Review

HAND
2016, Vol. 11(4) 396–402

DOI: 10.1177/1558944716643293
hand.sagepub.com

Current Concepts: Osteochondritis Dissecans of the Capitellum and the Role of Osteochondral Autograft Transplantation

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Abstract

Background: Osteochondritis dissecans (OCD) of the capitellum is a painful condition, which often affects young throwing athletes. Our current understanding regarding the etiology, risks factors, diagnosis, and efficacy of the available treatment options has expanded over recent years, however remains suboptimal. Recent data on patient-reported outcomes following osteochondral autograft transplantation (OAT) for the treatment of large osteochondral lesions of the capitellum have been promising but limited. This review seeks to critically analyze and summarize the available literature on the etiology, diagnosis, and reported outcomes associated with OCD of the capitellum and the use of OAT for its treatment. **Methods:** A comprehensive literature search was conducted. Unique and customized search strategies were formulated in PubMed, Embase, Scopus, Web of Science, and CENTRAL. Combinations of keywords and controlled vocabulary terms were utilized in order to cast a broad net. Relevant clinical, biomechanical, anatomic and imaging studies were reviewed along with recent review articles, and case series. **Results:** Forty-three articles from our initial literature search were found to be relevant for this review. The majority of these articles were either review articles, clinical studies, anatomic or imaging studies or biomechanical studies. **Conclusions:** Current evidence suggests that OAT may lead to better and more consistent outcomes than previously described methods for treating large OCD lesions of the capitellum.

Keywords: osteochondritis dissecans, elbow, capitellum, osteochondral autograft, osteochondral lesions

Introduction

Osteochondritis dissecans (OCD) is an acquired idiopathic condition of the articular surface primarily affecting young, active adolescents. This often painful disease process results from disruption of the subchondral bone and overlying hyaline cartilage. OCD has been well described in the knee, ankle, hip, shoulder, and elbow.[14] There is a wide spectrum of disease severity ranging from subtle subchondral lesions to large, full-thickness articular defects resulting in joint incongruity and deformity. The precise etiology and ideal management of OCD are areas of uncertainty and controversy. There is a growing body of promising, albeit limited evidence that supports using osteochondral autograft transplantation (OAT) for large, unstable lesions of the elbow to restore hyaline cartilage and congruity to the joint surface.

Etiology

Osteochondral lesions of the elbow predominantly occur as one of two distinct entities. Panner disease is a self-limited, atraumatic osteochondrosis of the capitellum affecting younger individuals (<10 years old), which most closely resembles the clinicopathology found in Legg-Calvé-Perthes disease.[3,7,31] Conversely, OCD can be a progressive lesion usually involving the dominant extremity associated with repetitive microtrauma secondary to valgus and axial loading of the elbow in young athletes.[3,15,31,42] OCD can involve any articular surface of the elbow; however, it most commonly affects the anterolateral aspect of the capitellum.[15,16,37]

The etiology of OCD in the elbow has yet to be conclusively determined. It most likely represents a multifactorial process driven by recurring articular compression in a susceptible region with a tenuous or "watershed" vascular supply and suboptimal articular cartilage.[18,21,31,43] In general, individuals who are skeletally immature are more susceptible to recurrent epiphyseal microtrauma.[30] The blood supply to the immature capitellum is derived from vessels traversing the epiphyseal articular cartilage and is without collateral support until physeal closure.[18,31] Therefore, repetitive radiocapitellar compression has the potential to compromise the blood supply to the

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subchondral bone. In addition, a biomechanical study performed by Schenck and colleagues[34] demonstrated that the lateral capitellum has softer articular cartilage when compared with that of the radial head. The authors implied that differences in the intrinsic properties of the articular cartilage create a mechanical discrepancy, which under high compressive loads could lead to increased strain and potential damage to the capitellum.

