

Functional recovery and clinical outcome after internal fixation using osteochondral autologous transplantation for osteochondritis dissecans of the knee

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ABSTRACT

Background

Functional recovery and return to sports after fixation of osteochondritis dissecans (OCD) lesion of the knee with osteochondral autologous transplantation (OAT) have not been well investigated.

Purpose

To retrospectively evaluate the functional recovery and clinical outcomes following internal fixation with OAT for OCD of the knee.

Study Design

Case series; Level of evidence, 4.

Materials and Methods

A consecutive series of patients who underwent OAT for OCD lesions between 2010 and 2020 were initially enrolled in the study. Patients with adult-onset OCD and those who underwent fragment removal and/or mosaicplasty were excluded. Lysholm score, Tegner activity scale, and return to sports rate/duration (at practice or training and pre-injury levels) were evaluated. Clinical factors influencing postoperative functional recovery were statistically analyzed.

Results

A total of 24 patients (26 knees) who met the inclusion/exclusion criteria were included in the study. There were 23 male and 1 female patients with a mean age of 14.7 years. Seventeen lesions were located in the medial femoral condyle (MFC) and 9 in the lateral femoral condyle (LFC). The mean follow-up period was 27.6 months. The mean Tegner activity scale score was 7.0 preoperatively and 6.5 postoperatively, with no

significant difference. The return to sports rate was 96.2% at the practice or training level and 84.6% at the pre-injury level, with an average return time of 5.1 months and 9.6 months, respectively. The time it took for patients to return to sports at their pre-injury level was significantly longer for those knees with lesions of the LFC (7 of 9 knees), averaging 12.9 months, compared to lesions of the MFC (15 of 17 knees), averaging 8.1 months. The rate of return to pre-injury level after primary surgery was significantly higher than after revision surgery following failed drilling.

Conclusion

Return to sports rates and clinical outcomes were favorable after fixation with OAT in patients with knee OCD. As for clinical factors affecting functional recovery, a shorter time to return to sports was observed in knees with medial lesions compared to lateral lesions. Furthermore, the rate of return to sports at the pre-injury level was significantly higher after primary surgery than after revision surgery following drilling.

What is known about the subject: Although OAT for OCD has shown generally favorable results, only several studies have examined return to sports rates after surgery.

What this study adds to existing knowledge: In our study, fixation with OAT for knee OCD lesions produced largely favorable results and a satisfactory rate of return to sports. In addition, Postoperative outcomes and return to sports rates were better for knees with MFC lesions compared to the LFC lesions and for knees after primary surgery compared to revision surgery.

INTRODUCTION

Osteochondritis dissecans (OCD) is a relatively rare disease in which the subchondral bone is affected and the overlying articular cartilage is secondarily damaged at a later stage.¹² Although the etiology of OCD remains unknown, factors such as inflammation, ossification, and repetitive trauma have contributed to its development.^{20, 45} Many procedures exist to treat OCD, but which one is the most ideal is still controversial. Skeletal maturity and lesion stability, along with patient age, are key to determining appropriate treatment.⁷ In general, non-surgical treatment with activity restriction has been adopted for stable lesions in skeletally immature patients, yielding a healing rate of approximately 50%.^{3, 8, 9, 41} Meanwhile, the healing rate for skeletally mature patients is reported to drop to around 30%.^{28, 37} Indications for surgery include failure of conservative treatment, unstable lesions, presence of mechanical symptoms or loose bodies, and pain in daily life and sports activities.⁴⁰ For stable lesions in skeletally immature patients, retrograde or anterograde drilling is the sole indication for treatment.^{2, 29} The most common surgical treatment for unstable OCD fragments is internal fixation,^{1, 7} and recent literature suggests that the healing rate after internal fixation in skeletally immature patients ranges from 75% to 100%,^{1, 24, 44} whereas the rate in skeletally mature patients is lower, approximately 70% to 85%.^{4, 21, 43} The surgical options for irreparable lesions are on osteochondral autograft/allograft, autologous chondrocyte implantation²³ or a combination thereof.³⁵ Treatment algorithm in our practice follows the aforementioned treatment guidelines.

