Osteochondral Autologous Transplantation for Treating Patellar High-Grade Chondral Defects

A Systematic Review

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Background: Patellar cartilage defects account for 34.6% of defects found during routine arthroscopy. These defects pose a challenge in orthopaedic surgery because they have been associated with worse outcomes after surgical repair compared with other chondral lesions within the knee.

Purpose: To systematically review the literature for evidence on results of osteochondral autologous transplantation (OAT) for the management of isolated patellar cartilage high-grade defects (International Cartilage Repair Society [ICRS] grade 3-4).

Study Design: Systematic review; Level of evidence, 4.

Methods: A systematic review of the literature was performed to find studies that addressed outcomes regarding OAT to treat patellar high-grade cartilage defects (ICRS grade 3-4). Studies addressing patient-reported outcomes, return to sports, or magnetic resonance imaging (MRI) at follow-up after isolated OAT procedures for patellar cartilage defects were included.

Results: A total of 5 studies were included in this review. We were not able to perform a meta-analysis as no studies had available data. A total of 102 patients who received an isolated OAT for a patellar chondral defect were included in these 5 studies. All patients showed significant improvement at final follow-up based on the following patient-reported outcome scores: Lysholm, International Knee Documentation Committee, Kujala, Tegner, and 36-Item Short Form Health Survey. We found that 4 studies used MRI during the first postoperative year to assess osteochondral plug integration and positioning. The results demonstrated that most plugs were integrated and correctly positioned when evaluated at follow-up, conducted on average after 12 months. Whether patients were able to return to sports was queried in 2 of the included studies, revealing that patients could return to their previous level in most cases (Tegner score, 5-9 at 2 years after surgery).

Conclusion: Results indicate that OAT is a safe and reliable technique to treat patellar high-grade osteochondral defects, allowing for significant improvement in patient-reported outcomes and return to sports.

Keywords: patella; autologous; transplantation; osteochondral; chondral; cartilage

Cartilage defects in the knee account for a significant burden of disease. This is especially the case among young individuals, and, more important, for young athletes who seek treatment with high expectations of symptomatic relief and probability of return to sports.[14] These lesions are associated with considerable pain and disability. Additionally, they present poor recovery given the limited capacity of spontaneous healing owing to the avascular and hypocellular characteristics of articular cartilage.[27] Special concern exists regarding patellar articular cartilage lesions, which account for 34.6% of defects found during routine arthroscopy,[11] especially because this cartilage is the thickest articular cartilage in the body and can withstand up to 6.5 times the body weight during activity.[20]

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Outcomes of patellar cartilage defects depend on variables such as lesion size, age, location on the articular surface, and depth; traumatic versus nontraumatic injury; and muscle strength or balance.[5,17,24] Adequate treatment has been challenging to standardize given the heterogeneity of the defects encountered.

Conservative management generally involves physical therapy, with the goal of restoring soft tissue balance in the patellofemoral joint, including muscular and capsuloligamentous balance. These goals may be obtained through stretching regimens to restore flexibility to multiple structures, such as the quadriceps, hamstrings, and iliotibial band. Strengthening regimens and gait training should also be performed, emphasizing proximal musculature.[16] Even when conservative management is correctly performed, it may not provide enough symptomatic relief, and thus, orthopaedic surgeons have faced the challenge of developing successful resurfacing techniques.

Surgical management has evolved in the past 20 years, with many techniques being developed to replace hyaline or hyaline-like cartilage in the defects.[19] These techniques can be classified into 3 repair mechanisms: marrow stimulation, cell-based implantation, and osteochondral grafting. Of these techniques, the only one that replaces hyaline cartilage in the defect is osteochondral grafting. However, autologous osteochondral grafting presents the risk of donor-site morbidity, a concern that needs to be addressed with patients. Allograft resurfacing is another alternative but the availability of allographs may not be widely available. Thus, this review focuses on autograft results.

