Original Article

Bioabsorbable Screw Fixation Provides Good Results With Low Failure Rates at Mid-term Follow-up of Stable Osteochondritis Dissecans Lesions That Do Not Improve With Initial Conservative Treatment

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Purpose: To evaluate the clinical and radiographic outcomes of patients who have undergone bioabsorbable screw fixation for intact, stable grade I and II osteochondritis dissecans (OCD) lesions for which at least 6 months of conservative management has failed. **Methods:** A retrospective review of prospectively collected data from a single institution was performed to identify patients who underwent internal fixation of stable grade I and II OCD lesions (according to the Guhl classification) between January 2010 and January 2020. Patients were included regardless of the presence of concomitant procedures. The inclusion criteria consisted of (1) primary surgery, (2) failure of at least 6 months of conservative management, (3) the use of a bioabsorbable screw (or screws), and (4) minimum 2-year clinical follow-up. Radiographs were obtained at a minimum of 1 year postoperatively. Patient demographic characteristics, clinical patient-reported outcomes, complications, and failure rates were noted. **Results:** Twenty-four knees among 23 patients (96% follow-up) were analyzed and followed up for 6.36 ± 3.42 years (range, 2.0-12.7 years). Patients showed statistically significant postoperative improvements in all patient-reported outcomes including the Lysholm score, International Knee Documentation Committee score, and Knee Injury and Osteoarthritis Outcome Score subscales ($P < .05$). In 3 knees (12%), a reoperation was required due to failure at an average of 3.64 years after the index procedure. No specific complications were attributed to the use of bioabsorbable screws. Patients in whom primary surgical treatment failed did not differ in demographic characteristics, arthroscopic findings, or surgical treatment from those who had successful treatment. **Conclusions:** Internal fixation of stable grade I and II OCD lesions with bioabsorbable screws produces reliable results with a 12% rate of failure in appropriately indicated patients in whom at least 6 months of conservative management has failed. Clinical outcomes improved significantly during the mid-term follow-up period. **Level of Evidence:** Level IV, therapeutic case series.

Osteochondritis dissecans (OCD) is a pathologic process of multifactorial etiology affecting the subchondral bone and overlying articular cartilage resulting in varying degrees of detachment and instability.[1] The prevalence of OCD lesions is estimated at 15 to 30 cases per 100,000 patients annually.[2] The knee is the primary joint affected, with a recent multicenter prospective database of over 1,000 knees showing a distribution of involvement as follows: medial femoral condyle, 66%; lateral femoral condyle, 18%; trochlea, 9.5%; patella, 6%; and tibial plateau, 0.2%.[3] Lesions that fail to heal may ultimately lead to degenerative changes, pain, and swelling deriving from the affected compartment, all contributing to limitations in activities.

Treatment decisions are primarily based on patients' physeal status as well as lesion characteristics, especially lesion stability.[4] Unstable lesions are defined as those with fluid or hyperintense signal deep to the OCD lesion on T2-weighted magnetic resonance imaging (MRI). Skeletally immature patients with intact, stable

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lesions are typically treated with conservative management, which has a reported success rate of 81% to 96% in these cases.[5] However, for patients in whom conservative treatment has failed or patients with unstable lesions, surgical treatment is recommended.[6] In skeletally mature patients, operative management is typically considered earlier given that OCD lesions have shown a poor capacity for healing after physeal closure.[7] Surgical options for stable lesions include drilling to stimulate vascular healing or reduction of fragments with screws, darts, or pins. Drilling without fixation for stable OCD lesions has been associated with variable and often unpredictable outcomes, with failure rates ranging from 0% to 33%.[8-12]

After making the decision to treat a patient with OCD fragment fixation, the surgeon has a variety of implant choices available. Variable and constant pitched cannulated metal screws have well-established clinical outcomes and allow for excellent compression of the fragment compared with K-wire fixation.[13] However, both metal screws and K-wires can bend, break, or become prominent and necessitate subsequent surgery for hardware removal. Bioabsorbable implants limit the necessity for hardware removal and result in less artifact on postoperative MRI. Among bioabsorbable implants, darts, pins, nails, and screws are available.[14] Because of their ability to provide compression thought to enhance healing, bioabsorbable screws in particular have grown in popularity for OCD fixation.

Outcomes using bioabsorbable screws for unstable OCD lesions have been well described.[15-20] On the other hand, fixation of stable OCD lesions for which conservative management has failed has been reported on less frequently. Din et al.[21] examined the efficacy of internal fixation of stable OCD lesions with bioabsorbable screws in 11 patients. They found promising results with this technique and suggested that such fixation may allow for faster rehabilitation timelines, avoidance of later hardware removal, and excellent long-term outcomes.[21]

The purpose of this study was to evaluate the clinical and radiographic outcomes of patients who have undergone bioabsorbable screw fixation for intact, stable grade I and II OCD lesions for which at least 6 months of conservative management has failed. We hypothesized that providing compression of the OCD fragment with a bioabsorbable screw would reduce patient symptoms and result in low rates of failure.

Methods

Patient Population

A retrospective review of prospectively collected data from a single institution was performed to identify patients who underwent internal fixation of OCD lesions between January 2010 and January 2020. Prior to study initiation, approval was obtained from the local institutional review board at Rush University Medical Center. Patients were included even if they underwent concomitant separate-site chondral operations or minor arthroscopic knee procedures.

Table 1. Arthroscopic Classification of Osteochondritis Dissecans: Guhl Classification[22]

Arthroscopic Appearance	Grade
Irregular softening of cartilage, no fissure; stable lesion	I
Articular cartilage fissured; stable lesion	II
Displaceable and defined fragment, still attached by cartilage; unstable lesion	III
Loose body and defect in articular cartilage; unstable lesion	IV

The inclusion criteria consisted of (1) primary internal fixation of stable grade I and II OCD lesions (according to the Guhl classification[22]) (Table 1), (2) failure of at least 6 months of conservative management, (3) the use of a bioabsorbable screw (or screws), and (4) minimum 2-year clinical follow-up. Each patient was assessed by the senior author (B.J.C.).

