisectomized knee, either performed in isolation or in conjunction with osteotomy.[12-14] Even though good results have been reported with this technique, MAT has traditionally been contraindicated in patients with full-thickness defects of the articular surface,[15] thus excluding a large segment of the patient population that is usually very symptomatic and could potentially benefit most from this procedure. Modern cartilage repair procedures, such as autologous chondrocyte implantation (ACI) and osteochondral allograft transplantation, can address such high-grade defects at the time of MAT and have the potential to improve outcomes even in patients presenting with more advanced degenerative changes.[16-18] Because of the close relationship between the meniscus and cartilage, any significant damage to one will lead to a rapid degeneration of the other.[19] Similarly, the benefits of conducting a realigning osteotomy along with MAT have been described.[20] Correcting the alignment of the knee will help mitigate reinjury or overload of the transplanted meniscus.

We have encountered a subgroup of patients presenting with a constellation of abnormalities, including meniscal deficiency, chondral damage, and tibiofemoral malalignment that collectively result in a strong predisposition for the rapid progression of osteoarthritis. This patient population is typically unresponsive to conventional treatment modalities, and even advanced techniques often fail unless they are performed in combination or in an appropriately staged fashion to address all pathological entities mentioned above. With careful preoperative planning, all abnormalities of the menisci, chondral surfaces, ligaments, and alignment can be identified and addressed in a staged or concomitant fashion. We describe our technique and experience with meniscal allograft transplantation in combination with cartilage repair and osteotomy in this patient population.

PREOPERATIVE EVALUATION

History and Physical Examination

Patients typically reported a history of prior knee trauma with subsequent total or subtotal menisectomy, which often resulted in near-complete resolution of pain. After a symptom-free period ranging from a few months to several years, these patients had a recurrence of joint line pain and swelling associated with weight bearing activities. The majority of patients underwent additional procedures (eg, repeat menisectomies and debridement of cartilage), but ultimately failed conservative and conventional surgical treatment.

Typical physical exam findings in this patient population included activity-related soft tissue swelling and joint effusion, unilateral tenderness with palpation of the joint line and femoral condyle, and mild laxity due to loss of cartilage and meniscal tissue. Dynamic assessment of gait often revealed a lateral (varus) or medial (valgus) thrust that was accentuated when patients were asked to walk backwards during the evaluation. In general, range of motion (ROM) was preserved in this population.

Imaging

Radiographic work-up should include standard weight-bearing anteroposterior (AP) views in extension, posteroanterior (PA) views in 45 degrees of flexion, flexion lateral, and axial sunrise views. Double-stance, weight bearing long-leg radiographs are obtained to assess lower extremity alignment and to determine the necessary degree of correction. Magnetic resonance imaging (MRI) is useful for the evaluation of the articular cartilage, menisci, and ligamentous structures, as well as to rule out or define associated pathology. MRI examination commonly shows evidence of compartment overload, such as reactive edema of the subchondral bone. In addition, MRI will review the extent of menisectomy and the degree and size of the relevant articular cartilage defects.

Indications and Contraindications

This combination procedure is indicated for young patients (although physiological age is vastly more important than chronological) who wish to be active, but experience weight bearing pain due to a combination of full-thickness chondral defects, meniscal deficiency, and malalignment. Significant joint space narrowing (>50%) or generalized osteoarthritis are considered contraindications, except in very young patients who have few other treatment options. Ligamentous instability has to be addressed in a staged or concomitant fashion.

Several factors should be considered when deciding on a staged versus concomitant approach to addressing comorbidities; staging requires multiple interventions and, therefore, several periods of restricted weight bearing, recuperation, and rehabilitation. Concurrent reconstruction offers the benefit of a single-time point intervention with less total time spent on recuperation, but due to the increased trauma and invasiveness of multiple concurrently performed procedures, there is an associated increased surgical time and risk of complications, such as stiffness. Generally, patient preferences, surgeon experience, logistics, and the clinical presentation should be considered when determining whether a staged or comprehensive approach should be adopted.

