The indications for hip arthroscopy have continued to expand. Presently, hip arthroscopy is frequently used for diagnostic purposes, removal of loose bodies, treatment of synovial chondromatosis, femoral acetabular impingement, labral pathology, instability, ligamentum teres rupture, and chondral disease. Chondral disease continues to present challenges for the treating orthopedist. Continued advances in hip arthroscopy and treatment options have led to improved outcomes.

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Arthroscopy of the hip has gained immense interest over the recent years. Advances in specialized equipment and diagnostic tools have allowed for the arthroscopic treatment of a multitude of hip pathologies. Early attempts at hip arthroscopy were limited to diagnostic measures, removal of loose bodies, and treatment of synovial chondromatosis. Improved equipment and diagnostic techniques have allowed hip arthroscopy to shift from a primary diagnostic tool to an effective therapeutic one. The indications for hip arthroscopy continue to expand. Currently treated conditions include femoral acetabular impingement (FAI), labral pathology, loose bodies, instability, ligamentum teres rupture, and chondral disease.

Chondral disease presents a unique challenge for the hip arthroscopist. The hip, unlike the shoulder or knee joint, is deeply recessed in the bony acetabulum, with a robust capsule and muscular envelope, making access challenging. Additionally, the treatment of chondral disease is made more difficult by the nature of the pathology. Cartilage defects do not regenerate and continue to challenge orthopedists. As is the case in any joint, cartilage injuries of the hip will not heal spontaneously. Thus, joint preservation procedures have become a growing area of interest.

Cartilage defects can be classified as acute, chronic, or degenerative. This includes lesions that are partial or full thickness. They can be traumatic or atraumatic in origin. Often, these lesions do not occur in isolation, but instead occur along with other intra-articular disorders such as degenerative joint disease, loose bodies, labral tears, hip dysplasia, slipped capital femoral epiphysis, instability or dislocation, osteonecrosis, and FAI.

Although treatment of cartilage defects is challenging, our understanding and ability to treat these lesions have continued to expand. The treatment paradigm developed for other joints also holds true in the hip. Treatment options can be divided into repair or restoration techniques. Current treatment techniques for existing injuries include abrasion chondroplasty, marrow stimulation techniques, mosaicplasty, peripheral rim trimming, autologous chondrocyte implantation (ACI), osteochondral allografts, fibrin adhesive products, and particulated juvenile chondral transplantation. Prevention of recurrent or progressive disease is paramount and includes the treatment of FAI to prevent the progression of chondrolabral delamination.

In the literature, McCarthy and Lee reported on a series of 457 hip arthroscopies. He noted that most chondral defects occurred in the anterior acetabular quadrant (59%) and tended to be associated with labral tears. Seventy percent of these defects were grade III or grade IV according to Outerbridge criteria. In the literature, McCarthy and Lee reported on a series of 457 hip arthroscopies. He noted that most chondral defects occurred in the anterior acetabular quadrant (59%) and tended to be associated with labral tears. Seventy percent of these defects were grade III or grade IV according to Outerbridge criteria.

Patient selection is critical in arthroscopic procedures of the hip. Short-term results are promising, but long-term outcomes are needed to demonstrate prevention or delay in the onset of osteoarthritis. Byrd and Jones reported on 52 hips treated with hip arthroscopy for a wide range of disorders, with a minimum of 10 years of follow-up. They stated a median improvement in Harris hip score (HHS) of 25 points.

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(56 preoperative, 81 postoperative). Fourteen patients subsequently underwent total hip arthroplasty (THA). The presence of arthritis at the time of the index procedure was an indicator of poor prognosis. Radiographic evidence of joint space narrowing (joint space ≤2 mm) has been shown to decrease the postoperative HHS and imparts a 39-fold greater risk of conversion to THA. It has been established that Outerbridge grade III or IV cartilage injury noted at arthroscopy or Tonnis grade I or greater degenerative disease on preoperative radiographs is associated with inferior clinical outcomes after hip arthroscopy.