Since the development of osteochondral autologous transplantation (OAT) by Wagner in 1964 and its further popularization during the 1990s by Hangody and others, multiple studies have shown good and excellent results at long-term follow-up (up to 93% excellent results).[4,7,13,14,19] This technique transplants 1 or multiple (mosaicplasty) osteochondral plugs from nonweightbearing surfaces of the femur into the defect.[9] It has the advantages of being a single-stage procedure, transplanting mature hyaline cartilage to the lesion, and presenting a brief rehabilitation period. It is also cost-effective.[10]

Even though excellent results have been published for this technique, little is known about the results of isolated OAT in the patella. Thus, the purpose of this study was to systematically review the available evidence of OAT for patellar cartilage defects, particularly regarding functional outcomes, postoperative imaging, and return to sports.

METHODS

Search Strategy

A comprehensive literature search following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)[26] guidelines was performed in the following databases: MEDLINE, EMBASE, The Cochrane Database, LILACS, BIREME, and Epistemonikos. We conducted 3 independent reviews in these databases and reviewed the references of the included papers in depth. Differences with respect to the inclusion of studies in the review were discussed among 3 authors (R.D., J.E., C.Y.). We accepted cross-sectional, case-control, and cohort studies, as well as clinical trials. Our review sought all studies that included the evaluation of osteochondral autografts for patellar chondral lesions, reporting clinical outcomes for this procedure during follow-up. Terms used for the search strategy included “patella,” “autologous,” “transplantation,” ”osteochondral OR chondral,” and “cartilage.” All references were managed by Mendeley (v1.19, Elsevier Inc).

Study Selection

Inclusion criteria were met if the studies

1. were related to management of chondral or osteochondral lesions of the patella with OAT,
2. only focused on OAT or had a reconstruction of the medial patellofemoral ligament associated with the procedure,
3. included high-grade lesions (defined as International Cartilage Repair Society [ICRS] grade 3 or 4), or
4. compared this technique with other procedures for the management of patellar lesions.

All the evidence available to date (search concluded December 2018) in English or Spanish was collected. We excluded from further analysis any studies that involved reconstruction of other ligaments within or around the knee, involved other cartilage lesions in a compartment different from the patellar articular surface, or included degenerative conditions. In-depth analyses of titles, abstracts, and references were conducted by the 3 reviewers equally. Inclusion and exclusion criteria were applied using the full-text studies. Once a study was included for review, the study design, sample size, variables analyzed, and final outcomes were collected and presented in a summary table with all the available evidence (Table 1).

Quality Assessment

The quality of the included studies was assessed by use of the National Institutes of Health (NIH) quality assessment tool for observational cohort and cross-sectional studies (https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools). All studies were assessed by 2 authors (R.D., J.E.) independently, who then discussed any differences until a consensus was reached.

RESULTS

We found a total of 104 studies. Of these, 21 were selected based on title pertinence. Abstract and in-depth analyses were conducted for each of these. Based on our in-depth analysis, 13 articles were excluded. A further 3 studies were then excluded after discussion among reviewers. One of these studies was a technical description with no patient follow-up, and the other 2 studies included patients with anterior cruciate ligament

TABLE 1
Summary of Collected Evidence

Lead Author (Year)	Country	Journal	Sample Size	Design	Follow-up, mo, Mean or Median (Range)
Astur[2] (2014)	Brazil	*J Bone Joint Surg*	33	Prospective case series 2008-2010	30.2 (24-54)
Astur[3] (2017)	Brazil	*Knee Surg Sports Traumatol Arthrosc*	20	Prospective case series 2012-2013	24
Cohen[8] (2012)	Brazil	*Rev Bras Ortop*	17	Prospective case series 2008-2011	19.8 (12-33)
Figueroa[12] (2011)	Chile	*Knee*	10	Prospective case series 2000-2007	37.3 (24-70)
Nho[28] (2008)	USA	*Am J Sports Med*	22	Prospective case series 2002-2006	28.7 (17.7-57.8)

reconstruction, which met our exclusion criteria. Our in-depth analysis and quality assessment was ultimately conducted with 5 studies (Figure 1) with a total of 102 patients. The included studies did not have adequate data for us to perform a meta-analysis.