Patient demographic characteristics were collected, including sex, age, body mass index, Workers' Compensation status, knee laterality, and concurrent smoking status. Clinical patient-reported outcomes (PROs) evaluated included the Lysholm score, International Knee Documentation Committee (IKDC) score, and Knee Injury and Osteoarthritis Outcome Score (KOOS) subscales. Subsequent surgical treatment was noted. Eligible subjects were required to have at minimum 1-year postoperative weight-bearing radiographs (4 views) to assess fragment healing and to detect any adverse effects related to the bioabsorbable screws.

The primary outcome of this study was the rate of clinical success after bioabsorbable screw fixation of stable OCD lesions. Failure, or lack of clinical success, was defined as revision with debridement or a subsequent cartilage procedure, radiographic evidence of nonunion, or diminished PRO scores compared with preoperative scores. Secondary outcomes included the rate of complications other than failure and analysis of radiographic changes at a minimum of 1 year postoperatively.

Surgical Technique

All surgical procedures were performed by the senior author (B.J.C.), a sports medicine fellowship-trained orthopaedic surgeon with a high-volume cartilage restoration practice. The surgical indication was specifically for a subset of patients with stable focal cartilage defects who had trialed 6 months of conservative treatment. Only after a lack of improvement with conservative measures were patients indicated for surgery. Each patient was confirmed to have stable lesions

Table 2. Patient Demographic Characteristics

Characteristic	Reoperation Free (n = 21)	Failure (n = 3)	*P* Value
Female sex	5 (24)	1 (33)	>.999*
Age, yr	15.2 ± 3.2	17.7 ± 1.5	.203†
BMI	24.3 ± 5.6	23.6 ± 1.9	.828†
Smoking status	0	0	NA
WC status	0	0	NA
Knee laterality: left	12 (57)	1 (33)	.576*
Symptom duration, yr	0.92 ± 0.90	1.19 ± 1.58	.660†
Physeal status: open	14 (67)	1 (33)	.533*
Sport participation			NA
Yes	16 (76)	0	
No	5 (24)	3 (100)	
Traumatic etiology	5 (24)	1 (33)	>.999*
Follow-up, yr	6.78 ± 3.38	3.43 ± 2.42	NA

NOTE. Categorical variables are presented as number (percentage of respective non-reoperation or reoperation group); continuous variables are presented as mean ± standard deviation.

BMI, body mass index; NA, not applicable; WC, Workers' Compensation.

*Fisher exact test.

†Wilcoxon rank sum test.

Table 3. Arthroscopic Findings and Operative Procedures

Characteristic	Reoperation Free (n = 21)	Failure (n = 3)	*P* Value
OCD arthroscopic grade			>.999*
1	16 (76)	2 (67)	
2	5 (24)	1 (33)	
Lesion location			>.999*
MFC	16 (76)	2 (67)	
LFC	5 (24)	1 (33)	
Lesion area, cm^2	2.0 ± 0.62	2.5 ± 0.67	.208†
Concomitant procedures			
Separate-site ACI biopsy	1 (5)	0	>.999*
Separate-site microfracture	1 (5)	0	>.999*
Separate-site loose body removal	1 (5)	0	>.999*
Suprapatellar pouch release	0	1 (33)	.125*
Plica excision	2 (9.5)	1 (33)	.343*
Synovectomy	0	1 (33)	.125*
Retrograde drilling	14 (67)	3 (100)	.530*
None	5 (24)	0	>.999*
No. of screws			>.999*
1	10 (48)	1 (33)	
2	11 (52)	2 (67)	
Screw size, n			>.999*
22 mm	1	0	
24 mm	8	1	
26 mm	21	4	
Biologic use			.343*
BMAC	2 (9.5)	1 (33)	

NOTE. Categorical variables are presented as number (percentage of respective non-reoperation or reoperation group); continuous variables are presented as mean ± standard deviation.

ACI, autologous chondrocyte implantation; BMAC, bone marrow aspirate concentrate; LFC, lateral femoral condyle; MFC, medial femoral condyle; OCD, osteochondritis dissecans.

*Fisher exact test.

†Wilcoxon rank sum test.

(Guhl classification type I or II) on diagnostic arthroscopy prior to proceeding with surgical fixation with a bioabsorbable screw.

In brief, under general anesthesia, the patient is positioned supine or with the operative leg draped freely in a 90° position on the operating table. After examination under anesthesia, diagnostic arthroscopic surgery is performed to visually confirm the osteochondral defect(s) and identify any other existing abnormalities. The senior author prefers an arthroscopic approach using standard anterolateral and anteromedial portals. The lesion is localized and graded via the Guhl arthroscopic classification.[22] Once the lesion is identified, retrograde drilling is typically performed into or around the lesion using a 0.062-inch Kirschner wire to produce vascular channels to enhance the healing effect. The wire is entered behind the lesion via the intercondylar notch and penetrated into the bony bed without entering the joint line or violating the articular cartilage, and the wire trajectory is confirmed using intraoperative fluoroscopy. Fixation of the lesion is then performed. A guidewire is placed orthogonally through the lesion and into the underlying bony base. The guidewire trajectory is over-drilled, and a 3-mm × 22-, 24-, or 26-mm Bio-Compression solid enhanced poly-L-lactic acid (PLLA) screw (Arthrex, Naples, FL) is placed to compress the lesion. Countersinking the implant by 1 to 2 mm is performed to limit damage to the surrounding cartilage and not impede articular congruity. In general, more than 1 point of fixation is preferred, but smaller lesions may be adequately fixed with 1 implant. When 2 or more implants are used, they are spaced depending on the lesion size to not converge on another or cause fracture. Bone marrow aspirate concentrate harvested from the proximal tibia was used via intra-articular injection as an adjunct at the end of the procedure in some cases after a thorough discussion of risks and potential benefits, with an indication that it is considered experimental and of unproven benefit at this time.