For unstable lesions, a number of internal fixation methods have been employed and their surgical outcomes have been reported. In the past, a variety of fixation devices have been used, including metal screws and biodegradable pins/rods

Fairly satisfactory results have been obtained, but some implant-related complications have been reported, such as migration or breakage of the implant, and foreign body reactions. Autogenous bone peg fixation is another option. However, there are concerns about loosening and fracture of the tibial donor site. Therefore, the optimum surgical treatment for unstable lesions remains controversial.³¹

In our practice, internal fixation with osteochondral autologous transplantation (OAT) is the primary surgical option for unstable (and potentially salvageable) OCD lesions, with the intent of achieving both mechanical stability and promoting biological healing. The advantage of OAT is that the OCD lesion is covered with hyaline cartilage with a host-specific subchondral bone plug.³⁰ In 1999, Berlet et al.⁵ were the first to report the "biological internal fixation" method, which applies the OAT technique to the fixation of unstable OCD lesions. In this method, an autogenous osteochondral plug is harvested from the ipsilateral knee and transplanted into the OCD lesion for fixation. Since then, fixation with OAT for unstable OCD has been reported in several case series papers, with generally favorable results.^{5, 15, 24, 33} However, few previous studies have examined the rate of return to sports after surgery.

The purpose of this study was to retrospectively evaluate functional recovery (return to sports) and clinical outcomes after internal fixation with OAT for OCD of the knee. We hypothesized that OAT for OCD would have a high return to sports rate and good clinical outcomes.

MATERIALS AND METHODS

Study design and subjects

In this retrospective study, we identified patients who underwent OAT for OCD lesions during the study period between April 2010 and March 2020, and reviewed our experiences with this procedure. This study was approved by the Clinical Research Ethics Committee of Hyogo Medical University and the Institutional Review Board at our facility (registration number: 3760).

As for the inclusion criteria, we selected OCD lesions that underwent in-situ fixation using OAT. Exclusion criteria included adult-onset OCD, cases with unsalvageable fragments for which fragment resection and mosaicplasty were performed, cases that were lost to follow up for more than 1 year after surgery, and those with incomplete clinical or radiographic data for the analysis.

Initial evaluation and treatment indications

All patients were forced to restrict their daily and sports activities due to persistent pain and catching in the knee. A comprehensive clinical evaluation, including physical examination and clinical score acquisition, was performed for each patient upon their initial visit. Radiographs were taken in the anteroposterior, lateral, and standing weight-bearing views, and magnetic resonance imaging (MRI) was performed. Radiographic evaluation was performed using the Brückl classification⁶ and by MRI using the Hefti classification.¹⁶ Based on the MRI findings, cases were then classified into one of the following five stages: Stage 1, small change of signal without clear margins of fragment; Stage 2, osteochondral fragment with clear margins, but without fluid between fragment and underlying bone; Stage 3, fluid is visible partially between fragment and underlying bone; Stage 4, fluid is completely surrounding the fragment, but the fragment is still in situ; Stage 5, fragment is completely detached and displaced

(loose body). In arthroscopic and gross examinations, OCD lesion type was determined according to the International Cartilage Repair Society (ICRS) classification system as follows: Grade 1, stable with continuity; Grade 2, partial discontinuity; Grade 3, complete discontinuity; Grade 4, dislocated fragment, loose within the bed or empty defect.

Conservative treatment was initially employed for stable lesions, and surgical treatment was indicated for cases that failed conservative treatment or for unstable lesions. Surgical treatment was based on grading of the lesion. Drilling was performed on stable ICRS Grade 1 lesions with a smooth and congruent surface. For unstable lesions, our primary option was internal fixation using OAT. We surmised that even a seemingly immobile lesion could exhibit mechanical instability due to subchondral avulsion.⁴⁵ Therefore, we employed fixation with OAT for both ICRS Grade 2 and 3 OCD lesions exhibiting partial or complete articular cartilage discontinuity. If the lesion was considered to be unsalvageable, we opted for a combination of fragment removal and mosaicplasty with OAT.

Surgical technique and postoperative rehabilitation

All cases were performed by either of the two senior authors (S.Y., H.N.) under general anesthesia. Initially, all patients underwent arthroscopy with an anterolateral and anteromedial portal to confirm the location and size of the OCD lesion and the ICRS-OCD grade. An arthrotomy was then made, and the size and surface integrity of the lesion was evaluated on gross examination. For the OAT procedure, the recipient site of the OCD lesion was prepared to a depth of 15 mm using an appropriately sized recipient cutting tube (6, 8, or 10 mm, Arthrex, OATS; osteochondral autograft transfer

system). Osteochondral grafts were harvested from the ipsilateral lateral femoral condyle. The harvest site was located at the anterior-distal aspect of the articular facet in the non-weight bearing area. During extraction, extreme care was taken to avoid injury to the epiphyseal plate in patients with open physis. Subsequently, in-situ fixation was performed by biological fixation using the autologous osteochondral plugs. The graft was inserted using a donor harvest device and gently pressed into the recipient site until it was flush with the surrounding cartilage. One or more plugs were used to cover at least 50% of the lesion surface. As a general rule, one plug in the center or two plugs to the periphery of the lesion were inserted until rigid stability could be achieved. (Figure 1).

