Open Reduction Internal Fixation of Isolated Chondral Fragments Without Osseous Attachment in the Knee

A Case Series

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Background: Isolated chondral fractures of the knee are a rare and challenging problem, typically occurring with an acute traumatic event such as dislocation of the patella or ligamentous injury. Historically, repair of unstable chondral fragments without osseous attachment has not been recommended due to concerns about the limited healing potential of cartilage.

Purpose: To describe a technique for fixation of large isolated chondral fractures of the knee and present 3 cases where large chondral fragments without osseous attachment were fixed successfully with chondral darts and biologic adhesive.

Study Design: Case series; Level of evidence, 4.

Methods: The senior author reviewed his case logs for all patients on whom he performed open reduction and internal fixation on large isolated cartilage fragments without osseous attachment. Three were extracted from his review. The clinical and radiographic outcomes were retrospectively reviewed.

Results: Successful results and complete healing was obtained in all 3 patients. This procedure can be done in the setting of concurrent injury, such as anterior cruciate ligament tear, using single- or multistaged chondral repair and ligament reconstruction techniques.

Conclusion: Isolated chondral fragment repair techniques provide the orthopaedic surgeon an additional option for treating these challenging injuries. Primary fixation can be accomplished for what have been historically considered "unsalvageable" fragments.

Keywords: cartilage; chondral; chondral fracture; fixation

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Chondral lesions, which have been documented in up to 63% of patients undergoing arthroscopy for evaluation of knee pain,[6,24] continue to challenge the orthopaedic surgeon. Because severely damaged cartilage does not repair itself, the past 2 decades have seen the creation of a large number of new surgical treatments designed for cartilage repair and restoration. Current treatments have demonstrated benefits, but high-quality, long-term outcomes data are lacking.[13] Repair techniques also present inherent disadvantages such as requiring multiple operations, donor site morbidity, and cost. Importantly, these techniques frequently describe the reconstruction of injuries that have violated the cartilage and the underlying subchondral bone (ie, osteochondral injuries). The ultimate goal is to fix the native articular cartilage while avoiding additional procedures or further donor site morbidity normally seen in other cartilage repair techniques.

Previous studies suggest that cartilage lesions without an osseous component will not heal.[8,9,11] Recent
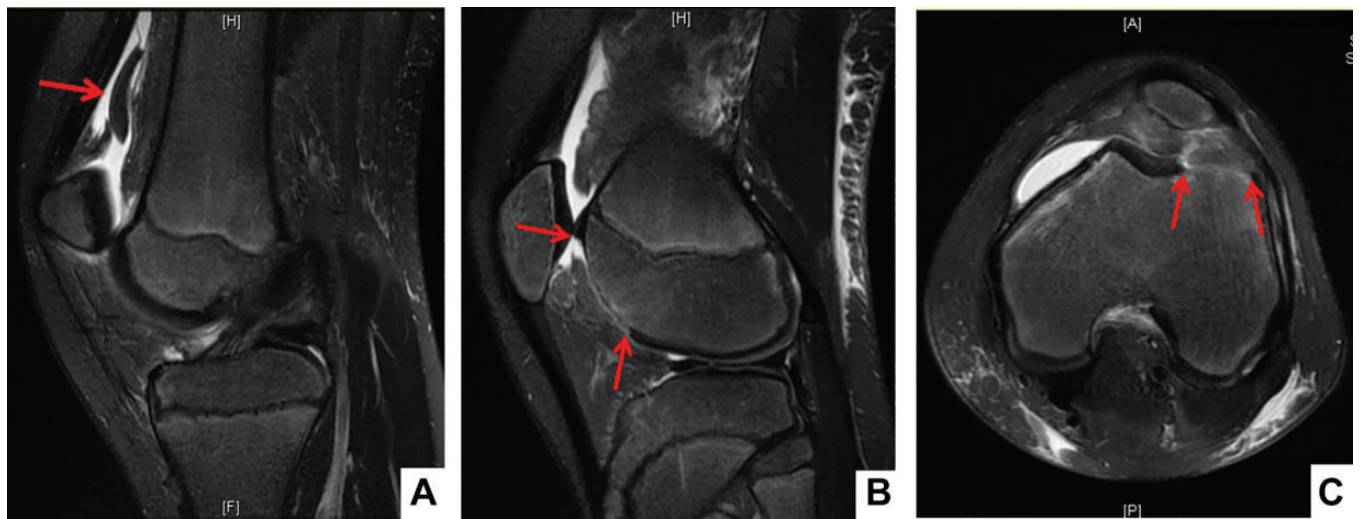
Figure 1. A 13-year-old male with large lateral femoral condyle chondral fracture after patellar dislocation. (A) T2-weighted sagittal image with a large chondral fragment (arrow) resting in the suprapatellar pouch. (B) T2-weighted sagittal image showing a lateral femoral condyle chondral defect (edges framed by arrows). (C) T2-weighted axial image with a large lateral femoral condyle defect (edges framed by arrows).