Rehabilitation Protocol

The postoperative protocol was relatively conservative given that this cohort of patients had already trialed a minimum of 6 months of conservative treatment without improvement in symptoms. Patients began heel-touch weight bearing between postoperative weeks 0 and 6. Knee bracing was not required. Exercise was encouraged and consisted of continuous passive motion therapy 6 hours daily for 6 weeks, quadriceps sets, patellar mobilization, calf pumps, and straight leg raises. By week 6, patients were permitted to increase weight bearing by 25% and encouraged to further

increase by 25% every 3 to 5 days as tolerated. Patients progressed to full weight bearing as tolerated with a gradual return to sport after 3 months. Minor adjustments were made to the rehabilitation protocol based on concomitant procedures performed.

Statistical Analysis

Statistical analyses were performed using RStudio (version 4.1.1; Boston, MA). Descriptive statistics for continuous variables were reported as means with standard deviations, and categorical variables were presented as frequencies and proportions. Patients with clinical failure were compared with those without failure at final follow-up. The Fisher exact test was used for comparison of categorical variables. The Shapiro-Wilk test was used to determine normality of the data; the Mann-Whitney U test was used for non-normally distributed data and the independent-samples t test was used for normally distributed data to compare continuous variables. Kaplan-Meier survival analysis was performed to determine survival probabilities. Radiographs were independently interpreted by 2 board-eligible orthopaedic surgeons (S.A. and J.C.) who were attending an ACGME (Accreditation Council for Graduate Medical Education)—accredited sports medicine orthopaedic surgery fellowship. Discordance between interpreters was settled by the senior author (B.J.C.). The level of statistical significance was set as $P < .05$.

Results

A total of 25 knees among 24 patients who underwent OCD fixation were identified, of which 24 knees among 23 patients (96%, 24 of 25 knees) had clinical follow-up of 6.36 ± 3.42 years (range, 2.0-12.7 years) (Table 2). One patient was excluded because the patient had less than 2-year clinical follow-up.

At final follow-up, 21 knees did not have evidence of failure (average follow-up, 6.78 ± 3.38 years) whereas failure occurred in 3 knees requiring a reoperation (average follow-up, 3.43 ± 2.42 years). These 2 groups were identified and statistically compared with each other.

Demographic and Surgical Variables

Demographic variables did not differ between the 2 groups ($P > .05$) (Table 2). Open physes were noted in 14 patients (66.7%) in the reoperation-free group compared with 1 patient (33.3%) in the failure group ($P = .533$). The average preoperative symptom duration between the reoperation-free and failure groups was similar (0.92 ± 0.90 years and 1.19 ± 1.58 years, respectively; $P = .660$).

Most lesions were Guhl grade I defects (75%, 18 of 24) and were located on the medial femoral condyle (75%, 18 of 24) (Table 3). Lesion area was similar between the reoperation-free and failure groups (2.0 ± 0.62 cm^2 and 2.5 ± 0.67 cm^2, respectively; $P = .2083$). A total of 17 patients underwent concomitant retrograde drilling from the intercondylar notch into the lesion. Eleven patients required 1 bioabsorbable screw for fixation, whereas the remaining 13 patients required 2 bioabsorbable screws. Screw size and the use of adjunctive bone marrow aspirate concentrate were similar between the 2 groups ($P > .05$).

PRO Measures

Eighteen patients in the reoperation-free group (18 of 21, 86%) had preoperative and postoperative PROs available for analyses. Patients showed statistically significant improvements in all PROs at the most recent time point ($P < .05$) (Fig 1). The mean postoperative Lysholm score was 87.1 ± 14.9; IKDC score, 82 ± 14.2; KOOS activities of daily living, 96.2 ± 9.1; KOOS pain, 91.3 ± 9.1; KOOS quality of life, 79.5 ± 27; KOOS sport, 83.6 ± 28.4; and KOOS symptoms, 89.3 ± 13.7. Average changes in PROs can be found in Appendix Table 1.

Reoperation and Failure Rates

Three patients underwent a subsequent reoperation at a mean time of 2.3 ± 1.4 years (range, 1.3-3.9 years). Reoperations included 1 case of medial femoral condyle osteochondral allograft transplantation (4%, 1 of 24), 1 case of lateral femoral condyle osteochondral allograft transplantation (4%, 1 of 24), and 1 case of microfracture with loose body removal (4%, 1 of 24). The rates of overall survival free from reoperation were 100%, 92%, and 87% at 1, 2, and 5 years, respectively (Fig 2).

Radiographic Outcomes

A total of 20 patients (21 of 25 knees, 84%) received postoperative radiographs at an average of 3.64 ± 3.15 years (range, 1-10.9 years) after the index procedure. In the reoperation-free group, 15 knees (71%) had well-incorporated OCD lesions—defined as interval loss of a radiolucent line between the OCD lesion and bony base—after screw fixation on radiographs obtained at an average of 4.92 ± 3.16 years (range, 1.41-10.93 years) postoperatively (Fig 3). Partial osseous integration—defined as improved congruency between the OCD lesion and underlying bony base—was noted in 3 knees (14%), occurring at postoperative year 1.12, located on the medial femoral condyle (1.92 cm^2); at postoperative year 1.38, located on the medial femoral condyle (1.44 cm^2); and at postoperative year 1.01, located on the lateral femoral condyle (1.40 cm^2). These 3 patients were clinically asymptomatic at postoperative years 4.11, 2.14, and 9.41, respectively. In addition, 3 knees (14%) showed lucency in the