**History and Physical Examination**

A thorough history and physical examination should be the initiation of any complete patient evaluation. The location of the pain is often discussed initially. Intra-articular hip pathology will most often be indicated by anterior groin pain, although it can be referred to the lateral thigh or posteriorly to the buttock. This pattern has been labeled the C-sign, as described by Byrd, as the patient will cup their hand over the greater trochanteric region (Fig. 1). Mechanical and radicular back pain must be ruled out as a contributing factor. Hip pathology may also present as knee pain. Attributes of the pain, such as frequency, duration, severity, exacerbating and relieving factors, and chronicity, must also be discussed.

Mechanical symptoms such as clicking, locking, or catching are often associated with labral pathology or loose bodies. Pain emanating from loose bodies may be intermittent as the loose body shifts with different activities. Medical history and surgical history can provide clues regarding diagnosis. Information about previous events such as bracing as a child, previous trauma to the hip or affected lower extremity, and any previous surgical intervention is an important piece of the history and should be elicited. Elite athletes are more likely to develop labral and chondral pathology, so past or current sports participation is important to determine. Specific sporting activities that have been associated with chondral and labral lesions of the hip joint include martial arts, soccer, rugby, and long-distance running.

A complete physical examination should be performed and entails weight and height recordings. Gait analysis may reveal a Trendelenburg gait pattern indicative of hip abductor weakness and/or hip pathology. Lumbar spine range of motion and straight leg raise test should be performed to rule out concomitant spinal pathology. A standard physical examination begins with palpation of bony landmarks as well as appropriate soft tissues. Side-to-side range-of-motion comparisons should be completed with the hip flexed to 90° to assess internal and external rotatory movements. Any catching, popping, or locking should be noted. Special tests for cartilage lesions are limited. The “straight leg raising against resistance test” attempts to create a large compressive force across the articular surface, resulting in groin pain. Partial-thickness lesions will be asymptomatic, whereas full-thickness lesions will be painful. Various provocative tests related to impingement exist and should be performed as part of a routine examination for hip pathology in the young patient. Our preferred impingement test involves bringing the hip into flexion and internal rotation while a compressive force is applied across the joint. The leg is then brought into extension as the hip is externally rotated in an attempt to isolate the cartilage lesion location (Fig. 2). The position of the hip when mechanical symptoms or pain is elicited should be noted. The preferred resting position of the hip can also offer clues to intra-articular pathology. An intra-articular effusion will force the joint into its loose-packed position, ie, the position that allows the most expansion of the capsule. In the case of the hip, this position is flexion, abduction, and external rotation.

**Imaging**

Plain radiographs taken to evaluate for fractures, dislocations, degenerative changes, hip dysplasia, calcified loose bodies, and bony lesions are essential. For the evaluation of the painful hip, standard plain radiographs include an A/P pelvis, 45° Dunn lateral, and false profile view. Critical evaluation of the pelvis radiograph is mandatory to ensure no rotation. An adequate anteroposterior pelvis radiograph must show the coccyx in line with the spinous processes and the inferior tip <2 cm from the pubic symphysis. Critical evaluation of the pelvis radiograph is mandatory to ensure no rotation. An adequate anteroposterior pelvis radiograph must show the coccyx in line with the spinous processes and the inferior tip <2 cm from the pubic symphysis. Advanced imaging often will include 3-dimensional computed tomography reconstructions to allow guidance of selective osteoplasty in the setting of concomitant FAI. Unfortunately, as in most joints, cartilage lesions are notoriously difficult to image. The sensitivity and specificity of magnetic resonance imaging (MRI) in accurately predicting cartilage lesions con-
sistent with arthroscopic findings are quite poor. Magnetic resonance arthrogram (MRA) is the current diagnostic tool of choice for labral or chondral pathology. Dilute gadolinium solution is injected intra-articularly to distend the capsule. Osteochondral lesions are typically outlined by gadolinium. In the literature, sensitivity and specificity have been reported as 47% and 89%, respectively. Caution is warranted, as high false-negative rates will limit its use in ruling out cartilage defects. Other recent advances in imaging include delayed contrast MRI (delayed gadolinium-enhanced MRI of cartilage). This technique has proven to enhance cartilage lesion diagnosis.