reports, however, have shown good healing in adolescents whose chondral fragments have been fixed to the lateral femoral condyle.[5,17-19,23] The senior author (D.C.T.) reviewed his case logs from 2006 to 2013 for all patients on whom he performed open reduction and internal fixation on large isolated cartilage fragments without osseous attachment. Due to the rarity of cartilage-only fragments amenable to fixation, only 3 were extracted from his review. No bone was noted on preoperative images (magnetic resonance imaging [MRI]) or gross examination intraoperatively in these cases, and all cases were traumatic in etiology. The clinical and radiographic outcomes were retrospectively reviewed and are reported on in this case report. Our purpose is to present a series of 3 patients who underwent repair of acute cartilage-only lesions (chondral fractures) of the knee to increase awareness of the healing potential of these injuries.

CASES

Patient 1

A 13-year-old male sustained a traumatic dislocation of his patella while playing basketball. He had no prior history of patellar instability or knee pain. Prior to this injury, he was involved in a variety of other sports without limitation. After his initial episode of dislocation, the patella was reduced and he was placed in a knee immobilizer. He had a large effusion and the initial radiographs, from an outside institution, showed no sign of fracture or dislocation. He was told at the outside institution to aggressively manage the effusion with ice and anti-inflammatory medication until symptoms improved. When this patient came to our attention (2 weeks

postdislocation), he continued to have a large effusion and significant pain with knee flexion. An MRI was ordered and a large chondral defect was noted on the lateral femoral condyle. A free chondral fragment was visualized in the suprapatellar pouch (Figure 1). Operative treatment was recommended.

Because this patient's physical examination and imaging were suggestive of a free isolated chondral injury to the lateral femoral condyle, a midline incision was made over the patella using a medial parapatellar approach. When the patella was everted, the large lateral femoral condylar defect was exposed (Figure 2). The chondral fragment was removed from the knee joint and placed in saline.

Preparation of the large defect began with removal of the fibrinous material within the defect as well as removal of the calcified cartilage layer; the subchondral bone was not violated. Using a small curette (Figure 2), the cartilage edges of the lesion were sharply excised to create stable shoulders. The fragment had hypertrophied as it had been displaced for several weeks, so a No. 15 blade was used to contour the fragment back to the shape of the defect. The cartilage removed from the fragment was sent for potential autologous chondrocyte implantation in the future, if necessary. Epinephrine-soaked sponges were applied to the defect to control any bleeding. The bed must be completely dry to avoid hematoma formation under the fragment, which may inhibit contact between the chondral fragment and the defect.