There is a strong foundation of evidence that supports repetitive articular compression as the prevailing factor in OCD formation and progression.* Unlike the knee and ankle, which are major weight-bearing joints, the elbow is subjected to a different variety of mechanical forces. These unique conditions are more commonly encountered in highly competitive baseball players and gymnasts. The considerable increase in participation in these sports at an earlier age has produced a significant rise in the incidence of stress-related injuries of the upper extremity.[30] In particular, the acceleration phase of the pitching motion produces a substantial valgus force on the elbow, which results in radiocapitellar compression.[10,18] Mihata and colleagues[26] conducted a biomechanical study to evaluate the effect of valgus torque on radiocapitellar joint contact pressure in elbows with and without OCD lesions of various sizes. They found that a valgus torque significantly increased contact pressures in the radiocapitellar joint regardless of the presence of an OCD lesion. In addition, larger lesions (15 mm and 20 mm) not only significantly increased the contact pressures compared with smaller lesions, but also increased the valgus laxity of the elbow. Therefore, once a lesion is present, it can significantly alter the biomechanics of the elbow to further increase valgus laxity and radiocapitellar compression. This concept is also supported by the clinical data of Takahara and colleagues,[38] in which baseball players with stable OCD lesions who continued to play developed progression of their lesions with loosening and fragmentation. Last, histopathologic analysis of articular cartilage from OCD lesions of the elbow has also suggested that repetitive stress and articular microtrauma are responsible for the pathologic changes in this disease process.[21]

Diagnosis

The diagnosis of OCD is primarily based on clinical exam and corroborated by imaging. The Minami classification system is frequently used when characterizing OCD lesions of the capitellum on plain radiographs (Table 1).[27] A 45° flexion anteroposterior film may allow for better visualization of the capitellum.[40] Plain films can be nondiagnostic early in the disease process; however, they may demonstrate a flattened, irregular, and sclerotic lesion. As the lesion progresses, fragmentation of the subchondral bone can result in intra-articular loose bodies (Figure 1). A study by Kijowski and De Smet[17] demonstrated that less than 50% of early cases of OCD of the capitellum were diagnosed on plain films. In addition, plain films failed to identify the presence of loose bodies in the majority of patients. Magnetic resonance imaging (MRI) is considered by some authors to be the imaging modality of choice as it allows for an earlier diagnosis compared with plain films and a more accurate evaluation of the stability of the lesion and integrity of the chondral surface.[3,9,31] MRI is better able to characterize the size and extent of articular involvement, which is critical for preoperative planning. Early in the disease process, changes are evident on T1-weighted imaging with a normal appearing T2 sequence. As the lesion becomes fragmented, a hyperintense signal surrounding the lesion signal on T2-weighted images becomes evident, which is the most significant predictor of an unstable lesion (Figure 2).[8,16,42] Jans and colleagues[16] determined that MRI is able to identify an unstable lesion with 100% sensitivity. In addition, MRI is also an extremely effective imaging modality for locating loose bodies in the posterior elbow and associated gutters, which occurred in 36% of patients in their study.[16]

Table 1. Minami Classification.[27]

Grade 1	Flattening or cystic changes in the capitellum
Grade 2	Subchondral detachment or fragmentation of lesion
Grade 3	Intra-articular loose body

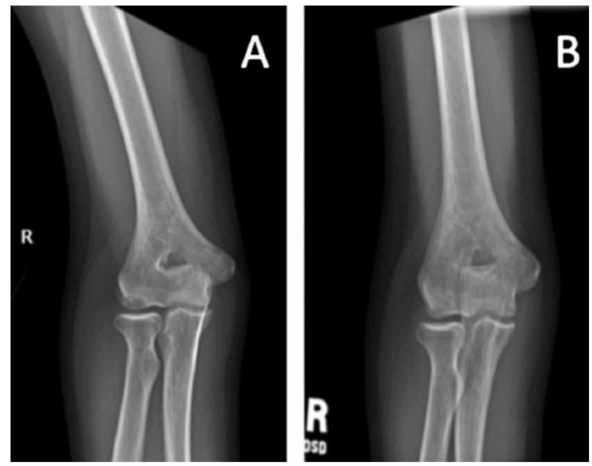

Figure 1. Anteroposterior plain films from a 13-year-old right-hand-dominant female gymnast/volleyball player who complained of 2 to 3 years of right elbow pain and mechanical symptoms during activity: (A) her preoperative films demonstrate a large Minami stage 2 capitellar defect; (B) her 3-month postoperative films demonstrate osseous integration of the graft and restoration of the articular surface.