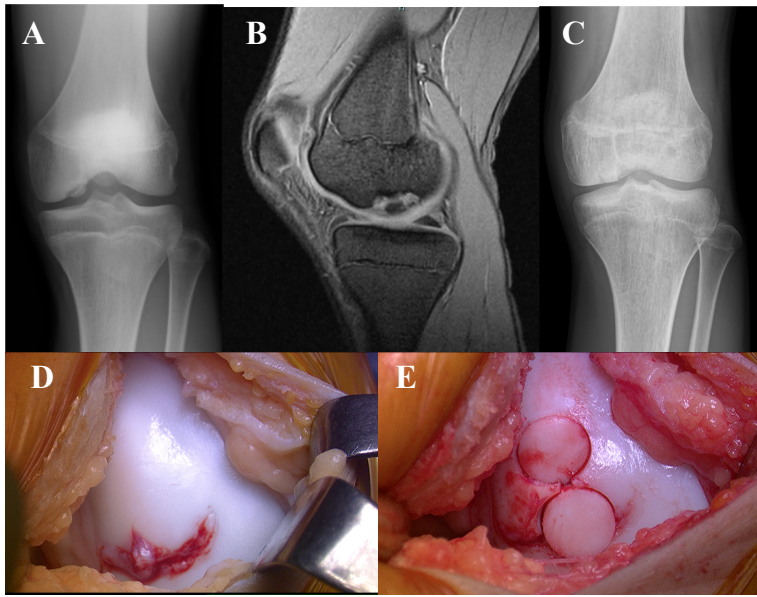


Figure 1. Serial image findings of a 16-year-old boy with OCD in the medial femoral condyle who underwent internal fixation using OAT.

- A) An anteroposterior radiograph reveals a demarcated lesion in the medial femoral condyle.
- B) Sagittal T2-weighted MRI image of the knee before surgery showing a bone fragment in situ completely surrounded by high-signal intensity line (Hefti classification Stage 4).
- C) A 4-month postoperative radiograph demonstrates progression of bony healing with apparently smooth joint congruity.
- D) An intraoperative photograph shows partial cartilage fissuring at periphery of the OCD lesion in the medial femoral condyle.
- E) In-situ fixation is performed by biological fixation using two 8-mm diameter autogenous osteochondral plugs under arthrotomy.

Postoperative physical therapy began the next day with a series of exercises and isometric movements to strengthen the quadriceps. The knee was immobilized with a brace for one week, and full range of motion exercises were started at the second postoperative week as tolerated. Weight-bearing was prohibited for the first four weeks postoperatively and gradually progressed to full weight-bearing at 6-8 weeks after

surgery. The patient was allowed to gradually return to sports at 4 months, taking into account bone union and muscle strength recovery.

Postoperative follow-up evaluations

All patients were followed up regularly surgery. Radiological examination was repeated every month until bony union was confirmed. The achievement of bone union was based on follow-up radiographic findings of integration at the interface between the OAT graft and the surrounding recipient bone. If there was uncertainty as to whether bony union had been achieved, CT imaging was used to further evaluate healing. We opted not to utilize MRI for routine serial imaging examination because we felt the status of the bony union could be better confirmed by radiographs and CT images. In addition to the monthly evaluations for bony healing, clinical and radiological examinations were conducted regularly at 6, 9, and 12 months, and every 3 to 6 months for up to 2 years, followed by yearly assessment thereafter. Clinical results were also assessed during the follow-up period using the Lysholm rating system.²²

As for the evaluation of postoperative functional recovery, the type of sports activity, time to return to the sports, and return rate were examined. Activity levels were determined using the Tegner activity scale,³⁸ and sports participation levels were assessed before and after surgery. Prior to surgery, most patients had to reduce their activity level due to knee pain. Therefore, the preoperative level was determined as the pre-injury level, and the postoperative sports activity level was assessed every month after surgery. Currently, there is no standardized or widely accepted definition for when an athlete has officially returned to sport. Functional recovery in postoperative return to sports was classified into two levels: pre-injury and participation. The pre-injury level

was defined as returning to the same level of sports activity as before the injury, and participation level was defined as returning to the level of practice or training. Clinical factors affecting the timing and rate of return to sports were also examined by comparing medial versus lateral femoral condylar lesions and primary versus secondary surgery following previous procedures such as drilling or meniscal surgery.