Anatomic cartilage anomalies of the acetabulum have recently been described in the literature. Dietrich et al in the *Journal of Radiology* discuss the findings of the supra-acetabular fossa (SAF; pseudodefect of the acetabular cartilage). These anatomical variants should not be confused with cartilage defects, and are normal anatomic findings (often seen bilaterally), which require no surgical intervention. The authors reviewed >1000 MRAs for the presence of SAF. They classified SAF into 2 types: type 1 was filled with contrast material on the MRA, and type 2 was filled with cartilage. The SAF lesions were also evaluated for subchondral reactions. They found no subchondral reactions around the SAF lesions, and at the time of arthroscopy, no cartilage defect was noted at the SAF lesion (Fig. 3).

**Operative Technique**

In our practice, the supine position is used on a standard radiolucent table, with a proprietary distraction unit (Smith and Nephew Endoscopy, Andover, MA) attached to the foot of the bed. Perioperative nerve block in the form of a fascioiliacus volume block is performed to maximize postoperative pain control. General anesthesia with complete neuromuscular blockade is administered to allow for adequate muscle relaxation for appropriate hip distraction. A large well-padded perineal post and well-padded boots are used. The hip is positioned in slight internal rotation, flexion, and abduction to assist with distraction. Distraction is then performed until approximately 1 cm of joint distraction is demonstrated fluoroscopically. The hip may be vented at this point steriley if there is difficulty in obtaining adequate distraction. The anterolateral portal is then placed in standard position under fluoroscopic guidance and is followed by a modified mid-anterior portal. We find that the

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**Figure 2** Hip circumduction test. Begin with hyperflexion, internal rotation, and axial compression. Return to neutral position by extending and externally rotating while maintaining axial compression. Document position of pain replication.

**Figure 3** (A) T2-weighted magnetic resonance imaging demonstrating supra-acetabular fossa. (B) Corresponding image obtained during arthroscopy.
face, with 12 o'clock located at the superior acetabulum. Described by location in terms of its position on the clock face. In an attempt to define additional radiographic parameters that may detect changes in the acetabular cavity with rim trimming. Five mm was resected off the anterior acetabulum in the 12- to 3-o'clock position. Anteroposterior radiographs were obtained, and the anterior rim angle and anterior wall angle were calculated. The anterior rim angle and anterior wall angle decreased by 1° for each millimeter of rim resected.17

Once the rim is trimmed and the cartilage is taken down to a stable base, the labrum is repaired to the prepared bed with the appropriate number of suture anchors to obtain visualized stability. Cadaveric studies define a safe zone for suture anchor placement to be 2.3-2.6 mm from the rim, with an anchor angle of 10°.18

**Chondroplasty**

There is certainly a role for chondroplasty in the hip. Although it may be most effective for partial-thickness cartilage defects with a loose flap, it can be used for full-thickness defects. The primary goal is to create a stable surface and thus mitigate the likelihood of future loose bodies and subsequent mechanical symptoms. Typically, this is cautiously performed using a motorized shaver to establish a smooth surface. In our practice, a prebent shaver can be very helpful for this task, as it allows a better angle and greater access to difficult-to-reach areas of the joint. We find that a combination of different portals can assist in accessing lesions. A standard anterolateral portal is used as is a modified mid-anterior portal and accessory distal anterolateral portal for acetabular lesions. To access lesions on the femoral head, these portals in addition to a more proximal and anterior portal that is located at the position of the classic anterior portal or slightly proximal to this can be used and localized with a spinal access needle. Byrd and colleagues reported their results of hip arthroscopy at a 10-year follow-up. Using a modified Harris hip score (mHHS), they reported a 19-point improvement in patients with chondral lesions treated with simple debridement. When patients with arthritic changes were excluded, the improvement increased to 38 points. Fifty percent of the patients had an improvement of >10 points at 2-year follow-up, 36% remained improved at the 5-year follow-up, and 79% had undergone conversion surgery to TKA by 10 years. The authors suggest a frank discussion with the patient regarding the likely need for arthroplasty in the future.16

**Peripheral Rim Trimming**

FAI is primarily a mixed disorder consisting of components of cam and pincer types. Often the paralabral cartilage will be damaged by the shearing effects of the cam lesion.2 Initially, this damage presents as a “wave sign” but can continue to progress to delamination.16