A summary of the general data of the included studies is presented in Table 1. All studies were conducted in North or South America: 1 study in the United States,[28] 1 study in Chile,[12] and 3 studies in Brazil.[2,3,8] All were published between 2008 and 2016. Regarding quality assessment, all studies were prospective case series (evidence level 4) that evaluated 1 or more of the following outcome scores: Lysholm score,[25] Kujala score,[23] International Knee Documentation Committee (IKDC) score,[1] Fulkerson score,[15] Tegner activity scale,[31] and 36-Item Short Form Health Survey (SF-36).[32] These scores were collected both preoperatively and after surgery at different time intervals (average 28 months of follow-up in group analysis). Also, 4 studies included magnetic resonance imaging (MRI) to assess osteochondral plug integration at follow-up. The consensus view of the 2 authors who conducted the quality assessment was that 4 studies were good quality and 1 study was fair.

Functional Outcomes

Regarding functional outcomes, all studies revealed improvement in the assessed scores during postoperative evaluations and at final follow-up. The study by Nho et al[28] showed that the IKDC score and the Knee Outcome Survey significantly improved between preoperative evaluation and final follow-up, with no difference in SF-36 scores. Their study also revealed that patients who received OAT as an isolated procedure presented better outcomes than patients who had other associated procedures. Figueroa et al[12] assessed comparative outcomes with the Lysholm score, demonstrating a significant improvement at final follow-up. Cohen et al[8] and Astur et al[2] both used Lysholm, Fulkerson, Kujala, and SF-36 scores to assess the outcomes. Whereas Cohen et al analyzed these scores in the whole sample, revealing significant improvements, Astur et al[2] compared these scores within their sample between size of the lesion (>2 or <2 cm), location of the lesions (lateral facet, medial facet, or both), and number of OATs used. No differences were reported in functional outcomes regarding defect size. In contrast, better outcomes were seen in patients with an isolated lateral facet lesion compared with patients who had lesions on both the medial and lateral facets. Furthermore, the Lysholm score showed better outcomes in patients who had 1 OAT compared with patients who required more than 1 OAT.

Astur et al[3] followed a series of 20 patients who received only 1 OAT plug, systematizing follow-up at 1 week preoperatively, 3 days after surgery, 6 months postoperatively, and late follow-up at 24 months postoperatively. The investigators analyzed specific functional outcomes including pain, gait pattern, edema, muscle trophism, muscle strength, patellar mobility, and knee range of motion using Tegner and Kujala scores. Their study revealed the following:

1. A significant decrease in pain was found when preoperative evaluation was compared with 6 and 24 months of follow-up.
2. A significant improvement in gait pattern was found between the preoperative point and 6 months after surgery; all patients showed normal gait patterns at 24 months of follow-up.
3. Knee swelling increased during the immediate postoperative period but decreased significantly at 6 and 24 months.
4. Muscle strength improved significantly between immediate postoperative and late follow-up points, as did knee range of motion, whereas muscle trophism and patellar mobility did not show variations at any time point.

Regarding functional scores, both Tegner and Kujala scores significantly improved when the authors compared preoperative assessment and final follow-up.