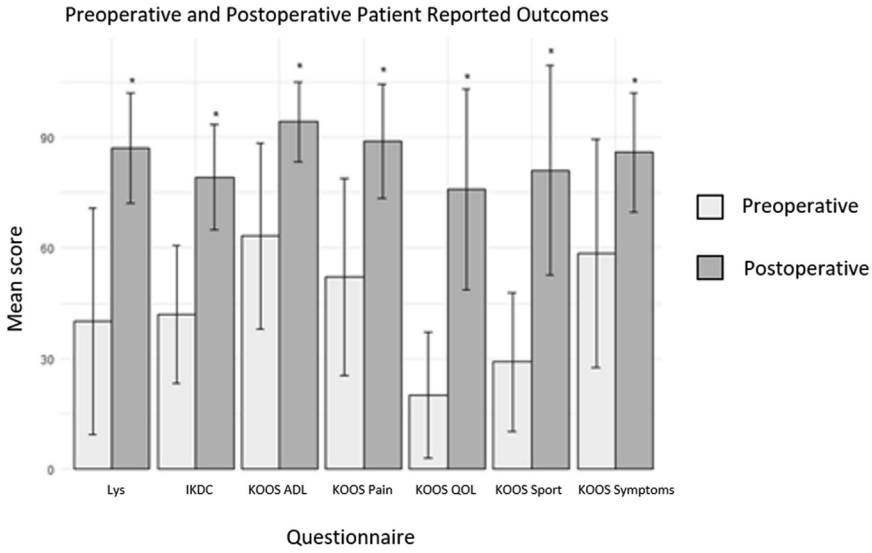

Fig 1. Mean patient-reported outcome scores preoperatively and after fixation of osteochondritis dissecans lesions. Questionnaires included the Lysholm score (Lys), International Knee Documentation Committee score (IKDC), and Knee Injury and Osteoarthritis Outcome Score (KOOS) subscales preoperatively and at most recent follow-up. Error bars represent standard deviations, and asterisks represent significant improvements compared with preoperative scores ($P < .05$). (ADL, activities of daily living; QOL, quality of life.)

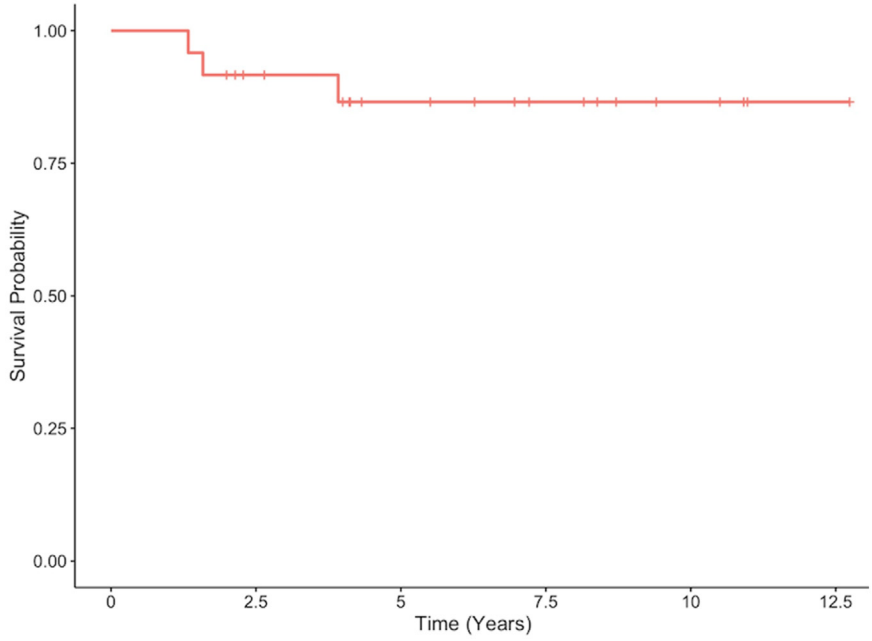

Fig 2. Kaplan-Meier survival analysis of reoperation after internal fixation of stable grade I and II osteochondritis dissecans lesions with bioabsorbable screws. The rates of overall survival free from reoperation were 100%, 92%, and 87% at 1, 2, and 5 years, respectively.

area of the bioabsorbable screw (Fig 4), although they were clinically asymptomatic at a mean follow-up of 6.26 ± 2.14 years. Lesion congruity to the subchondral plate was improved in all patients in whom failure did not occur. Radiographic and MRI data for the 3 patients in the failure group are presented in Table 4, and example postoperative MRI scans in a patient requiring reoperation are shown in Figure 5.

Discussion

The primary finding of this study was that improved clinical outcomes with a 12% failure rate were seen at a mean clinical follow-up of 6.36 years in patients who underwent bioabsorbable screw fixation for intact, stable grade I and II OCD lesions (according to the Guhl classification) for which at least 6 months of conservative management has failed. Patients showed statistically significant postoperative improvements in all PRO measures. A total of 3 knees (12%) required a reoperation at an average of 3.64 years after the index procedure, giving survivorship rates of 100%, 92%, and 87% at 1, 2, and 5 years, respectively. No specific complications were attributed to the use of bioabsorbable screws, and patients in whom primary

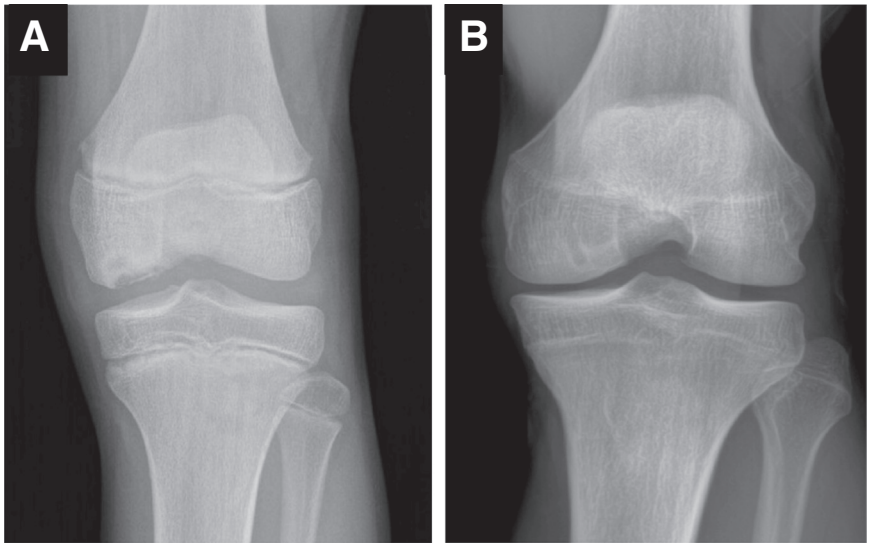

Fig 3. Preoperative (A) and postoperative (B) anteroposterior radiographs of left knee in skeletally immature patient with medial femoral condyle osteochondritis dissecans (OCD) in whom clinical success was achieved at 6.96 years of follow-up without reoperation. The postoperative radiograph, obtained at 5.17 years postoperatively, showed a well-incorporated and healed OCD lesion after bioabsorbable screw fixation.