Clinical and radiological data collected during the preoperative and consecutive follow-up periods were obtained from the patient records and subjected to the analysis. Patient data on demographics, functional recovery status, and postoperative complications were extracted from the chart review.

Statistical analysis

Continuous data are expressed as mean and SD, and the categorical data are expressed as frequencies and percentages. The paired t-test was used to compare the pre- and post-operative Lysholm scores. The nonparametric Wilcoxon test was used to compare the Tegner activity scale before and after surgery. Return to sports evaluations were conducted with the paired t-test and chi-square test. Significance was set at $p < 0.05$.

RESULTS

During the study period, OAT for OCD was performed in 34 patients and 37 knees. Among those, 5 knees (including 2 adult-onset OCD knees) that underwent loose

body removal or mosaicplasty and 6 knees in 5 patients who could not be followed up with more than 1 year or for whom clinical/radiological data were not complete were excluded from the study. As a result, a total of 24 patients (26 knees) who met the inclusion/exclusion criteria were included in the study. **Tables 1** and **2** present the demographic and clinical profile of the study population. Seventeen of the OCD lesions were located in the medial femoral condyle (MFC) and 9 on the lateral femoral condyle (LFC). MRI Hefti classification was as follows: stage 3 in 11 cases and stage 4 in 15 cases. ICRS - OCD classification was as follows: 12 knees in grade 2 and 14 knees in grade 3. The mean follow-up period was 27.6 months (range 12 to 120 months). Regarding previous surgeries, 7 knees (2 medial and 5 lateral condyle lesions) underwent drilling as a primary procedure for stable OCD, while saucerization with or without repair of the lateral discoid meniscus was performed in 6 knees.

Table (1) Demographics of the study population.

Total patients / knees, n	24 / 26
Sex	Males 23 / Females 1
Side	Right knees 7 / Left knees 19
Age (years)	14.7 ± 3.8 [range, 8-22]
Height (cm)	160.8 ± 14.8 [range, 124-185]
Weight (kg)	50.9 ± 12.3 [range, 24-71]
BMI (kg/m ²)	19.3 ± 2.5 [range, 15.4-23.9]

BMI; body mass index

Table (2) Clinical profile of the study population.

Coronal size (mm)	11.2 ± 3.2 [range, 6.6-20.0]
Sagittal size (mm)	16.4 ± 6.0 [range, 7.1-32.5]
Depth (mm)	5.3 ± 1.6 [range, 2.9-8.8]
Number of plugs	1.4 ± 0.5 [range, 1 - 2]
Location	
MFC / LFC	17 / 9
The Brückl radiographic classification	
Stage 3 / 4	14 / 12
The Hefti MRI classification	
Stage 3 / 4	11 / 15
ICRS OCD classification	
Grade 2 / 3	12 / 14
Previous surgery	
Failure to heal after drilling	7
Saucerization with or without repair for lateral discoid meniscus	6

- 245 MFC; medial femoral condyle
- 246 LFC; lateral femoral condyle
- 247 OCD; osteochondritis dissecans of the knee
- 248 ICRS; international cartilage repair society
- 249 OAT; osteochondral autologous transplantation

250

251 **Table 3** shows the outcomes at one year. The Lysholm score showed

252 significant improvement from 70.0 preoperatively to 96.0 postoperatively ($p < 0.01$).

Regarding return to participation and pre-injury level, 96.2% of patients were able to return to participation, which took an average of 5.1 months, and 84.6% returned to pre-injury level, which took an average of 9.6 months. The Tegner activity scale decreased from 7.0 before injury to 6.5 after surgery, with no significant difference. Bony union was achieved within one year in all knees.

Table (3) Rate of return to sports activities at 1 years after surgery and sports related results.

n = 26 knees	
Return to participation rate	96.2% (25 knees)
Return to pre-injury level rate	84.6% (22 knees)
Time period of return to participation (mo)	5.1 ± 2.6 [range, 3-16]
Time period of return to pre-injury level (mo)	9.6 ± 4.6 [range, 5-23]

	Pre-injury	Postoperative	P-value
Tegner activity scale	7.0 ± 0.7 [range, 6-9]	6.5 ± 1.0 [range, 3-9]	n.s.
	Preoperative	Postoperative	
Lysholm score	72.4 ± 6.9 [range, 61-95]	96.0 ± 3.8 [range, 83-100]	p < 0.001

Table 4 shows the results for return to sports according to lesion site.