Once appropriately shaped, the chondral fragment was placed in the defect and fixed with chondral darts (Arthrex). In this case, 12 darts were required to stabilize the fragment. Darts were placed at least 3 mm apart to avoid cracking the fragment and buried at least 1 mm below the cartilage surface. The edges of the fragment were
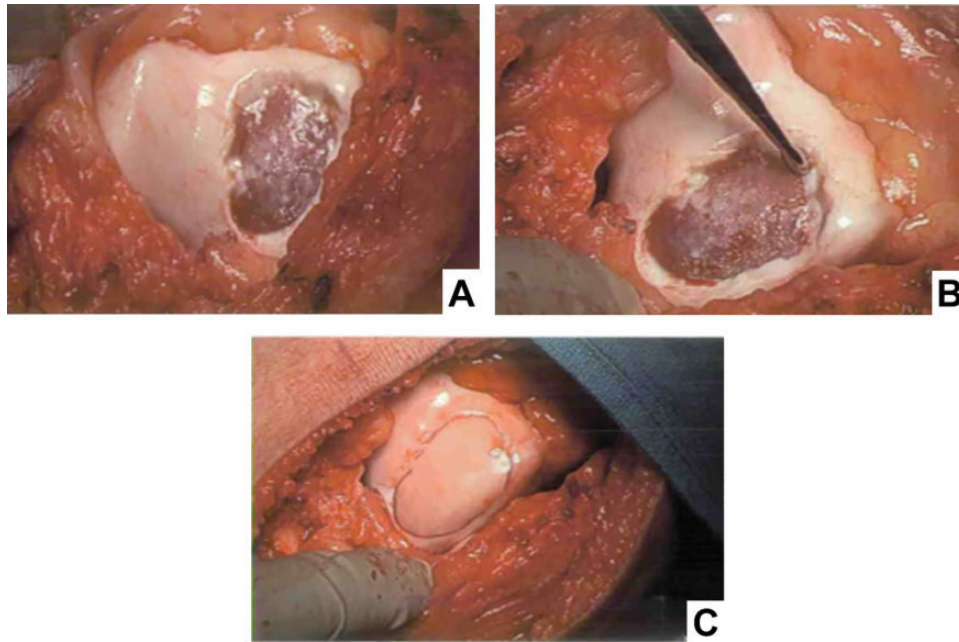
Figure 2. Chondral defect preparation. (A) A medial parapatellar approach allows patellar eversion. The defect is exposed and fibrinous material removed. (B) Curette was used to debride the calcified cartilage layer. (C) Free chondral fragment trimmed to fit back in the defect. The fragment edges should be sharply cleaned with a No. 15 blade.
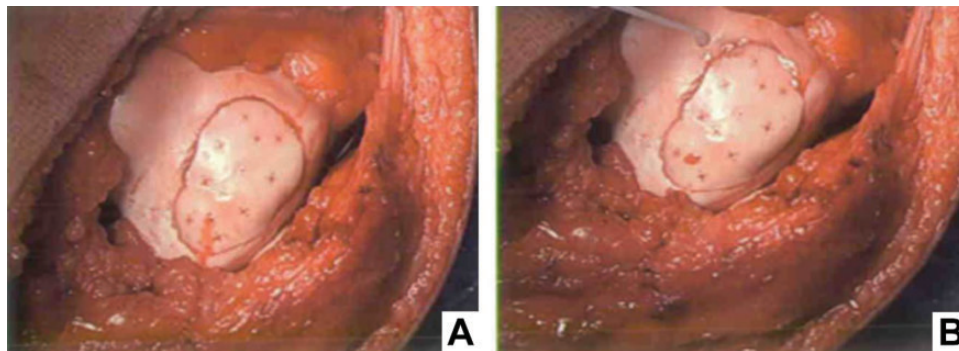

Figure 3. Chondral fragment fixation and sealing. (A) The fragment is fixed with chondral darts, evenly spaced, supporting the edges to avoid tilting. (B) Fibrin glue (Tisseel) is applied to the edges to seal the fragment in place and provide additional fixation.

stabilized early to avoid any tilting. Tisseel fibrin glue (Baxter) was then applied to the entire rim of the repaired fragment to seal the edges (Figure 3). Once the Tisseel was dry, the wound was irrigated thoroughly and closed in layers. Of note, in situations where the cartilage at the edges of the fragment does not fit perfectly, 6-0 Vicryl sutures (Ethicon) can be used to sew the fragment into the defect and augment the Tisseel fibrin glue. After fragment fixation, the medial patellofemoral ligament was imbricated to stabilize the patella.

The patient was placed into a hinged knee brace locked in full extension for 2 weeks. He was allowed to do straight-leg raises and isometric quad set exercises with the brace locked. At 2 weeks, he began using a continuous passive motion machine with progressive advancement to 90° of flexion over a 1-month time frame; he remained nonweight-bearing for 6 weeks. At 6 weeks after surgery, he was allowed to unlock the brace and begin full weightbearing. Once he had full motion and quadriceps strength, he was allowed to discontinue using the brace. He was instructed not to do any deep squat exercises until 4 months after surgery. At 3 months after surgery, he was pain free and continuing physical therapy. MRI revealed excellent early healing and integration of the fragment with the surrounding cartilage (Figure 4).