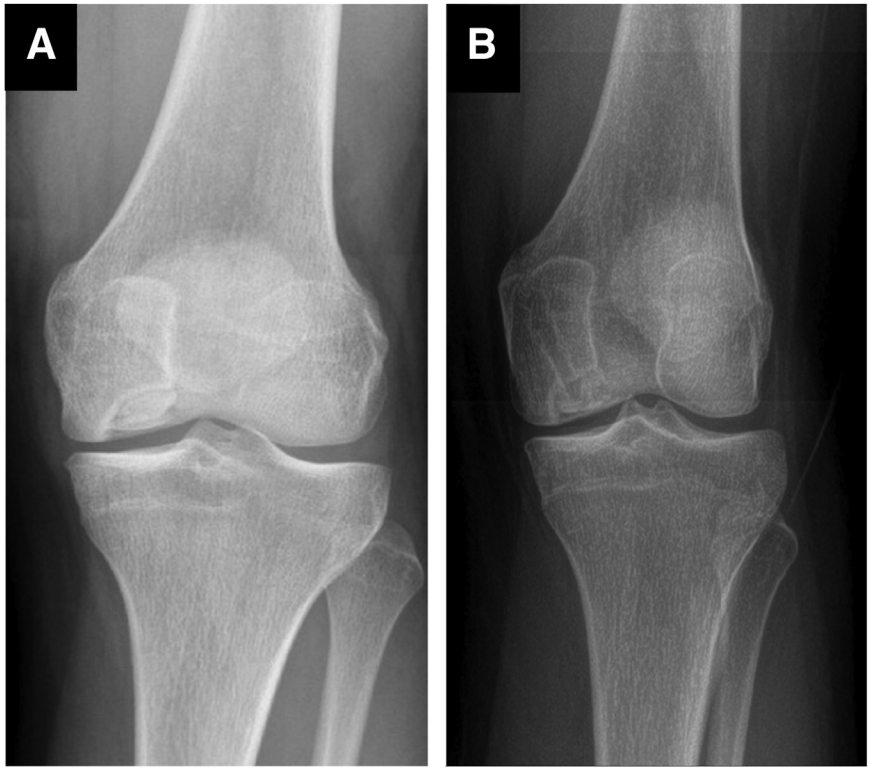

Fig 4. Clinically asymptomatic lucent changes around lesion in patient in reoperation-free group. Preoperative (A) and postoperative (B) anteroposterior radiographs of left knee in skeletally mature patient with medial femoral condyle osteochondritis dissecans in whom clinical success was achieved at 6.27 years follow-up without reoperation. The postoperative radiograph, obtained at 6.06 years postoperatively, showed lucency around the lesion, although the patient remained asymptomatic.

surgical treatment with bioabsorbable screw fixation failed did not differ in demographic characteristics, arthroscopic findings, or surgical treatment from those who had successful treatment.

This study sought to evaluate fixation of specifically stable OCD lesions for which conservative management has failed. The vast majority of stage I or II OCD lesions will remain asymptomatic and spontaneously heal without clinical impact. However, in patients who do present with symptoms, rest and activity modification will often lead to spontaneous healing without surgical intervention. In those who remain symptomatic, drilling without stabilization as reported in the literature provides variable outcomes, and often, these patients present for further treatment.[8-12] Thus, arthroscopically assisted internal fixation provides another alternative to drilling, allowing compression across the osteochondral region to promote biological healing.

Table 4. Radiographic and MRI Data of Patients Requiring Reoperation

	Age, yr/Sex	Lesion Location/ Size, mm/Grade	Physeal Status	Chief Complaint Postoperatively	Postoperative XR and/or MRI Interpretation	Time to Failure, yr	Reoperation Procedure	Intraoperative Findings
Patient 1	18/M	MFC/14 × 16/2	Closed	Pain and swelling after playing basketball 2.5 yr postoperatively	XR: subtle lucent changes around screw MRI: 1.5 × 1−cm lucent changes, cartilage delamination, and underlying bony edema	3.92	Microfracture and debridement of MFC in right knee	No evidence of screw, 8 × 10−mm area of cartilage delamination
Patient 2	19/F	LFC/14 × 14/1	Closed	Initial improvement with return of symptoms while horseback riding 7 mo postoperatively	MRI: no underlying bony edema, as well as no major changes related to implant or fragmentation	1.58	OCA of LFC in left knee	Screw intact but not protruding, stable lesion, evidence of healing, etiology of pain unknown
Patient 3	16/M	MFC/18 × 18/1	Open	Pain and swelling 9 mo postoperatively; unknown cause	XR: lucency around screw and fragmentation MRI: underlying bony edema, lucency around screw, and some fragmentation	1.34	OCA of MFC in right knee	Screw intact, no inflammatory response, new 32 × 18−mm loose fragment

NOTE. Lesion characteristics, radiographic and MRI findings, and reoperation procedures are listed for the 3 patients with failure after bioabsorbable screw fixation of stable osteochondritis dissecans lesions.

F, female; LFC, lateral femoral condyle; M, male; MFC, medial femoral condyle; MRI, magnetic resonance imaging; OCA, osteochondral allograft transplantation; XR, radiography.

Prior literature on fixation of OCD lesions has largely focused on the outcomes of unstable lesions. In a systematic review on unstable lesions comparing the rate of radiographic union, PROs, and reoperation rate after fixation with metal screws, K-wires, and biodegradable devices, Leland et al.[23] found comparable rates of healing and clinical outcome measures regardless of fixation device. Rates of reoperation ranged from 0% to 44%, whereas mean postoperative Lysholm scores ranged from 42 to 98 and IKDC scores ranged 53 to 85.[23] The results of our study mirror these prior data on operative fixation of unstable lesions.