Comparing medial and lateral femoral condyle lesions, there was no significant difference in the Lysholm score, return to participation, or return to pre-injury level rates. However the time to return to pre-injury level was significantly slower for those with lateral lesions (12.9 months) compared to those with medial lesions (8.1 months).

266 **Table (4)** Time period and rate of return to sports at location and grade.

	MFC	LFC	p-value
Time period of return to participation (mo)	4.7 [range, 3-8]	6.1 [range, 3-16]	0.19
Time period of return to pre-injury level (mo)	8.1 [range, 5-14]	12.9 [range, 5-23]	0.02
Return to participation rate	100%	89%	0.16
Return to pre-injury level rate	88%	78%	0.481
Lysholm score	96.0 [range, 94-100]	96.0 [range, 83-100]	n.s.

267 MFC; medial femoral condyle

268 LFC; lateral femoral condyle

269 ICRS; international cartilage repair society

270

271 **Table 5** describes the return to sports rates after the primary and secondary
 272 surgeries. There were no significant differences in return to participation rates or
 273 Lysholm score between the two groups, but the return to pre-injury level rates were
 274 significantly lower after drilling from the secondary surgery, at 57% compared to 95%
 275 after primary surgery.

276 **Table (5)** Rate of return to sports after secondary and primary surgeries.

	Secondary surgery (Following drilling)	Primary surgery	p-value
Return to participation rate	86%	100%	0.092
Return to pre-injury level rate	57%	95%	0.018
Lysholm score	94.0 [range, 83-100]	95.9 [range, 90-100]	0.327

277

278 Sixteen of the 24 patients had follow-up results for more than 2 years. At the
 279 final follow-up, which ranged from 24 to 120 months, the Lyshom score and the Tegner

activity score averaged 96.8 ± 4.4 (range, 83-100) and 6.1 ± 1.3 (range, 3-7), respectively. Therefore, the improvement in clinical outcomes was maintained at mid- to long-term follow-up. No donor site morbidity, complications, or infections related to the index surgery were observed in any of the cases during the entirety of the study. Only one patient underwent reoperation (drilling) 4 years after surgery.

DISCUSSION

The principal findings showed that fixation with OAT for knee OCD lesions in this study resulted in largely acceptable outcomes and satisfactory functional recovery. As for clinical factors affecting return to sports, a shorter time to return to sports was observed in cases with MFC lesions compared to LFC lesions. In addition, the rate of return to pre-injury level was significantly higher after primary surgery than after revision surgery following drilling.

Drilling is a generally accepted surgical option for stable juvenile OCD lesions while internal fixation (with or without bone grafting) is suitable for unstable lesions. For unstable lesions requiring fixation, various fixation methods have been reported, including variable pitch screws, partially threaded cannulated screws, bioabsorbable screws, pins, and bone sticks or bone pegs.^{17, 19, 26, 39} Although good clinical outcomes have been reported for the use of the implants for fixation, various complications have also been reported, including cartilage lesions, osteonecrosis, synovitis, and implant failure due to loose body formation.^{14, 18, 24, 27, 42} In addition, these procedures have

inherent shortcomings because they do not promote biological healing enhancement. Bone peg/stick fixation may eradicate the implant-related issues, but potential complications such as loosening and fracture at the tibial donor site remain a concern.^{10, 14}

The OAT technique called “in situ fixation”, in which the osteochondral fragment is fixed with autogenous osteochondral plugs, has been practiced as an alternative surgical option for unstable OCD lesions.^{5, 13, 32, 34, 36} Studies have reported good to excellent clinical results in 95% and 91% of patients with a mean follow-up of 3.4 and 4.5 years, respectively.^{24, 25} Fixation with an osteochondral plug allows for firm stability associated with bone-to-bone contact and subsequent rapid healing at the interface. Therefore, both mechanical and biological enhancement for tissue healing can be attained. Another advantage of this method is that the reconstructed articular surface is smooth and congruent. This is because the original articular surface of the OCD fragment is restored in situ with the original thickness of the articular cartilage. Our results showed that, although the follow-up period was short, bone union was achieved in all cases, and the Lysholm score had also significantly improved.