We prefer to address these lesions via a rim resection. The acetabular rim is cleared of the overlying capsule using a combination of radiofrequency ablation and a motorized shaver. A 4.5-mm prebent burr (ConMed, Linvatec, Largo, FL) is then used to resect the appropriate amount of rim to achieve a stable osteochondral junction. We find that a prebent burr is incredibly useful for this portion of the procedure, as it allows for a less aggressive capsulotomy while still preserving the ability to reach the entire rim. At this time, any pincer lesion is addressed as long as the center edge angle is >25°. Gross and colleagues evaluated a cadaveric model in an attempt to define additional radiographic parameters that may detect changes in the acetabular cavity with rim trimming. Five mm was resected off the anterior acetabulum in the 12- to 3-o’clock position. Anteroposterior radiographs were obtained, and the anterior rim angle and anterior wall angle were calculated. The anterior rim angle and anterior wall angle decreased by 1° for each millimeter of rim resected.17

Microfracture has demonstrated good long-term outcomes in the treatment of knee cartilage defects.19 Promising outcomes in the hip have also been demonstrated over the short- to medium-term follow-up.20 Microfracture is the most common marrow-stimulating technique performed. The goal is to create channels in the subchondral bone to release multipotent stem cells, growth factors, and platelets from the marrow (Fig. 4A/B). The goal is to create a fibrin superclot that will eventually remodel into fibrocartilage to fill the defect.3 Unfortunately, mature fibrocartilage contains predominately type I collagen, with only minimal amounts of type II collagen. This limits the durability of this repair tissue when compared with native articular cartilage.21

The technical principles developed for the treatment of lesions of the knee have been carried over to the treatment of the hip.21 Lesions amenable to microfracture are identified via diagnostic arthroscopy, and the size and depth of the lesion are noted. In general, microfracture is preferred for smaller lesions that are well contained, with a total area of <4 cm² in size.22 Literature in the treatment of lesions of the knee has demonstrated that lesions <4 cm² respond better to microfracture than those >4 cm² in size.19

Initially, a motorized shaver is used to prepare the site to remove any loose cartilage and debris. In some cases, if the angles are not favorable to perform a microfracture, an abrasion chondroplasty can be performed instead. In this case, a prebent burr can help in gaining access to these difficult-to-reach lesions. A ring curette may be used to...
obtain perpendicular shoulders of normal cartilage around the lesion to serve as a stabilizer of the newly formed clot. A standard curette is then used to remove the calcified cartilage layer, with care taken to not penetrate the subchondral bone. Arthroscopic awls are used to create multiple holes in the subchondral bone to serve as channels for the stem cells. Initially, the holes are created around the periphery, and then in the middle of the lesion. In the hip, on the acetabular side, we find it most useful to place the camera in the standard anterolateral portal, with the microfracture awls introduced via the modified mid-anterior portal or an accessory distal anterolateral portal. It can be difficult to keep the microfracture awl perpendicular to the joint surface, and steady pressure should be used. Often, a pilot-type hole can be created simply using manual pressure before any mallet strikes. Additionally, a specially designed microfracture awl is available for acetabular microfracture, which allows for mallet strikes at a more perpendicular vector (Smith and Nephew, Andover, MA). Previous literature has recommended the holes to be 3-4 mm apart and 2-4 mm in depth. After the process is complete, the pump pressure is reduced to allow visualization of the efflux of blood and marrow products from the microfracture sites.

**Osteochondral Autograft Transplantation (Mosaicplasty)**

Osteochondral autograft transplantation or mosaicplasty may be considered for lesions too large for microfracture and in the revision setting when microfracture or abrasion chondroplasty has failed. Damaged weight-bearing surfaces of the acetabulum or femoral head may be considered for osteochondral transfer procedures. One may also consider mosaicplasty when dealing with subchondral plate damage. The initial preparation of the lesion is similar to microfracture. Care is taken to accurately determine the size of the lesion and the necessary size and number of osteochondral plugs. Preferred harvest sites include the peripheral non–weight-bearing zones of the femoral head anteriorly or the ipsilateral knee, which has been well described in the literature. This is typically the region resected for treatment of a cam-type FAI lesion. The recipient bed is prepared with appropriate drilling. The harvested bone plugs are then inserted into the recipient bed using a press-fit technique. Care is taken to ensure a uniform chondral surface. Any bone removed during the drilling of the recipient bed can be used as bone graft for the drill holes in the donor bed. Any exposed subchondral regions of the lesion can be microfractured to allow full coverage of the defect.