In 2006, Din et al.[21] published the only case series, to our knowledge, that reports on the outcomes after fixation of stable knee OCD lesions. They examined 12 knees in 11 patients with a mean age of 14.8 years who had 1-year minimum clinical follow-up (average, 2.7 years). Ten grade I and two grade II OCD lesions were internally fixed with bioabsorbable screws. The operative indication in the previous study was similar to that in our study, treating patients who remained symptomatic despite conservative management. Radiographic analysis at 6 months showed improved healing, although Din et al. did not comment on any adverse effects related to the implant itself. Their cohort did not encounter any reoperations, although transient synovitis developed at postoperative week 2 in 1 patient, which resolved after conservative management. At final follow-up, all patients were satisfied with their results as assessed via a survey. According to the scoring system utilized by this study, 8 knees were graded as excellent and the remaining 4 were graded as good. Our case series found similar improvements in patient symptoms and satisfaction through statistically significant improvements in PROs. The reoperation rate of 12% found in our study, however, is higher than that of 0% found by Din et al. The reasons for the discrepancy may be the larger sample size in our study and the longer follow-up of our patients, as well as a uniquely athletic population of sports medicine patients. Specifically, the mean timing of reoperation in our study (3.64 years) was longer than the mean follow-up (2.7 years) in the study by Din et al. This highlights the importance of maintaining longer-term clinical follow-up in patients treated with bioabsorbable screws for stable OCD lesions of the knee.

It is important to note that most studies specifically examine outcomes in either skeletally mature or immature patients. Our series included 15 skeletally immature patients (63%) and 9 skeletally mature patients. Physeal status, open or closed, did not influence the rate of failure ($P = .533$). It is interesting to note that recent studies have shown that the outcomes of arthroscopic fixation between skeletally mature and immature individuals may not differ as much as previously thought. Wang et al.[24] in 2020 showed no

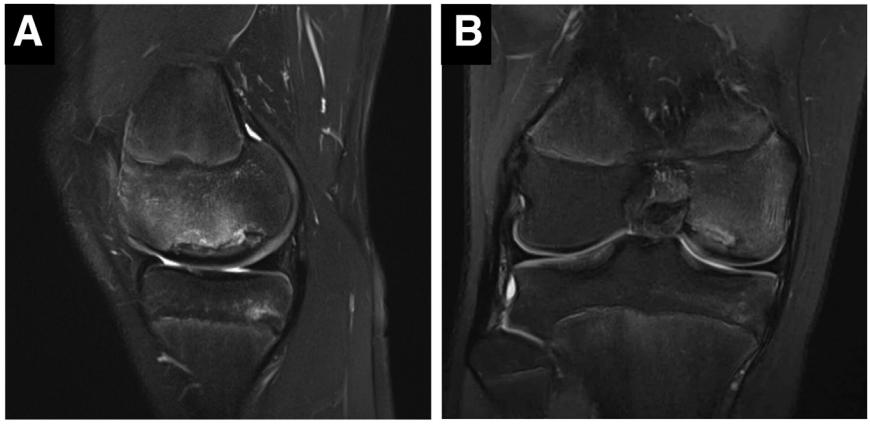

Fig 5. Preoperative magnetic resonance imaging (MRI) of right knee in patient 3 (failure group). The patient ultimately required reoperation with osteochondral allograft at 1.3 years postoperatively for an initial medial femoral condyle osteochondritis dissecans lesion. The sagittal T2 (A) and coronal T2 (B) MRI slices show the medial femoral condyle lesion with subchondral edema.

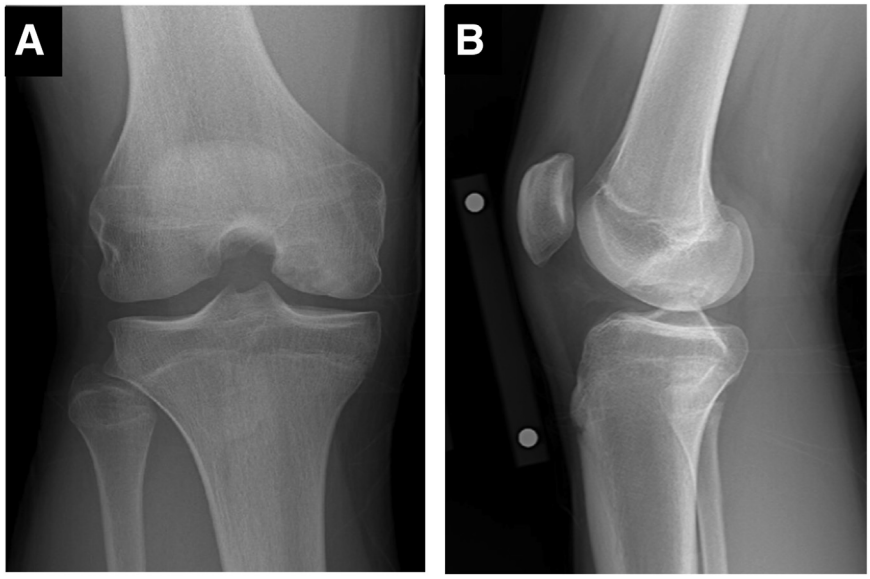

Fig 6. Postoperative radiographs of right knee in patient 3 (failure group): weight-bearing radiographs obtained 1 year postoperatively in patient with medial femoral condyle osteochondritis dissecans in whom primary fixation with bioabsorbable screw failed and reoperation with osteochondral allograft was required at 1.3 years postoperatively. The posteroanterior tunnel view (A) and the lateral view (B) show lucency and fragmentation at the lesion site.

statistically significant difference in failure rate between patients with closed physes and those with open physes (30% and 40%, respectively; $P = .721$). Similarly, Wu et al.[25] in 2018 showed that skeletal maturity had no significant impact on failure rate after fixation (risk ratio, 0.68; 95% confidence interval, 0.29-1.72; $P = .40$). It is possible that our study and the previous studies, however, are underpowered to detect differences between physeal status groups.