Yonetani et al⁴⁵ conducted a histological evaluation of cylindrical samples obtained from stable juvenile OCD lesions and showed that a separation was present at the subchondral layer even in seemingly stable ICRS grade 2 lesions. Therefore, even for ICRS grade 2 lesions in this study, fixation with OAT was indicated, considering the possibility of underlying instability. Furthermore, in fixation using OAT, pathological tissue consisting of fibrous tissue and sclerotic bone are removed, and a substantial amount of healthy cancellous bone is implanted as autogenous bone grafting.

Return to sports

Examination of the evidence for athlete outcomes reveals just how little is known about this disease. Athletes have different needs for treatment compared to the general public. Although many studies have focused on sports-related outcomes after surgical treatment of knee OCD, few have specifically examined return to sports rates. Sasaki et al³³ reported that all 12 patients who underwent OAT for juvenile OCD returned to their previous level of sports activity at an average of 5.7 months after surgery. However, previous reports have had mixed results and the definition of return to sports remains ambiguous, making it difficult to determine a clinical standard. The finding of this study was that this surgical treatment option allowed for adequate return to sports rates although return to sports rates decreased slightly when a return to sports was defined as a return to pre-injury level. According to the results of our study, only 1 case was unable to return to participation, and the recovery rate to pre-injury level was 84.6%.

The rate and period of return to sports were significantly influenced by lesion location. A shorter return to sports time was observed in lesions of the MFC compared to LFC lesions. This was also supported by Webb et al.⁴² who analyzed healing rates for internal fixation of unstable OCD lesions in skeletally immature patients, finding that all 5 failures occurred in the 11 knees with LFC lesions. This result may be related to the discoid lateral meniscus. It has been reported that 11.3% to 14.5% of lateral discoid menisci are associated with lateral condylar OCD, while lateral discoid menisci are present in 89% of the lateral OCD knees.¹¹

Another factor affecting functional recovery identified in this study was a history of surgery on the same knee. Of the 26 knees, included in this study, seven previously underwent surgical drilling and six had a history of discoid meniscal repair. When the fixation with OAT was conducted after failed drilling, the return to pre-injury level rate was significantly lower than that after the primary OAT procedure. Failure to heal after drilling was more common in lateral lesions, with 6 cases in lateral compared to 1 case in medial lesions. The higher rate of drilling of lateral lesions may have confounded a fair comparative analysis between MFC and LFC lesions. The small sample size in this study precluded further analysis regarding how each of these two factors (lesion location and revision surgery) influenced postoperative functional recovery. Repeat surgeries may have caused prolonged pain and muscle weakness, which may have delayed the patient's return to sports. In the future, comparative analysis of functional outcomes between drilling and other surgical procedures should be considered.

Return to sports was evaluated as being able to return to the same sport as before the injury, so actual athletic performance was not evaluated. The most common cause for not returning to sports was residual pain, but, in some cases, the patient had changed sports. The involvement of social factors must also be taken into account, since this includes cases in which the patient changes sports due to advancement in higher education or employment, regardless of competitive level.

Limitations

There were some limitations included in this study. First, the study was descriptive and the results were not compared with other methods. Second, the follow-

up period (minimum of 1 year) was too short, and the progression of osteoarthritis would be higher if the follow-up period were longer. Moreover, long-term observation is necessary to monitor for unexpected long-term complications, especially lesions at the harvest site. Third, the study involved a small number of patients. In the analysis of the present study results, two factors (lateral lesions and revision surgery) were identified as potential factors affecting postoperative functional recovery; however, the sample size was too small to run a multiple regression for each confounder. Consequently, it was not possible to determine whether one, or both, might be the independent factor related to poorer outcomes. In addition, the preponderance of male subjects was a drawback that precluded fair statistical analysis of prognostic factors. Fourth, the level of sports activity is varied among the study subjects, making it difficult to make a fair assessment of the surgical effect on postoperative functional recovery.

CONCLUSION

Return to sports rates and clinical outcomes were favorable after fixation with OAT in patients with OCD of the knee who wished to continue their sports activities, achieving 96.2% and 84.6% return to sports rates at participation and pre-injury levels. As for clinical factors influencing functional recovery, a shorter return to sports time was noted in patients with medial lesions compared to those with lateral lesions. Furthermore, the rate of return to the pre-injury sports level was significantly higher after primary surgery than after revision surgery following drilling.

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