SURGICAL TECHNIQUE

Special Instrumentation

Depending on the types of concurrent procedures performed, specialized equipment will be needed for the osteotomy, such as appropriate femoral or tibial fixation plate systems, and bone graft material, such as allograft bone chips and demineralized bone matrix. Meniscal transplantation can be performed utilizing a number of different, proprietary instrumentation kits, which are usually supplied by the transplant organization providing the meniscal allograft. Cartilage repair will require the use of an allograft workstation if a fresh osteochondral allograft is planned or if specialized microinstruments are used for suturing of the periosteal flap in case of ACI. Lastly, a large C-arm and radiolucent table is helpful to assess alignment, instrumentation, and fixation during the osteotomy.

Positioning

The procedures can be performed either on a standard operating room table with leg extension or radiolucent table to allow C-arm use. Alternatively, the foot of the bed can be dropped, which facilitates meniscal transplantation, while the patient's leg can be rested on a Mayo stand during the other procedures. In either case, positioning should allow adequate flexion of the knee to expose posterior defects.

Technical Steps

We generally perform the reconstructive procedures in an order determined mainly by the type of cartilage repair utilized. The significant abduction or adduction moments required to reduce the meniscal allograft under the femoral condyle during implantation can compromise fixation of a previously performed osteotomy. Therefore, in our practice, the technical steps of the osteotomy are always performed after MAT. Osteochondral cylinder transfer or osteochondral allograft transplantation can be performed at any time during the procedure. ACI, however, should be performed as the last intervention due to the delicate nature of the periosteal graft. Further detail on these procedures can be found in the respective dedicated chapters in this textbook.

Meniscal Allograft Transplantation

MAT utilizes a size- and side-matched, frozen meniscal allograft with attached bone block,[9] as described in a dedicated chapter. Briefly, meniscal dimensions are determined from preoperative radiographs. Accounting for magnifica-

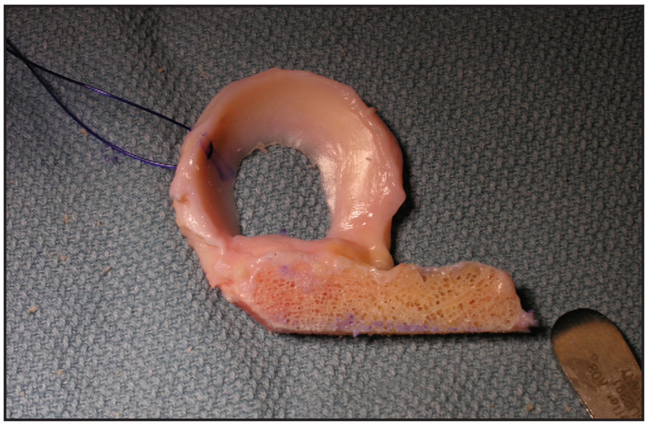

Figure 22-1. Prepared lateral meniscal allograft. The bone block has been sized to fit the trough created on the tibial plateau, and a #1 PDS suture has been attached to the junction of the middle and posterior third to assist in reduction of the graft under the femoral condyle.

tion, the distance between the ipsilateral tibial spine and the edge of the tibial plateau on the AP radiograph is measured, providing the graft width. Graft length is calculated by measuring the distance between the anterior and posterior edge of the tibial plateau on the lateral radiograph; this distance is then multiplied by 0.7 for lateral grafts and 0.8 for medial grafts. We prefer the bridge-in-slot technique for both medial and lateral MAT, but other techniques such as the keyhole or dove-tail techniques are comparable. We do not, however, encourage suture fixation of the meniscal horns without a bone block, as described by some authors, due to concerns over the reliability of the repair. The bridge-in-slot technique utilizes a 7- to 8-mm wide bone bridge that preserves the meniscal horn attachments for secure graft fixation on the tibial plateau (Figure 22-1). The original meniscus is arthroscopically debrided down to a 1 to 2 mm rim of bleeding tissue. A 3 to 4 cm longitudinal, transpatellar incision provides access to create a recipient slot or trough in the tibial plateau. The slot is aligned with the original meniscal horn attachment sites, effectively removing part of the ipsilateral tibial spine. For a medial meniscal transplant, the most medial fibers of the tibial ACL insertion are partly released off the tibial spine prior to creation of a slot in the tibial plateau with a burr and rasp. The bone bridge is introduced into the recipient slot, and the attached meniscus is reduced under the femoral condyle by applying the appropriate varus or valgus stress. Secure fixation of the bone bridge is achieved with a resorbable interference screw, and peripheral fixation is performed following established meniscal repair principles with 10 to 12 sutures utilizing accessory posteromedial or posterolateral incisions.