At most recent follow-up (1 year after surgery), the patient had returned to full activity, including playing tennis. He has no pain and his motion is equal to the contralateral side; the only difference is slightly decreased quadriceps tone compared with the contralateral side.
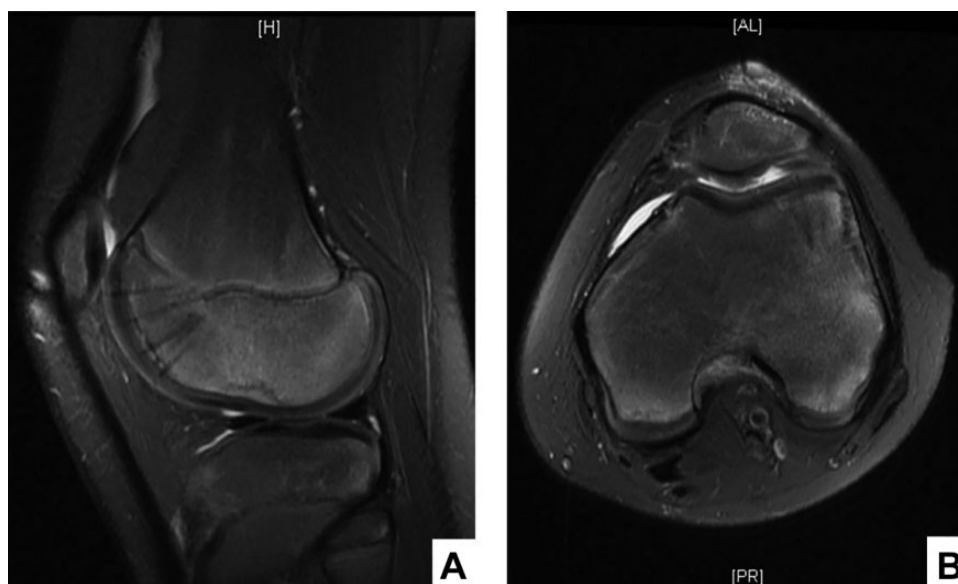
Figure 4. Three-month postoperative magnetic resonance image. T2-weighted (A) sagittal and (B) axial images showing a smooth, healing chondral surface with chondral darts in place.

Patient 2

A 29-year-old male injured his left knee playing ultimate Frisbee 1 month prior to evaluation. Clinical examination showed the patient to have an anterior cruciate ligament (ACL) tear, full-thickness medial femoral condyle chondral injury with large loose body, and medial and lateral meniscal tears. Prior to surgery, the patient was made aware of the possibility of a 2-stage procedure considering the complex nature of his injuries.

In the first-stage procedure, a 3-cm chondral loose body was identified arthroscopically and then removed from the knee through a large posteromedial portal. The medial meniscus repair, partial lateral meniscectomy, and ACL stump debridement were completed during arthroscopy. Next, an anteromedial incision was made over the defect to facilitate open reduction internal fixation of the chondral fragment. The fragment was trimmed to contour into the defect. The defect was debrided carefully to remove the calcified cartilage layer without damaging the subchondral bone. The fragment was fixed with 9 chondral darts, and the edges of the fragment were sewn to adjacent tissue with 6-0 Vicryl sutures for additional fixation. Tisseel fibrin glue was then applied to the entire rim of the repaired fragment to seal the edges.

The patient did well postoperatively from his first operation, working to regain range of motion and heal his medial meniscus repair. He was nonweightbearing for 3 months after surgery but was able to work on range of motion and strengthening in physical therapy. The second procedure, the ACL reconstruction, was completed approximately 4 months later after the patient had regained his motion and strength. His prior medial femoral condyle chondral repair was progressing well (Figure 5). The cartilage fragment had incorporated into the adjacent cartilage tissue. There was minimal fraying on the posterior edge of the repair, and a small piece of one of the chondral darts

was removed. As his medial meniscus repair had healed, he was able to complete a standard ACL reconstruction rehabilitation protocol.

He subsequently returned to all preoperative activities. Figure 6 shows progressive MRI images of the chondral injury after the initial surgery (3 months, 14 months, and >3 years). At his most recent follow-up (>3 years after chondral repair), he continues to do well, has full range of motion, no recurrent effusions, and no tenderness over the medial femoral condyle.