Mosaicplasty has the advantage of resurfacing the defect with native hyaline cartilage and can restore both articular cartilage and diseased subchondral bone. This is a single-stage procedure with relatively low cost. This technique does have the disadvantage of the potential morbidity created by the harvest sites and the limited amount of “expendable” cartilage. Care is always taken to be cognizant of the contour of the resurfaced articular cartilage.

**Osteochondral Allograft Transplantation**

One may also consider allograft bone plugs. Recent published work by Krysh and colleagues report on the short-term outcomes of acetabular osteochondral allograft transplantation accomplished via a surgical hip dislocation. Early results indicate full incorporation of the graft at 18 months. They also report no progression of arthritic changes, as noted on MRI, at 24 months.
Autologous Chondrocyte Implantation

For chondral lesions deemed too large for microfracture, one may also consider ACI. The technical principles for the hip are very similar to those described for the knee. The technique requires both a harvesting procedure and an implantation procedure. The advent of biodegradable scaffolds (matrix-induced chondrocyte implantation) has allowed for the application of ACI to femoral or acetabular chondral defects via arthroscopy. These scaffolds are not currently Food and Drug Administration approved for use in the United States, but have been used effectively in Europe. Insertion and sewing of a type 1/3 bilayer collagen patch is not possible arthroscopically, but can be done in the setting of a surgical hip dislocation.

Recently, Fontana et al published their results of ACI versus simple debridement, in which they describe their preferred technique.25 They performed arthroscopy in the lateral decubitus position. A 2-stage procedure was performed, with the initial stage to include diagnostic arthroscopy, identification of the lesion, and harvesting of the cartilage biopsy from the area surrounding the pulvinar. The second stage occurred approximately 30 days later. The defect was initially prepared in a manner similar to microfracture, with exposure of the subchondral bone and development of clear margins of healthy articular cartilage. Arthroscopic fluid was stopped, and the joint was suctioned of remaining fluid. The cultured chondrocytes were embedded in a bioabsorbable matrix that was rolled and passed through a cannula to be placed directly into the prepared defect. After the implant was positioned, traction was released, and the hip was taken through a series of extension and rotation movements. Traction was then reapplied, and the graft was confirmed to be stable.

Fibrin Adhesive

Fibrin adhesive products have demonstrated positive outcomes in the literature.26,27 Fibrin adhesive is a biological substance that has seen a wide range of use in other specialties.28-31 Fibrin acts as a scaffold and aids in the release of growth factors and stimulation of fibroblast differentiation.32,33 The literature has demonstrated fibrin adhesives’ ability to seal delaminated cartilage, recruit mesenchymal stem cells, and present a scaffold for cartilage regrowth.34 Fibrinogen is converted to fibrin via an enzymatic reaction of thrombin. Aprotinin assists in delaying the fibrinolytic action of plasmin.35

This technique allows native hyaline cartilage to be preserved and reattached to subchondral bone.27 Histologic studies of delaminated hyaline cartilage have demonstrated viable chondrocytes, making preservation of the articular cartilage flap optimal.36-38

Recent studies demonstrate encouraging midterm results with the proposed technique.26,27 In the hip, this technique has been described for chondralabral delaminated cartilage typically caused by a cam type FAI. A wave sign or carpet sign is often present, indicating delamination.27 The authors recommend a minimum of 1 cm of delamination from the chondralabral junction. The delaminated region must be completely enclosed with hyaline cartilage; any exposed subchondral bone will likely be best treated by microfracture. Access is gained behind the delaminated cartilage through the development of the labral sulcus, with radiofrequency ablation followed by a small incision to gain access under the delaminated cartilage. Next, the joint is drained of irrigation fluid to allow for setting of the fibrin glue. The fibrin adhesive is then injected into the cartilage pocket via a needle typically placed through the anterolateral portal. The delaminated cartilage is then held firmly to the underlying subchondral bone by an angled arthroscopic punch to allow the adhesive to set. The fibrin glue will set in 2 minutes. Any excessive adhesive will spill into the central compartment and can be removed with arthroscopic instrumentation. The chondralabral junction is then sealed, typically using radiofrequency ablation.27 Suture anchors may also be used to adhere the labrum to the rim, especially if a rim trim was performed. Release of traction further aids in compression of the newly repaired delaminated cartilage. Postoperative weight bearing is toe-touch weight bearing for 4 weeks. Preoperative activity levels are generally allowed after 3 months.