Imaging Outcomes

We found that 4 studies used MRI to assess postoperative condition of the inserted autografts. Astur et al[2] routinely studied their patients with knee MRI at 6 and 12 months after surgery, using T2-relaxation time mapping sequences to evaluate osteochondral bone plug integration. This study showed that at 6 months, 83% of the plugs had complete osseous integration, increasing to 100% at 12 months; no incongruence in the articular surface was found. Another study by the same group (Astur et al[3]) used the same MRI sequences at 6 and 24 months after surgery to assess plug integration. They revealed that at 6 months of follow-up, 60% of plugs had complete integration, increasing to 90% at 24 months. Figueroa et al[12] asked for a single follow-up

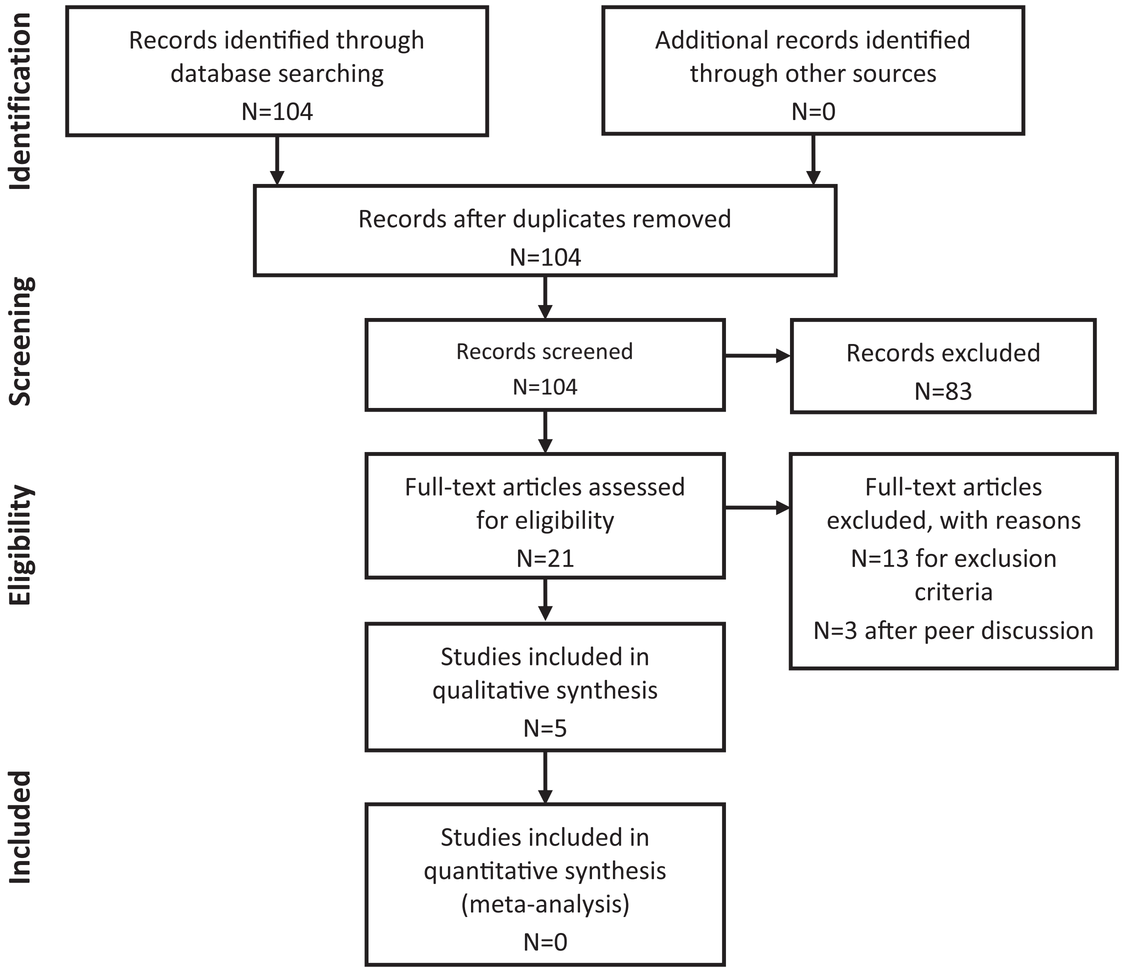

Figure 1. PRISMA (Preferred Reporting Items for Systematic Meta-Analyses) method for selection of papers.