Patient 3

A 30-year-old male sustained a twisting injury to the knee while playing soccer. Physical examination and MRI confirmed medial and lateral meniscal injuries, full-thickness chondral injury to the medial femoral condyle, and a complete ACL tear. The decision was made to complete the entire procedure in 1 stage because it was a smaller chondral fragment, and our experience gave us more confidence that these can heal. At the time of arthroscopy, the 12 × 18-mm chondral fragment was found to be in good condition. After medial meniscal repair, lateral meniscal debridement, and ACL reconstruction, an incision was made along the anteromedial aspect of the joint to repair the chondral fragment. Using 4 chondral darts, the fragment was repaired in a similar fashion as described previously including 6-0 Vicryl sutures at the periphery. Tisseel fibrin glue was again added as an additional adhesive.

The patient had an uneventful initial course after surgery. He was nonweightbearing for 6 weeks to protect the meniscal repair and chondral fixation and remained in a brace for approximately 8 weeks. Eight months after the initial procedure, the patient underwent diagnostic arthroscopy for recurrent knee effusions. At second-look arthroscopy, there was some fraying of the ACL graft; the
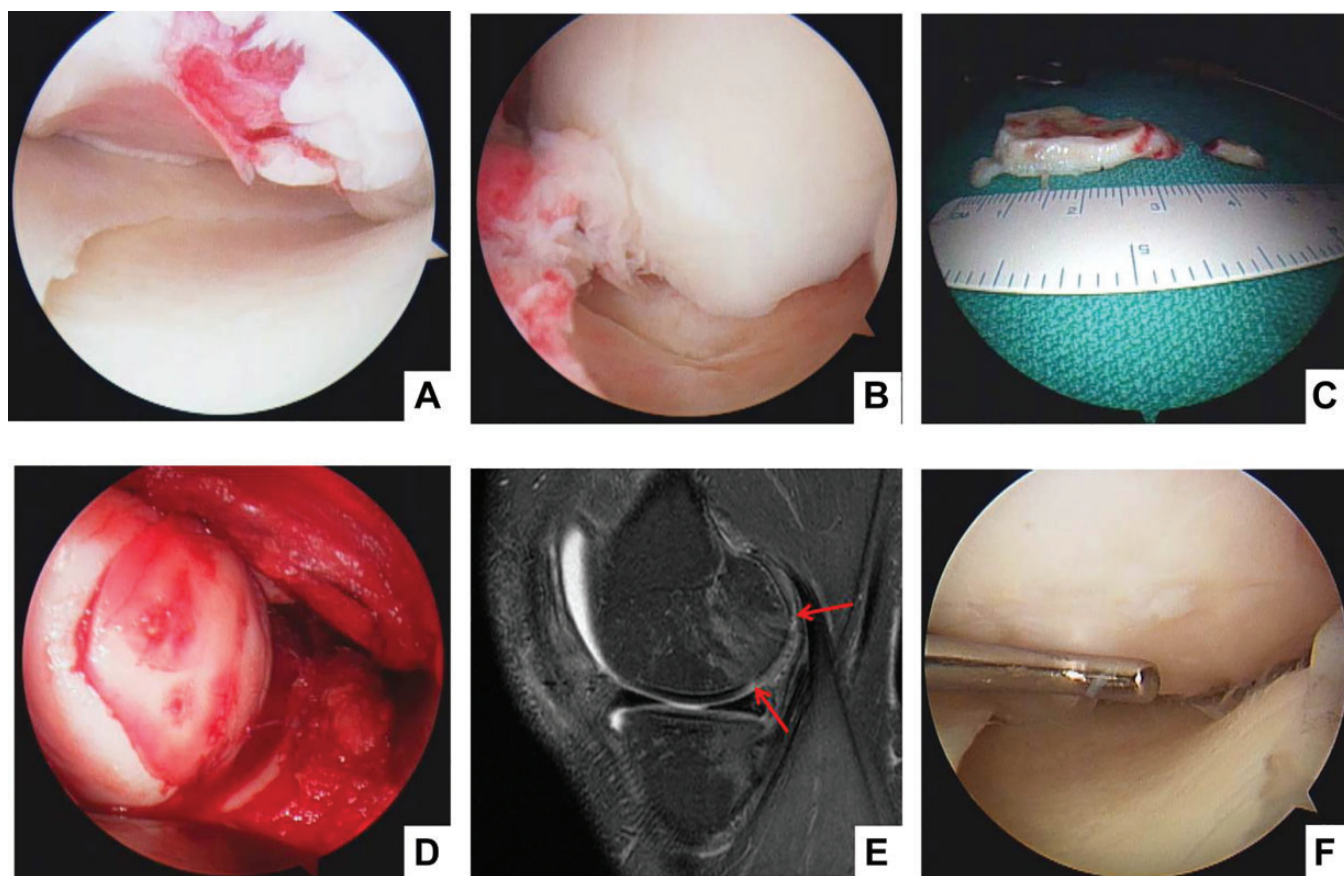
Figure 5. Chondral fragment repair and second-look arthroscopy on a left medial femoral condyle lesion in a 29-year-old male. (A) Initial arthroscopic evaluation with a large chondral lesion noted with irregular edges. (B) A 3-cm chondral fragment was found in the posteromedial compartment and (C) removed via a posteromedial portal for preparation. (D) The chondral fragment was repaired with chondral darts and sutured at the edges. (E) The 3-month postoperative magnetic resonance image shows healing of the fragment but still maturing edges (arrows). (F) The 4-month postoperative second look at the time of the patient's anterior cruciate ligament reconstruction. The cartilage appears well, with no loose edges or signs of fragmentation.
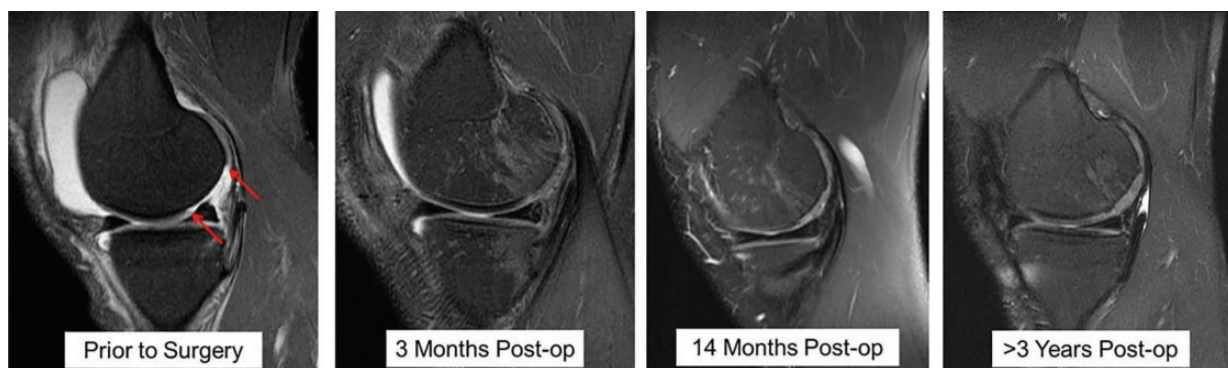