Particulate Juvenile Chondral Transplantation

No literature can be found supporting the use of a particulate juvenile chondral graft (DeNovo NT; Zimmer, Inc, Warsaw, IN) in the hip joint, but the technology does lend itself to the unique constraints of femoral acetabular chondral pathology, as it could be adapted to an arthroscopic technique. Creating a mold of the lesion (a step in the current technique) would be challenging arthroscopically. Promising early results have been demonstrated in the knee, and future improvements in technique and instrumentation may make this a viable option in the future.

Postoperative Management

Typically, patients are discharged home on the operative day. Adequate postoperative pain control is achieved with the nerve block and appropriate home-going medications. The patient immediately begins cold therapy via a circulating system and is fitted with a brace that limits range of motion to 90° of hip flexion, neutral hip extension, and 30° of external rotation. A continuous passive motion unit is used for 6-8 h/d in the first 6-8 weeks postoperatively. The patient begins therapy on postoperative day 1. Crutch-assisted weight bearing is performed, with weight bearing limited to no >20 lbs for those undergoing cartilage restorative work.

Outcomes

Outcomes of arthroscopically treated chondral lesions of the hip are limited compared with the literature pertaining to the
knee. However, with the expansion of indications for hip arthroscopic procedures, the literature on outcomes has increased. Byrd and Jones reported on a 2-year follow-up of all comers for hip arthroscopy. They reported on 38 patients, of which 15 were diagnosed with chondral lesions. These patients had an improvement in HHS of 18 points, and the entire cohort had a median improvement of 28 points. The type of treatment was not indicated.39

At this time, microfracture remains the mainstay for cartilage procedures of the hip. Much work has been done regarding microfracture in the knee for full-thickness cartilage defects. Steadman and colleagues have provided a great deal of literature. In 2003, they published a long-term follow-up of >70 patients.10 Patients reported a significant decrease in pain and swelling over the course of the study. Age was determined to be the only predictive factor affecting Lysholm score improvement. Those aged <35 years showed greater improvement than those aged >35 years. Based on these positive long-term results, they believe microfracture is safe and effective at treating knee cartilage lesions. Unfortunately, the literature regarding hip microfracture remains in its infancy. Philippon et al20 provided a second-look study of 9 cases of acetabular chondral defects treated with microfracture and evaluated during revision arthroscopy. They report an average percentage fill of 91%, with 8 of the 9 patients having 95%-100% coverage.

The literature pertaining to mosaicplasty of the hip is also sparse. Initial discussions center on previous results reported in the knee literature. Marcacci et al followed patients for 7 years. A follow-up MRI demonstrated that in 60% of the patients, there was good integration of bone and maintenance of the cartilage cap. Patients reported good or excellent results 77% of the time.40

Limited research has been done pertaining to outcomes of ACI. Fontana et al recently published a controlled retrospective study of 30 patients with acetabular chondral defects. Fifteen patients were treated with autologous chondrocyte transplantation (ACI), and 15 were treated with arthroscopic debridement. The mean follow-up was 74 months. HHS was assessed pre- and postoperatively. Patients treated with ACI (HHS, 48.3-87.4) demonstrated a significant improvement in HHS compared with the debridement group (HHS, 46-56.3).25

Stafford et al recently published their midterm results using fibrin adhesive for reattachment of delaminated chondral flaps in 43 patients treated for FAI. Patients were assessed pre- and postoperatively with the mHHS at a mean of 28 months. The mHHS for pain improved significantly from 21.8 to 35.8. The mHHS for function also showed significant improvement from 40.0 to 43.6.27

Conclusions

Injured articular cartilage has limited ability to regenerate, and full-thickness lesions may contribute to the premature development of osteoarthritis.41 For those patients who have failed nonoperative measures, cartilage-preserving surgical treatment may be necessary. In general, these techniques can be thought of as palliative, reparative, or restorative. Options include abrasion chondroplasty, peripheral rim trimming, microfracture, mosaicplasty, ACI, and fibrin adhesive products. Short-term results are promising, but long-term studies are necessary to demonstrate delay and prevention of subsequent osteoarthritis.

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