Cartilage Repair

Depending on size and location of the chondral defect, arthroscopic or open approaches are utilized for cartilage repair. Small to medium-size lesions are amenable to arthroscopic microfracture or osteochondral autograft cylinder transfer, while larger lesions require a formal arthrotomy for osteochondral allograft transplantation or ACI. Summarizing these procedures, microfracture is performed for small lesions by debriding the defect to create stable vertical shoulders of surrounding cartilage and completely violating the calcified layer with a curette or motorized shaver in a single direction. With special microfracture awls, multiple holes are created within the defect, perforating the subchondral bone to produce bleeding and bring marrow elements into the defect. The blood and marrow elements form a blood clot with mesenchymal cells that, over time, creates fibrocartilaginous repair tissue.

Osteochondral autograft transfer (OAT) is primarily indicated for smaller lesions that can be addressed with 1 or 2 osteochondral plugs. The technique involves the replacement of chondral defects with osteochondral cylinders harvested from lesser weight bearing areas of the same knee. The donor site is typically approached through a small lateral retinacular arthrotomy, and plug insertion is performed arthroscopically through portals placed to optimize perpendicular preparation and insertion.

Osteochondral allograft transplantation is indicated for chondral lesions that are relatively large, uncontained, or associated with significant bone loss. The chondral lesion is measured with a sizing guide and then reamed to a depth of approximately 7 mm. An osteochondral dowel of similar curvature and dimensions is harvested from a size- and side-matched fresh donor allograft condyle and press-fit into the recipient hole (Figure 22-2). Resorbable pins can be added as needed if secure fixation cannot be achieved through press-fit alone.

Lastly, ACI is a two-stage procedure in which a cartilage biopsy is first harvested arthroscopically and subsequently expanded in cell culture. It is indicated for large or multiple defects with minimal bone loss, especially symptomatic defects of the patellofemoral joint. After 4 to 6 weeks, the cells are reimplanted through a peripatellar arthrotomy. The lesion is debrided to create stable, vertical shoulders with removal of intralesional osteophytes or sclerosis of the subchondral bone when necessary (Figure 22-3). A periosteal flap is harvested from the anteromedial surface of the tibia and sutured to the cartilage surrounding the defect. Uncontained defects occasionally require the use of microsuture anchors for supplemental fixation. After the periosteal flap is secured with multiple sutures, the now-covered defect is tested for water-tightness. Additional sutures and fibrin glue are utilized as needed to seal any leakage from the suture line (Figure 22-4). Finally, the cells are resuspended and injected into the defect.

Osteotomy

Osteotomies are generally performed on the femoral side to correct valgus deformities and on the tibial side for varus malalignment. Preoperative, long-leg alignment radiographs are utilized to calculate the required degree of