Rates of osseous healing after bioabsorbable screw fixation have been previously described, although the literature again has focused on unstable lesions. Webb et al.[26] showed a 75% rate of evidence of osseous integration among 20 knees at an average of 2.5 years postoperatively assessed via MRI (9 patients), radiography (10 patients), and computed tomography scan (1 patient). Similarly, Tabaddor et al.[19] detailed radiographic rates of healing among 24 patients: 9 patients (37.5%) showed interval healing of unstable OCD lesions, 1 patient (4%) showed no significant change, 13 patients (54%) showed complete healing, and 1 patient (4%) had evidence of loose bodies at an average radiographic follow-up of 1.6 years (range, 0.21-6 years). It can be difficult to compare our rates of osseous healing after fixation of stable lesions with previously reported healing rates for unstable lesions. However, in our study, the postoperative radiographs of the patients in the reoperation-free group showed that the lesion had been fully incorporated in 15 knees (71%; average radiographic follow-up, 4.92 years), whereas the remaining knees had partial osseous integration, defined as improved congruency between the OCD lesion and underlying bony base (average radiographic follow-up, 1.17 years). These healing rates are equivalent to those of previous bioabsorbable screw studies.

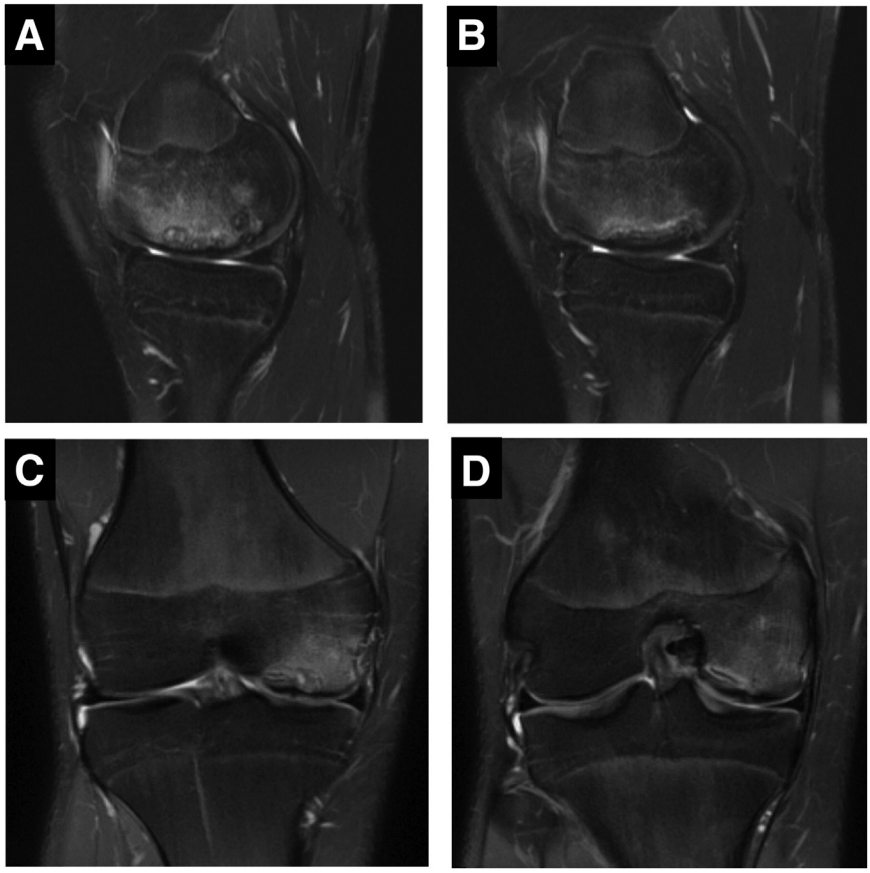

Fig 7. Postoperative magnetic resonance imaging (MRI) of right knee in patient 3 (failure group), who required reoperation with osteochondral allograft at 1.3 years postoperatively for initial medial femoral condyle osteochondritis dissecans lesion. Postoperative MRI was performed at 13 months postoperatively. The sagittal T2 (A, B) and coronal T2 (C, D) MRI slices show the medial femoral condyle lesion with ongoing subchondral edema.

Complications of PLLA bioabsorbable screws have been reported to include reactive synovitis with effusion, partial absorption leading to screw failure and prominent hardware, osteolysis around the implant, and aseptic exudates.[16,27] In this study, the reoperation-free group's postoperative radiographs showed excellent fixation of the operative OCD lesion with no major adverse effects related to the procedure or implant. Three patients were noted to have lucency surrounding the screw, although they were clinically asymptomatic at a mean follow-up of 6.26 ± 2.14 years.

Radiographic and MRI analysis of the 3 patients who required a reoperation showed lucent changes surrounding the implant, overlying articular cartilage delamination, and progression of subchondral edema at the lesion site (Figs 6 and 7). It is difficult to discern in these cases whether failure was related to the implant type or other processes related to the biology of the osteochondral fragment. The senior author's review of the imaging indicated that none of these failures or changes were directly related to the PLLA screws used and found that such failures or changes may represent a paucity of bone formation or replacement of the drill hole where the screw is positioned.

Limitations

This study is not without limitations. Given the limited occurrence of bioabsorbable screw fixation at our institution, this small retrospective case series could benefit from a larger cohort and longer-term follow-up. Future studies establishing clinically significant outcomes such as the minimal clinically important difference (MCID), substantial clinical benefit (SCB), and patient acceptable symptomatic state (PASS) for the operative treatment of OCD lesions would be beneficial. Another limitation of this study is that our cohort was not compared with a group of patients who received drilling alone. The decision to use a combined technique that includes internal fixation for OCD lesions classified as grade I and II radiographically was largely based on the historical variability of the clinical outcomes after drilling alone, as well as the senior author's experience in managing patients who have experienced failure of an initial attempt to render patients asymptomatic with the ability to return to pain-free activities. Patients also underwent a conservative postoperative protocol, which may have contributed to lesion healing as well. Although industry funding only contributed to postoperative radiographs, there may be inherent bias related to company involvement.

Conclusions

Internal fixation of stable grade I and II OCD lesions with bioabsorbable screws produces reliable results with a 12% rate of failure in appropriately indicated patients in whom at least 6 months of conservative management has failed. Clinical outcomes improved significantly during the mid-term follow-up period.