Figure 6. Long-term magnetic resonance follow-up images of a large left knee medial femoral condyle chondral repair. Image prior to surgery has red arrows demarcating the edges of a large chondral lesion. Over time, the lesion has healed well, and no chondral loss is noted.

frayed portions of the graft were removed using a shaver. The chondral repair was fully reincorporated to the surrounding tissue. Figure 7 shows initial and second-look arthroscopic photos of the chondral lesion.

At the most recent follow-up (18 months after his initial procedure), the patient continues to improve. He has no pain with daily activities or walking but does note soreness with exercise. He has 10° less of flexion on
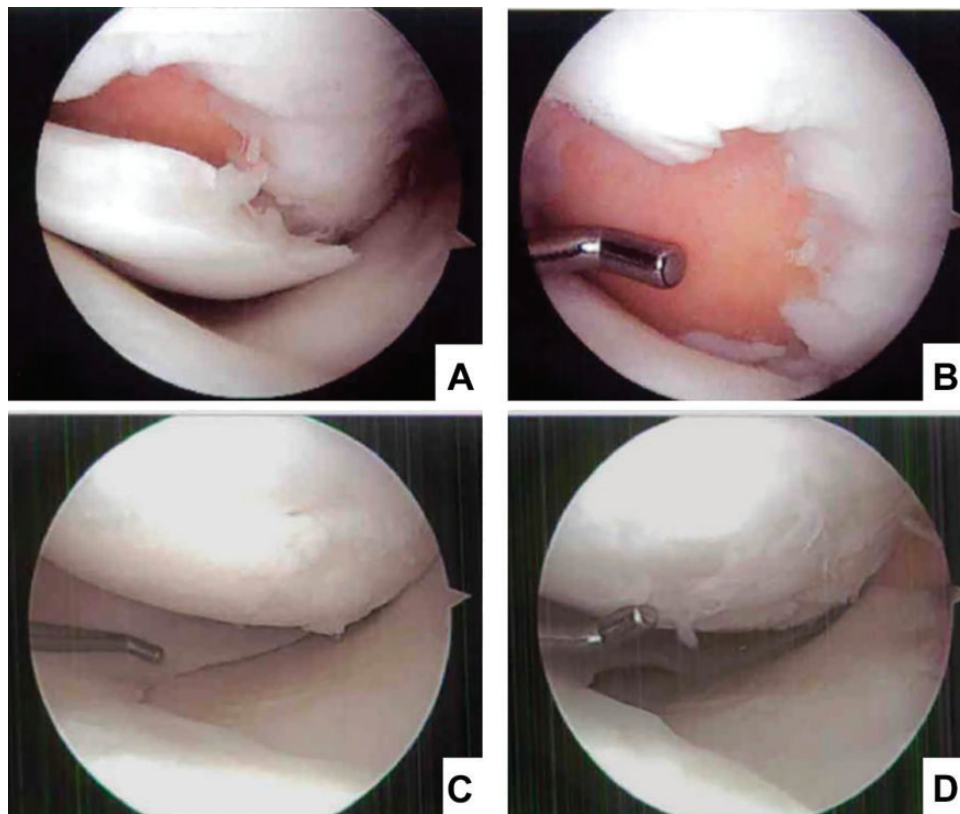
Figure 7. Second-look arthroscopy for a healed medial femoral condyle chondral lesion: a 30-year-old male with medial femoral condyle chondral fracture in the setting of an anterior cruciate ligament (ACL) tear. (A and B) Large chondral-only fracture with intact subchondral bone prior to repair. (C and D) The medial femoral condyle cartilage was intact and well incorporated at second-look arthroscopy for debridement of the partial ACL tear and scar resection in the suprapatellar pouch.

the operative side compared with the contralateral side. He is continuing to work on his range of motion and strengthening his quadriceps, as directed by physical therapy.

DISCUSSION

Cartilage lesions of the knee are a difficult but frequent problem for orthopaedic surgeons. This can be particularly challenging in the young active patient whose high-level athletic expectations do not correspond with his or her surgical options. While many treatment options exist such as curetting, microfracture, resurfacing procedures, and biologic augmentation after removing the fragment, there are little data on the outcomes of primary fixation of the cartilage-only fragments. Often deemed "unfixable" or "unsalvageable," these fragments, which are often quite large, are routinely excised from the knee and discarded.[1,14,16,20,22]

Operative fixation of loose osteochondral fragments within the knee has been well studied, and many surgeons will attempt fixation of these fragments if there is adequate subchondral bone still attached to the fragment.[2,3,10,21,25] Much of this literature comes from studying patients with osteochondritis dissecans (OCD). However, this

recommendation does not universally extend to cartilage-only fragments. Anderson et al[4] presented 5 patients with OCD who had cartilage-only lesions without any macroscopically visible subchondral bone attachment. Ages ranged from 13 to 25 years (mean age, 19 years), and 2 lesions were located on the lateral femoral condyle while the remaining 3 were located on the medial femoral condyle. Four of the 5 lesions were stable 12 weeks after surgery while 1 had some slight motion in the one-third of the lesion that required debridement and drilling of the unhealed portion. Overall, results were good; Knee injury and Osteoarthritis Outcome Score (KOOS) subscales for knee pain, knee symptoms, and function in activities of daily living were similar to published age-matched controls. Scores for sports and recreation function and knee-related quality of life, however, were lower.