MRI at an average of 8 months after surgery. This MRI was analyzed by a senior musculoskeletal radiologist, who assessed signal intensity of the cartilage on the plug compared with native cartilage. Also, morphologic features of the repaired area, cartilage interface status, and subchondral edema were assessed. Integrity of plug cartilage was defined by using the ICRS classification. Findings in this study revealed that all plugs presented flush characteristics with the surrounding native cartilage, with no fissures between the plug–native cartilage interface in 60% of cases. Eighty percent of patients had mild subchondral edema, and the cartilage of all grafts was classified as ICRS 1A. In the study by Nho et al,[28] MRI scans were available for analysis for 14 of 22 (63.63%) patients; the scans were conducted with a 1.5- or 3.0-T MRI machine at an average postoperative follow-up of 17.3 months (range, 4.9-33.2 months). This investigation revealed a 67% to 100% cartilage repair fill in the study group but observed a cartilage mismatch in 28.6% of studied grafts due to an excessive prominence of the graft.

Return to Sports

Return to sports as an outcome was addressed by only 2 of the included studies. Figueroa et al[12] assessed return to sports directly through an open question at follow-up regarding variations in activity level due to knee symptoms; no validated score was used in this study. All patients who were analyzed reported a preoperative amateur level of sports, and none of them reported any sport activity level limitation due to knee pain at final follow-up. Astur et al[3] evaluated sports activity using the Tegner activity level scale preoperatively, immediately after surgery, and at 6 and 24 months of follow-up. Before surgery, Tegner scale results ranged between 0 and 5, decreasing immediately after surgery to a range between 0 and 1. At follow-up, after patients had been allowed to return to sports activities after 6 months, patients reported Tegner levels between 2 and 6. The patients reported a range between 5 and 9 after 2 years of surgery, with an average score of less than 7. A summary of study results is detailed in Table 2.

TABLE 2
Summary of Results of Collected Evidence[a]