Osteochondral Autograft Transplantation (OAT)

A growing body of evidence supports OAT as a reliable and effective treatment for unstable osteochondral lesions. OAT involves removing a cylindrical portion of

*References 5, 9, 15, 19, 21, 25, 28, 30, 31, 36, 42, 43.

Figure 2. Coronal (A) and sagittal (B) T2-weighted magnetic resonance images demonstrating an unstable osteochondritis dissecans lesion in the anterolateral capitellum as evident by the hyperintense signal surrounding the lesion.

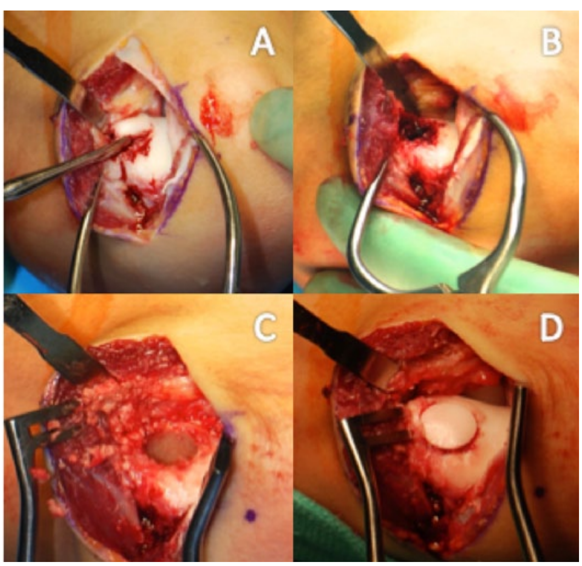

Figure 3. Intraoperative images from a 16-year-old right-hand-dominant male undergoing osteochondral autograft transplantation for an unstable capitellar osteochondritis dissecans lesion: (A) the lesion is unstable as it is easily elevated from the capitellar surface; (B) the resulting capitellar defect following debridement of the fragment; (C) the capitellar graft site following reaming for graft preparation; (D) restoration of the articular surface after a 10-mm osteochondral plug is placed.

non-weight-bearing articular cartilage with underlying subchondral bone and transplanting it to a different area of the body to fill an osteochondral defect (Figure 3). Various donor sites have been described; however, the most commonly reported are the superolateral aspect of the lateral femoral condyle[1,3,15,37,41,42] and the costal cartilage.[24,28,29,32,36] The ability to utilize the patient's own hyaline cartilage to

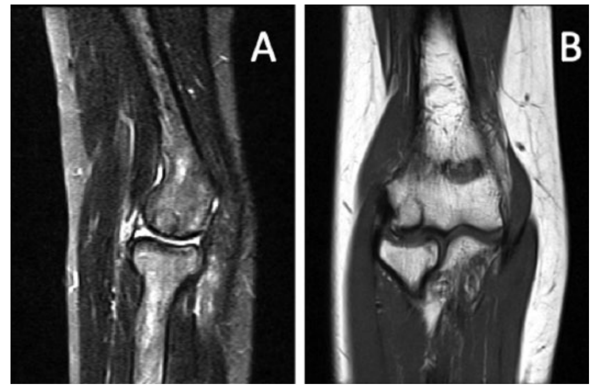

Figure 4. (A) Sagittal T2-weighted and (B) coronal T1-weighted magnetic resonance images demonstrating osseous integration of an osteochondral autograft with restoration of a congruent articular surface 3 months after undergoing osteochondral autograft transplantation.