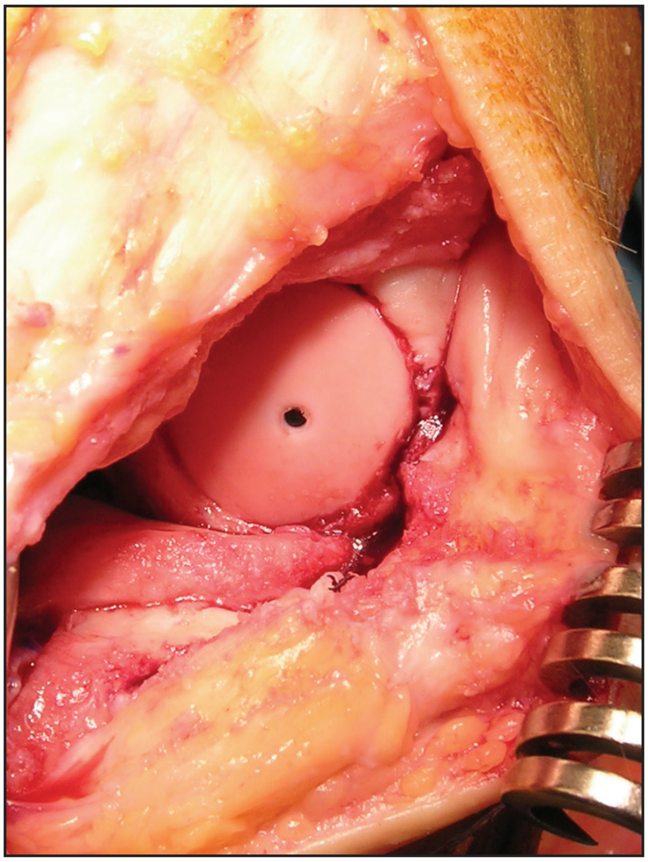

Figure 22-2. Chondral defect after press-fit placement of the fresh osteochondral allograft dowel. A concurrently performed meniscal allograft can be seen in place just underneath the condyle.

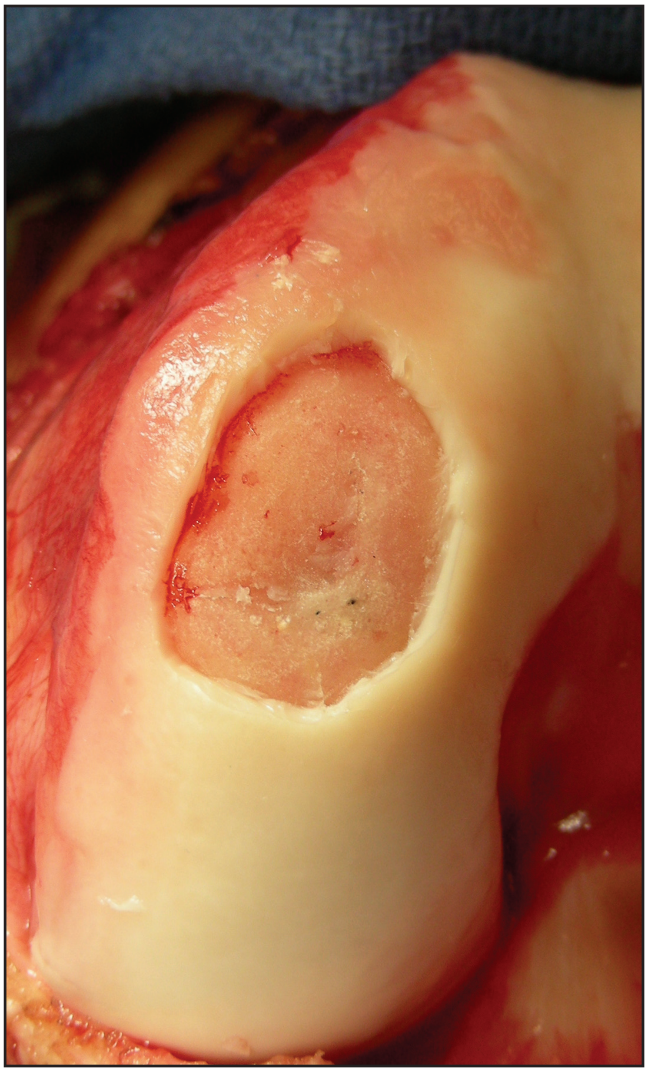

Figure 22-3. A focal chondral defect of the femoral condyle after preparation to create vertical shoulders.

correction; for varus alignment, after measuring the width of the tibial plateau, a mark is placed up to 62% of the width from the medial tibial border depending on the desired degree of correction. Lines are drawn from this mark to the centers of the femoral head and talus. The required angle of correction is formed by the intersection of these lines (Figure 22-5). Notably, in this patient population, we may elect to avoid significant overcorrection of varus malalignment and ultimately change the weight bearing line to about neutral or just to the lateral tibial spine. For valgus disease, we rarely correct the weight bearing line to beyond neutral.

In general, we prefer opening wedge osteotomies because this technique requires less operative time, and can more easily be adjusted intraoperatively in both the sagittal and coronal plane. In the proximal tibia, it also protects the proximal tibio-fibular joint and peroneal nerve and complicates subsequent total knee replacement to a lesser degree than a closing wedge procedure. In addition, the technical steps of concomitant medial meniscus transplantation or ligament reconstruction are relatively unaffected with opening wedge tibial osteotomies.