Lead Author (Year)	Measured Outcomes	Results
Astur[2] (2014)	Lysholm, Kujala, Fulkerson, and SF-36 scores; MRI	Lysholm: 57.27 ± 19.97 preoperative to 80.76 ± 12.26 postoperative ($P < .001$). Fulkerson: 54.24 ± 18.89 preoperative to 80.42 ± 10.20 postoperative ($P < .001$). Kujala: 54.76 ± 17.61 preoperative to 75.18 ± 12.47 postoperative ($P < .001$). SF-36: all questionnaires showed significant improvement except General Health. Subgroup analysis (Lysholm): – No differences between patients with lesions >2 cm or <2 cm. – Better scores in patients with an isolated lateral facet lesion ($P < .05$). – Better scores in patients with a single plug ($P < .05$). MRI: 100% plug integration at 1 year of follow-up with no articular surface incongruence.
Astur[3] (2017)	Pain, gait pattern, knee swelling, muscle trophism, muscle strength, patellar mobility, and knee ROM; Tegner and Kujala scores; MRI	Pain: – Significant improvement comparing pain before surgery with 6 and 24 months postoperative ($P < .05$). – Significant improvement comparing 3 days postoperative with 6 and 24 months postoperative. Gait pattern: – Significant differences comparing preoperative evaluation with 6 months postoperative ($P = .001$). – 24 months after surgery, 100% exhibited normal gait. Knee swelling: Significant decrease at 6 and 24 months postoperative ($P < .05$). Muscle trophism: no significant differences. Muscle strength: significant improvement between 3 days postoperative and evaluation at 6 and 24 months ($P < .05$). Patellar mobility: no differences at any time point. Knee range of motion improved between preoperative evaluation and 24 months of follow-up (28° increase; $P < .05$). Tegner score – 0-5 preoperatively. – 5-9 at 24-month follow-up. Kujala: 55.9 preoperative to 76.9 at 24 months postoperative ($P < .001$). MRI: 90% bone plug integration at 24 months.
Cohen[8] (2012)	Lysholm, Kujala, Fulkerson, and SF-36 scores	16 patients received 1 transfer; 1 patient received 2 transfers. Lysholm: 54.59 ± 25.99 preoperative to 75.76 ± 18.89 postoperative ($P = .019$). Fulkerson: 52.53 ± 25.8 preoperative to 78.41 ± 18.76 postoperative ($P = .001$). Kujala: 49.82 ± 22.04 preoperative to 73.47 ± 17.66 postoperative ($P = .002$). SF-36: Significant improvement in limitation due to physical factors, body pain, vitality, social factors, and limitation due to emotional factors. Significant correlation between Kujala and SF-36 in limitation due to physical factors and pain segments ($P < .05$).
Figueroa[12] (2011)	Lysholm and IKDC scores; return to sports; MRI	Lysholm: 73.8 ± 8.36 preoperative to 95 ± 4.47 postoperative ($P < .05$). IKDC: 93.6 ± 1.74 postoperative. Return to sports: no changes in sports activities due to knee pain. MRI: all cases presented flush characteristics compared with adjacent cartilage, 80% mild bone marrow edema, all plugs classified as ICRS 1A.
Nho[28] (2008)	IKDC, SF-36, and ADL of the Knee Outcome Survey; MRI	IKDC: 47.2 ± 14 preoperative to 74.4 ± 12.3 postoperative ($P = .028$). ADL: 60.1 ± 16.9 preoperative to 84.7 ± 8.3 ($P = .022$). SF-36: 64 ± 14.8 preoperative to 79.4 ± 15.4 postoperative ($P = .059$). MRI: 14 patients (63.63%) had 67%-100% cartilage repair fill; flush in 10 patients, mismatch to adjacent cartilage in 4 patients (plugs too proud).

[a]Scores are presented as mean ± SD. ADL, activities of daily living; ICRS, International Cartilage Repair Society; IKDC, International Knee Documentation Committee; MRI, magnetic resonance imaging; ROM, range of motion; SF-36, 36-Item Short Form Health Survey.

DISCUSSION

This systematic review shows that OAT is a good alternative to treat patellar high-grade cartilage defects. It presents good to excellent functional outcomes at midterm follow up (average follow-up of included studies, 28 months). Regarding imaging, full osteochondral integration was seen at 12 months of follow-up. Also, most plugs were flush with the adjacent articular surface in most cases. A favorable level of return to sports was seen with this intervention, including return to preoperative levels.

We decided to include studies that addressed other procedures performed in the patellofemoral compartment, as these procedures would not confound the functional outcomes attributable to recovery in this compartment's symptoms. Other procedures performed within or around the knee were further excluded, as a recovery of symptoms in other compartments could confound outcome scores used to isolate the effect of patellar OAT on its own. On this topic, no influence was found of addressing the medial patellofemoral ligament reconstruction concomitantly with OAT compared with isolated patellar OAT in the studies analyzed.

Concern has existed regarding functional outcomes in patellar cartilage defects, even though these defects tend to be scarce. Older series that have evaluated outcomes in this articulation show similar outcomes to those published by Hangody et al[18] in 2010, revealing that functional scores tend to be worse in comparison with other compartments in the knee.[21,29,30] OAT tends to deliver good and excellent outcomes in the knee, demonstrating that outcomes tend to be better in the femur compared with the patellofemoral compartment (91% vs 74%).[18] In contrast, more recent evidence has shown better outcomes regarding OAT compared with other techniques such as microfracture. Gudas et al[17] showed 96% good and excellent results in OAT, whereas microfracture had 52% good and excellent results in an athletic population. Regarding only patellofemoral articular defects,[10] better outcomes have been demonstrated in an athletic population similar to the population studied by Gudas et al. Furthermore, another recent series, which included 12 patellofemoral lesions within a sample of 62 patients, found that OAT is a good alternative for the treatment of focal cartilage defects, with good results in long-term follow-up (mean follow-up of 8 years).[33] Following the trend of recent evidence, this review has shown that OAT or mosaicplasty is a useful alternative for the treatment of focal cartilage defects in the patella, with most patients reporting excellent functional outcomes at 2 years of follow-up.