recreate the articular surface while transferring subchondral bone to provide a strong mechanical support is the most significant advantage of OAT. Conversely, other treatment options such as drilling and microfracture rely on fibrocartilage formation and a variable degree of lesion fill. This not only results in a biomechanically inferior articular surface compared with hyaline cartilage, but it also may fail to reestablish deficient subchondral bone stock.[14,42,43] Hangody and Füles[14] have made substantial contributions to the development of the technique for OAT in a variety of lesion locations and have demonstrated good to excellent results at 10 years of follow-up. Furthermore, histologic examination following transplantation has demonstrated viable and congruent hyaline cartilage incorporation with the native tissue in addition to filling of the donor site with fibrocartilage.[14] MRI is very useful for demonstrating graft incorporation following OAT (Figure 4). Recent medium to long-term prospective studies by Gudas and colleagues[11,12] comparing OAT with microfracture and debridement for osteochondral lesions in the knee have demonstrated better outcomes with OAT. A recent systematic review consisting of level I and level II studies also demonstrated good outcomes with OAT of the knee, with most athletes returning to competitive activity by 6 months.[22] Osteochondral lesions in the ankle are more commonly the result of acute trauma[33]; however, recent short-term and long-term studies have demonstrated good to excellent outcomes in about 90% of patients.[13,35]

Classification

The management of OCD of the elbow is primarily based on the stability of the lesion. Takahara and colleagues[38] made one of the most pivotal contributions to the treatment of OCD of the capitellum by establishing a classification system based on lesion stability (Table 2). A stable lesion has

Table 2. Takahara Classification.[38]

	Capitellar physis	Range of motion	Radiographic changes	Treatment
Unstable	Closed	Restricted >20°	Fragmentation (either displaced or nondisplaced)	Operative intervention
Stable	Open	Normal	Localized flattening or radiolucency	Elbow rest/nonoperative

the potential to heal completely with a period of rest and altered activity and typically occurs in patients with an open physis, minimal radiologic changes, and relatively normal elbow range of motion during initial examination. Patients with stable lesions who were treated with activity modification had excellent results, with all but 1 demonstrating complete spontaneous healing. Furthermore, patients with an open physis treated conservatively had significantly better outcomes regarding pain relief and return to sports compared with individuals with a closed physis.[38] Mihara et al[25] also reported excellent results, with spontaneous healing occurring in 94% of patients with an open capitellar physis undergoing nonoperative treatment. Furthermore, they noted that 83% of early-stage lesions healed with nonoperative management compared with only 11% of late-stage lesions. These findings are also supported by Matsuura et al[23] who found that 90% of early-stage lesions healed with nonoperative treatment compared with only 53% of advanced stage lesions. Stable lesions are most commonly treated with 3 to 6 months of elbow rest and a combination of nonsteroidal anti-inflammatory drugs, bracing, and physical therapy.[†]

Unstable lesions have significantly better outcomes with surgical management.[38] These lesions were defined by Takahara et al[38] as having at least one of the following characteristics: a closed physis, fragmentation, or decreased range of motion of the elbow of greater than 20° compared with the contralateral side. In the series of Takahara et al, unstable lesions demonstrated significantly better pain relief and ability to return to sports when treated surgically. In addition, only 1 of 11 patients with a closed physis treated with elbow rest demonstrated healing.[38] Similarly, only 50% of patients treated nonoperatively with a closed physis in the series of Mihara et al demonstrated healing.[25] Aside from unstable lesions, surgical management is usually reserved for patients who fail 6 months of nonoperative management. Various surgical treatments have been proposed, including drilling, microfracture surgery, debridement, fragment excision, loose body removal, and OAT.[2,9,14,15,22,31,36]