Maletius and Lundberg[15] reported on fixation of large chondral fragments on the lateral femoral condyle in an 18- and a 21-year-old patient and showed that only one-third to one-half of the defect healed. One case was traumatic and the other occurred during a time of intense training but with no known traumatic event. They determined there was still a thin layer of bone attached to the cartilage in the locations where it healed. All other reports of healing chondral fragments have been in adolescent patients (Table 1) and have discussed lesions of the lateral femoral

TABLE 1
Fixation of Chondral Fragments in Adolescents[a]

Study	Age, Sex	Sport	Location	Fixation	Results
Nakamura et al[18]	11, M	Soccer	Lateral femoral condyle	4 bioabsorbable pins	Full activities at 2 y
Lawrence et al[12]	12, M	Skateboarding	Lateral femoral condyle	Suture bridge fixation	Full activities at 2 y
	13, M	Soccer	Lateral femoral trochlea	3 bioabsorbable pins	Full activities at 2 y
Uchida et al[23]	12, M	Running	Lateral femoral trochlea	3 bioabsorbable pins	Full activities at 2 y
	13, M	Soccer	Lateral femoral trochlea	Bioabsorbable pins	Full activities at 2 y
Chan et al[5]	12, M	No sport	Lateral femoral condyle	Bone fixation nails, bioabsorbable suture anchors, and suture	Healed at the time of medial patellofemoral ligament reconstruction at 1 y
Nakayama and Yoshiya[19]	14, M	Soccer	Lateral femoral condyle	8 cortical bone plugs	Full activities at 2 y
Morris et al[17]	14, M	Basketball	Lateral femoral trochlea/ condyle	Chondral darts	Full activities at 1.5 y

[a]M, male.

condyle and trochlea. Uchida et al[23] reported that they required second-look arthroscopy in 2 of their patients due to the bioabsorbable pins backing out. Postoperatively, both Nakamura et al[18] and Lawrence et al[12] allowed their patients to return to sporting activities at 6 months.

In the adolescent patient population, purely chondral lesions usually occur in isolation resulting from twisting injuries, usually during sporting activities. Lesions of the lateral femoral trochlea are likely the result of an underlying patella subluxation or dislocation event. In the adolescent patient, the twisting injury is thought to cause a shearing fracture where the transition from cartilage to bone is weakest. Biomechanically, it has been shown that the adolescent knee has decreased shear strength at the transition from cartilage to bone when compared with younger or older knees.[7] Our 13-year-old patient (patient 1) demonstrated a similar mechanism of injury and location as previous studies.[5,12,17,18,23] Conversely, the adult patients in the study sustained cartilage lesions during pivoting injuries, resulting in ACL and meniscal tears. An injury resulting from a high-impact force is likely needed to break the cartilage free from the underlying bone since weakness at the cartilage-bone interface is not present. While most adolescent patients can return to sports in 6 months and be symptom free at 2 years, our 2 adult patients may not be able to return to sports as quickly since their lesions were associated with ACL and meniscal injuries.

There are a few weaknesses in this report, most notably the small sample size and case series format without any comparison group. We also used multiple fixation devices and did not collect any formal patient-reported outcomes to report. It is our belief that although this study has minimal numbers of patients and no standardized fixation method, we do show that loose cartilage fragments might not be as "unsalvageable" as previously thought. Fixation does require a patient to be compliant with weightbearing restrictions and rehabilitation so patient selection is important. Future work needs to be performed to further study chondral fixation of free fragments in this patient population. It would be beneficial to prospectively randomize these

patients to free chondral fixation versus microfracture or other resurfacing procedures and then follow them with standardized imaging, objective range of motion and strength testing, and functional outcome scores.

CONCLUSION

Chondral fractures in the knee are very difficult to treat. Acute chondral fractures with unstable cartilage fragments can be seen in isolation in adolescents but typically are seen in combination with ligamentous injuries in adults. We recommend that fixation of full-thickness chondral fractures should be attempted for any full-thickness lesion where the chondral fragment is still intact. There is no time limit on when this procedure can be carried out; however, the earlier the procedure is performed, the less likely the piece will fragment and not be amendable to repair. Ideally, surgical repair of these chondral fragments should be attempted within 2 weeks of injury. We have shown that repairing these fragments with multiple fixation devices, including chondral darts, absorbable sutures, and a biologic adhesive, can lead to successful results with MRI and arthroscopically documented healing on second-look arthroscopy. Cartilage-only fragments can heal in the adult as well as in the adolescent patient. Internal fixation of chondral fragments should be considered in acute articular cartilage injuries.

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