In the femur, opening wedge osteotomy is performed through a lateral approach that is located away from the medial neurovascular structures. We typically bone graft our opening wedge osteotomies with a combination of structural allograft wedges and cancellous autograft obtained from the distal femur or proximal tibia to lower the risk of nonunion.

POSTOPERATIVE ISSUES

Rehabilitation Protocol

Patients remain nonweight bearing in a hinged knee brace and daily continuous passive motion (CPM) treatments for 6 weeks. Motion is not restricted with the exception of flexion beyond 90 degrees while weight bearing,

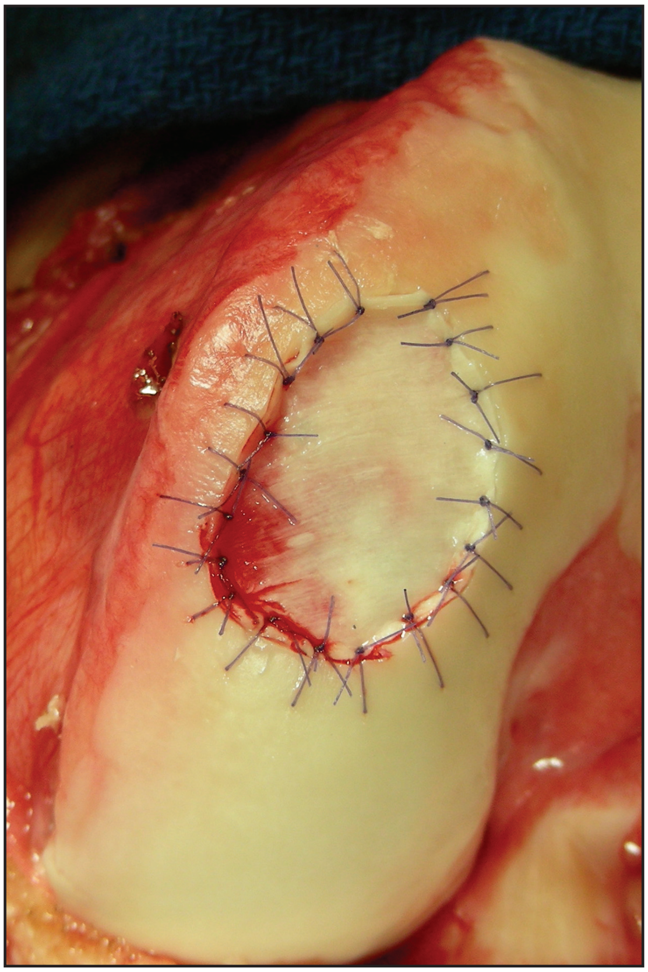

Figure 22-4. The patch has been sutured in place.