Indications for OAT in the Elbow

Defining the indications of OAT for treating osteochondral lesions of the elbow is an evolving process. Recent literature suggests that the location and size of OCD lesions are of primary importance when determining optimal operative treatment.[2,19,26,38,42] The location of the lesion is likely the most important factor for considering OAT. Several authors have suggested that lateral capitellar lesions are more debilitating, causing patients to be more symptomatic preoperatively. In addition, they are more technically demanding intraoperatively, potentially resulting in suboptimal outcomes.[15,20,24,36,42] A recent biomechanical cadaver study demonstrated that large lateral capitellar lesions significantly increased radiocapitellar contact pressure and the valgus laxity of the elbow compared with smaller and central lesions.[26] The authors posited that larger laterally located lesions are more likely to explain the more advanced symptoms at presentation and necessitate more aggressive management. Various authors advocate for OAT when capitellar lesions are greater than 50% of the articular width due to the potential for radial head engagement and the decreased likelihood for good outcomes without procedures that restore bone stock and stability associated with an intact lateral column.[31,38]

Recent clinical studies have established a precedent for the use of OAT for lateral lesions of the capitellum. Kosaka and colleagues[20] noted that in “lateral widespread” lesions, inferior outcomes were reported with osteochondral peg fixation compared with OAT. In their series, 50% of lateral widespread lesions treated with peg fixation required revision surgery, whereas none of the patients treated with OAT for these laterally extending lesions required revision.[20] Other authors such as Shimada et al[37] and Yamamoto et al[42] have commented on the technical difficulties associated with reconstructing laterally extending lesions, which may account for inferior outcomes. Nishinaka and colleagues[28] have suggested that costal osteochondral autograft is particularly useful when dealing with large lateral capitellar defects. In these cases, a single costal graft can be used to cover a larger portion of the defect compared with the multiple cylindrical osteochondral plugs required in mosaicplasty.[36]

Kolmodin and Saluan[19] have recently proposed their own modification of the Takahara classification system to account for lesion location. In their new classification system, a line longitudinally bisecting the radial head extending through the capitellum is made on anteroposterior plain films with the arm in 45° of flexion while completely supinated. Lesions located medially to this line are considered to be type II lesions that can be successfully managed with simple debridement or repair. Lesions located laterally to this radial head center line are type III lesions, which require more aggressive treatment with reconstruction of the

[†]*References 9, 15, 19, 23, 25, 28, 31, 36-38, 43.*

articular surface.[19] This classification is based on the notion that larger lateral lesions have a worse prognosis and should be approached more aggressively.

Outcomes of OAT for Osteochondral Lesions in the Elbow

Over the past decade, several studies have demonstrated promising outcomes using OAT for treating osteochondral lesions of the elbow.[3,15,24,28,36,37,41,42] Shimada and colleagues[37] published one of the earliest studies utilizing OAT in the elbow. Excellent outcomes were reported in all but 2 of the 10 patients. In addition, second-look surgery demonstrated successful remodeling of the graft over time to create a uniform articular surface. The authors were also among the first to recognize that preexisting osteoarthritis is a risk factor for poor outcomes. Yamamoto et al[42] were among the first to investigate outcomes regarding return to sport in young baseball players undergoing OAT for osteochondral lesions in the elbow. Good to excellent outcomes were reported in all 18 patients, with all but 2 returning to competitive baseball. Subsequent mid-term follow-up studies by Ansah et al[3] and Iwasaki et al[15] also reported exceptional outcomes regarding improvement in pain and return to sport. In the series of Iwasaki et al,[15] 95% of the patients were pain free at median follow-up of almost 4 years and 89% of patients were able to return to the same level of competition as they had participated in previously. Moreover, neither study found evidence of degenerative changes in the elbow or loose body formation during the follow-up period. A long-term follow-up radiographic study by Vogt et al[41] supports these findings by demonstrating good to excellent follow-up at 10 years, with MRI evidence of well-incorporated grafts.