Disclosures

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References

1. Grimm NL, Weiss JM, Kessler JI, Aoki SK. Osteochondritis dissecans of the knee: Pathoanatomy, epidemiology, and diagnosis. *Clin Sports Med* 2014;33:181-188.
2. Friel NA, Bajaj S, Cole BJ. Articular cartilage injury and adult OCD: Treatment options and decision making In: *Insall & Scott Surgery of the Knee*. Ed 5. Philadelphia, PA: Churchill Livingstone Elsevier, 2011;153-162.
3. Nissen CW, Albright JC, Anderson CN, et al. Descriptive epidemiology from the Research in Osteochondritis Dissecans of the Knee (ROCK) prospective cohort. *Am J Sports Med* 2022;50:118-127.
4. Accadbled F, Vial J, Sales de Gauzy J. Osteochondritis dissecans of the knee. *Orthop Traumatol Surg Res* 2018;104: S97-S105.
5. Andriolo L, Candrian C, Papio T, Cavicchioli A, Perdisa F, Filardo G. Osteochondritis dissecans of the knee—Conservative treatment strategies: A systematic review. *Cartilage* 2019;10:267-277.
6. Pascual-Garrido C, McNickle AG, Cole BJ. Surgical treatment options for osteochondritis dissecans of the knee. *Sports Health* 2009;1:326-334.
7. Cahill BR. Osteochondritis dissecans of the knee: Treatment of juvenile and adult forms. *J Am Acad Orthop Surg* 1995;3:237-247.
8. Lykissas MG, Wall EJ, Nathan S. Retro-articular drilling and bone grafting of juvenile knee osteochondritis dissecans: A technical description. *Knee Surg Sports Traumatol Arthrosc* 2014;22:274-278.
9. Hefti F, Beguiristain J, Krauspe R, et al. Osteochondritis dissecans: A multicenter study of the European Pediatric Orthopedic Society. *J Pediatr Orthop B* 1999;8:231-245.
10. Kocher MS, Micheli LJ, Yaniv M, Zurakowski D, Ames A, Adrignolo AA. Functional and radiographic outcome of juvenile osteochondritis dissecans of the knee treated with transarticular arthroscopic drilling. *Am J Sports Med* 2001;29:562-566.
11. Anderson AF, Richards DB, Pagnani MJ, Hovis WD. Antegrade drilling for osteochondritis dissecans of the knee. *Arthroscopy* 1997;13:319-324.
12. Gunton MJ, Carey JL, Shaw CR, Murnaghan ML. Drilling juvenile osteochondritis dissecans: Retro- or transarticular? *Clin Orthop Relat Res* 2013;471:1144-1151.
13. Friederichs MG, Greis PE, Burks RT. Pitfalls associated with fixation of osteochondritis dissecans fragments using bioabsorbable screws. *Arthroscopy* 2001;17:542-545.
14. Bradley KE, Allahabadi S, Jansson HL, Pandya NK. Outcomes of bioabsorbable fixation in the treatment of osteochondral lesions of the knee in adolescent patients. *Knee* 2022;37:180-187.
15. Camathias C, Gögüs U, Hirschmann MT, et al. Implant failure after biodegradable screw fixation in osteochondritis dissecans of the knee in skeletally immature patients. *Arthroscopy* 2015;31:410-415.
16. Chun KC, Kim KM, Jeong KJ, Lee YC, Kim JW, Chun CH. Arthroscopic bioabsorbable screw fixation of unstable osteochondritis dissecans in adolescents: Clinical results, magnetic resonance imaging, and second-look arthroscopic findings. *Clin Orthop Surg* 2016;8:57-64.
17. Bogallo JM, Godino Izquierdo M, Dalla-Rosa J, Ramos González L, Arjona Díaz M, Guerado E. Unestable knee osteochondritis dissecans: Arthroscopic fixation with bioabsorbable device. *Rev Esp Cir Ortop Traumatol (Engl Ed)* 2021;65:408-416.
18. Komnos G, Iosifidis M, Papageorgiou F, Melas I, Metaxiotis D, Hantes M. Juvenile Osteochondritis dissecans of the knee joint: Midterm clinical and MRI outcomes of arthroscopic retrograde drilling and internal fixation with bioabsorbable pins. *Cartilage* 2021;13: 1228S-1236S (suppl).
19. Tabaddor RR, Banffy MB, Andersen JS, et al. Fixation of juvenile osteochondritis dissecans lesions of the knee using poly 96L/4D-lactide copolymer bioabsorbable implants. *J Pediatr Orthop* 2010;30:14-20.
20. Kocher MS, Czarnecki JJ, Andersen JS, Micheli LJ. Internal fixation of juvenile osteochondritis dissecans lesions of the knee. *Am J Sports Med* 2007;35:712-718.
21. Din R, Annear P, Scaddan J. Internal fixation of undisplaced lesions of osteochondritis dissecans in the knee. *J Bone Joint Surg Br* 2006;88-B:900-904.
22. Guhl JF. Arthroscopic treatment of osteochondritis dissecans: Preliminary report. *Orthop Clin North Am* 1979;10: 671-683.
23. Leland DP, Bernard CD, Camp CL, Nakamura N, Saris DBF, Krych AJ. Does internal fixation for unstable osteochondritis dissecans of the skeletally mature knee work? A systematic review. *Arthroscopy* 2019;35: 2512-2522.
24. Wang K, Waterman B, Dean R, et al. The influence of physeal status on rate of reoperation after arthroscopic screw fixation for symptomatic osteochondritis dissecans of the knee. *Arthroscopy* 2020;36:785-794.
25. Wu IT, Custers RJH, Desai VS, et al. Internal fixation of unstable osteochondritis dissecans: Do open growth plates improve healing rate? *Am J Sports Med* 2018;46: 2394-2401.

26. Webb JE, Lewallen LW, Christophersen C, Krych AJ, McIntosh AL. Clinical outcome of internal fixation of unstable juvenile osteochondritis dissecans lesions of the knee. *Orthopedics* 2013;36:e1444-e1449.

27. Scioscia TN, Giffin JR, Allen CR, Harner CD. Potential complication of bioabsorbable screw fixation for osteochondritis dissecans of the knee. *Arthroscopy* 2001;17:E7.