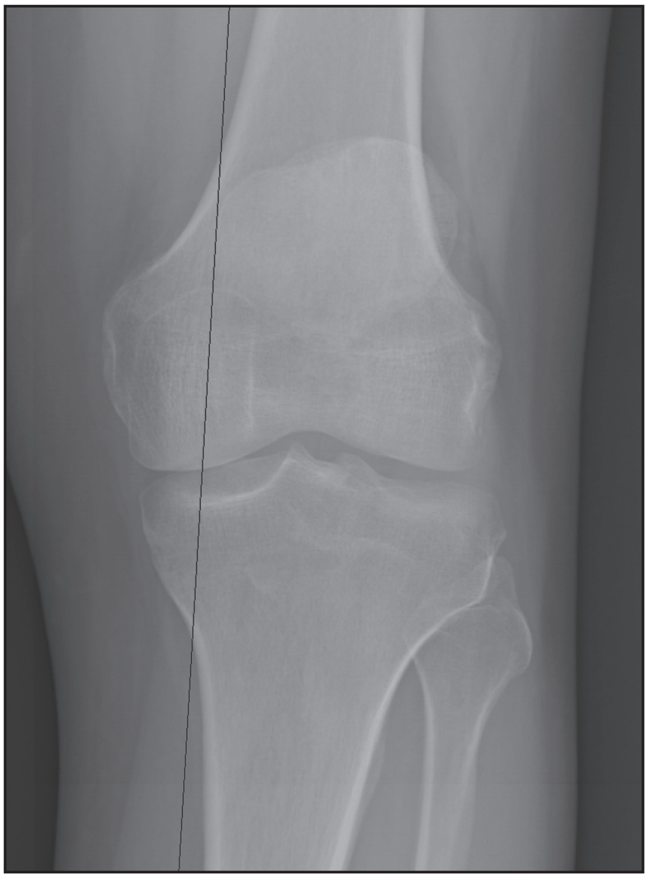

Figure 22-5. Anteroposterior radiograph for planning of a corrective osteotomy (cropped image from a long-leg alignment film). The weight-bearing axis lies in the medial compartment in this varus aligned knee.

which could overload the meniscal repair. Seven to 10 days postoperatively, skin sutures are removed, and patients are started on a supervised physical therapy program with gentle ROM exercises and quadriceps conditioning. After 6 weeks, weight bearing is advanced to full, and formal quadriceps strengthening is added to the program. Most activities of daily living are allowed after 3 months, with a return to noncontact, noncutting sports after 4 to 5 months. After 12 months, patients are allowed to return to unrestricted activities.

Complications

Besides the usual risk of infection, patients are at risk for stiffness and nerve damage. The use of a tourniquet can be helpful during certain parts of the procedure, such as the meniscal repair, but it is important to avoid prolonged ischemia time over 2 hours due to the increased incidence of nerve damage and deep-vein thrombosis (DVT). Opening wedge osteotomy has a risk of nonunion and is relatively contraindicated in smokers and heavy patients; the use of bone graft is strongly recommended.

RESULTS

Results of concurrent meniscal transplantation, cartilage repair, and osteotomy are not well represented in the literature. In the following section, we present our results for 5 male and 2 female patients with a mean age of 32 years (range: 18 to 43). The mean time from injury to treatment was 18 months (range: 4 to 60). Follow-up averaged 24 months (range: 12 to 50 months). All patients had previous subtotal or total menisectomies and full-thickness chondral defects that were associated with malalignment that was decreased or corrected to neutral with osteotomy; the mean preoperative varus alignment was 7 degrees, and the mean preoperative valgus alignment was 6.5 degrees. Postoperatively, ROM quickly returned in all patients, and progressively increased from an average of 96 degrees at the 1-month follow-up to an average of 127 degrees at the last follow-up.

Patients demonstrated significantly improved scores for the Lysholm (preop: mean=34; last follow-up: mean=77; 129% increase, p=0.003), IKDC (26 and 63, respectively;

138% increase, *p*=0.014), KOOS-Pain (47 and 84; 77% increase, *p*=0.010), KOOS-Symptom (55 and 74; 34% increase, *p*=0.038), KOOS-Activities of Daily Living (53 and 91; 74% increase, *p*=0.024), and KOOS-Quality of Life (11 and 48; 348% increase, *p*=0.018). There were non-statistical trends toward improvement in the KOOS sport score, as well as the SF-12 Physical Component Summary and Mental Component Summary subgroups. Of our seven patients, six were able to return to full activities without restrictions, and one has mild symptoms playing basketball.

CONCLUSION

Patients presenting with chondral disease, meniscal deficiency, and malalignment represent a formidable treatment challenge. Clearly, there remains a desire to avoid knee replacement in chronologically young patients or physiologically young patients who desire to remain active without the limitations that might be imposed by arthroplasty components. When bipolar disease prevails, osteotomy alone may be indicated. The limitations of osteotomy include incomplete pain relief and persistent symptoms related to effusions and ambient barometric pressure changes. Patients with relatively normal contralateral compartments and healthy tibial cartilage may benefit significantly following the treatment of femoral disease with chondral resurfacing, meniscal deficiency with meniscal allograft transplantation, and correction of malalignment in a concomitant or logical staged fashion. These should be considered extraordinary challenging surgical cases that require an experienced operating team due to the technical aspects inherent in these procedures. Most importantly, patient expectations must be managed appropriately, and no procedures should threaten what might otherwise be considered an inevitable need for arthroplasty at some point in the lineage of the patient's care.

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