More recent studies by Shimada et al[36] and Nishinaka et al[28] have demonstrated promising results using costal osteochondral autograft for advanced lesions of the capitellum. Shimada and colleagues[36] were the first to use costal osteochondral autograft in a larger cohort of patients after authors like Oka and Ikeda[29] and Sato et al[32] described the technique in small case series. Shimada and colleagues[36] reported on 26 patients with greater than 15-mm lesions and 3 years of follow-up. All patients were able to resume pain-free daily activities by 4 to 6 weeks after surgery. Patients were able to return to sports by 6 months, with pitchers resuming full-intensity activity by 9 to 12 months. Of note, 4 of the 5 patients who required further surgery were pitchers who resumed a high-intensity throwing program within 12 months and had MRI evidence suggestive of poor revascularization of the graft. Nishinaka and colleagues[28] reported that all 22 pitchers were able to resume full pitching activity an average of 7.5 months following surgery. Furthermore, 4 patients required an additional surgical procedure; however, they were all able to return to full competitive activity following revision surgery.

Outcomes of OAT for osteochondral lesions in the elbow have compared very favorably to more conservative operative treatment strategies, such as debridement and fragment removal. Mihara and colleagues[24] performed one of the few studies that compared the outcomes of various treatment strategies for OCD of the capitellum. Poor results were reported for fragment removal and drilling, with many of these patients progressing to have osteoarthritic changes and decreased range of motion compared with preoperative evaluation. Conversely, all academically eligible patients who received OAT were able to return to playing baseball within 4 months. Takahara et al[38] also found significantly better outcomes with reconstructing the articular surface using OAT compared with debridement and fragment removal alone, particularly for lesions that comprised greater than 50% of the capitellar width.

Long-term follow-up of conservative procedures for OCD in the elbow have produced relatively poor results, with several authors reporting high rates of persistent elbow pain, progression of osteoarthritis, and recurrence of mechanical symptoms.[4,6,39] In particular, Bauer et al[4] and Takahara et al[39] reported that 42% and 46% of patients, respectively, had persistent elbow pain following conservative treatment of OCD. Moreover, Takahara et al[39] reported that no patients in their study were able to return to their previous level of athletic competition. In light of these results, some authors advocate for only fragment removal without reconstruction when there is a very small central lesion.[24] This recommendation is also supported by a biomechanical study by Mihata et al,[26] who found that central lesions less than 5 to 10 mm did not increase the radiocapitellar contact pressure with valgus torque or increase the valgus laxity of the elbow compared with elbows without a lesion.

Conclusion

Osteochondral lesions in the elbow can result in significant pain and disability in the young athlete. The etiology of OCD has yet to be fully defined; however, current evidence suggests a multifactorial process involving repetitive articular compression secondary to valgus overload in a region with a tenuous vascular supply and suboptimal articular cartilage. The management of OCD in the elbow is an area of uncertainty and controversy due to the infrequent occurrence of these lesions and the relative paucity of available data. OAT has been successful in alleviating pain, reestablishing normal elbow function, and allowing athletes to return to a high level of competition. The indications for this procedure are gradually being defined as more studies investigate clinical outcomes. Based on available evidence, OAT appears to be best suited for larger (>1 cm) lesions involving the lateral aspect of the capitellum. Short- and midterm studies have demonstrated excellent functional outcomes as well as maintained graft incorporation; however, long-term follow-up is necessary to better characterize OAT as a treatment strategy in OCD of the elbow.

Ethical Approval

This study was approved by our institutional review board.

Statement of Human and Animal Rights

This review study did not involve human or animal subjects.

Statement of Informed Consent

This review article required no informed consent.

Declaration of Conflicting Interests

Regarding financial relationships unrelated to the study, A.B. reports consulting for Arthrex, Inc., and stock/stock options with A3 Surgical; and J.N.L. reports consulting for Innomed and research funding from Synthes Paoli, PA.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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