Another topic of interest regarding this type of lesion is the ability to return to sports, especially for athletes. A major concern for this population is whether they will be able to return to their normal activities and, in the cases of elite athletes, whether they will continue their career. Recent evidence has shown that OAT achieves a better rate of return to sports compared with other techniques for the treatment of cartilage defects in the knee. A systematic review by Lynch et al[24] found that in comparison with microfracture or autologous chondrocyte implantation, OAT had better clinical results with a better rate of return to sports and maintenance of preoperative sports activity level. In elite soccer players who underwent OAT, 89% of players returned to their previous level of sports, showing that results for lesions in the patellofemoral compartment were good.[30] Furthermore, another review revealed that OAT had the best return to sports rate (89%) followed by osteochondral allograft with 88%, highlighting that microfracture achieved only 75% return to sports.[6] Globally, OAT has shown good results in professional athletes with a mean follow-up of 9.6 years.[18]

MRI has been shown to be a useful imaging resource to assess plug integration and level of plug cartilage with respect to native surrounding cartilage. An important aspect of OAT is that joint surface congruity must be respected to allow for a smooth range of motion and prevent cartilage wear and possible early degeneration. Koh et al[22] demonstrated that a misalignment of only 0.5 mm (above native cartilage) increases contact pressure on the plug's cartilage by 50%. Thus, one of the most important factors that may determine the success rate of OAT is the correct placement of the bone plug. In this matter, studies assessed in this review asked patients for an MRI during the first year of follow-up to assess plug integration and joint congruity. These studies revealed that almost all grafts had incorporated at 12 months of follow-up and were flush with adjacent native cartilage.

As with any systematic review, our study was limited by the level of evidence found and included for assessment. The evidence found for this study was limited to prospective case series (level 4 evidence), with no high-level evidence being found. Even though the evidence included was not as high as we would have expected, following the NIH criteria for quality assessment, 4 of 5 studies were determined to have a good methodology and only 1 study was deemed as fair. A further limitation of this study was that given the nature of the evidence included, no data could be recovered to create a meta-analysis that would allow us to analyze available evidence in a pooled manner.

Even though our study has limitations, its strengths need to be highlighted. We found that 4 studies included MRI to assess follow-up osteochondral plug integrity and placement. These studies demonstrated that plug integration and positioning were adequate in most patients.

Further studies should focus on developing higher level evidence for the treatment of isolated patellar cartilage defects to assess more precisely the variables that influence outcomes in these patients. Nevertheless, this review sheds light on the evidence that OAT is a useful, safe, and reliable technique to treat patellar cartilage defects in the general and athletic population, allowing for a safe return to sports and a higher rate of return to sports, outcomes of interest for most patients.

CONCLUSION

OAT for the treatment of patellar cartilage defects is a useful alternative and offers good and excellent results at short- and mid-term follow-up. This procedure significantly improves patient-reported functional outcomes including Lysholm, IKDC, Kujala, and Tegner scores, offering a good rate of return to sports both for general and athletic populations. OAT should be offered to patients with high-grade patellar chondral defects when nonoperative management has not proven successful in managing anterior knee symptoms. Based on current evidence, MRI should be conducted at the 12-month follow-up to assess plug integration and the plug's cartilage integrity.

OAT is a predictable technique regarding return to sports rate and osteochondral plug integration within the first year of follow-up; this review provides evidence that surgeons should offer this technique for the treatment of patellar chondral defects.

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