Review Article

Osteochondritis Dissecans of the Capitellum: Current Concepts

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Abstract

Osteochondritis dissecans (OCD) of the capitellum is an uncommon disorder seen primarily in the adolescent overhead athlete. Unlike Panner disease, a self-limiting condition of the immature capitellum, OCD is multifactorial and likely results from microtrauma in the setting of cartilage mismatch and vascular susceptibility. The natural history of OCD is poorly understood, and degenerative joint disease may develop over time. Multiple modalities aid in diagnosis, including radiography, MRI, and magnetic resonance arthrography. Lesion size, location, and grade determine management, which should attempt to address subchondral bone loss and articular cartilage damage. Early, stable lesions are managed with rest. Surgery should be considered for unstable lesions. Most investigators advocate arthroscopic débridement with marrow stimulation. Fragment fixation and bone grafting also have provided good short-term results, but concerns persist regarding the healing potential of advanced lesions. Osteochondral autograft transplantation appears to be promising and should be reserved for larger, higher grade lesions. Clinical outcomes and return to sport are variable. Longer-term follow-up studies are necessary to fully assess surgical management, and patients must be counseled appropriately.

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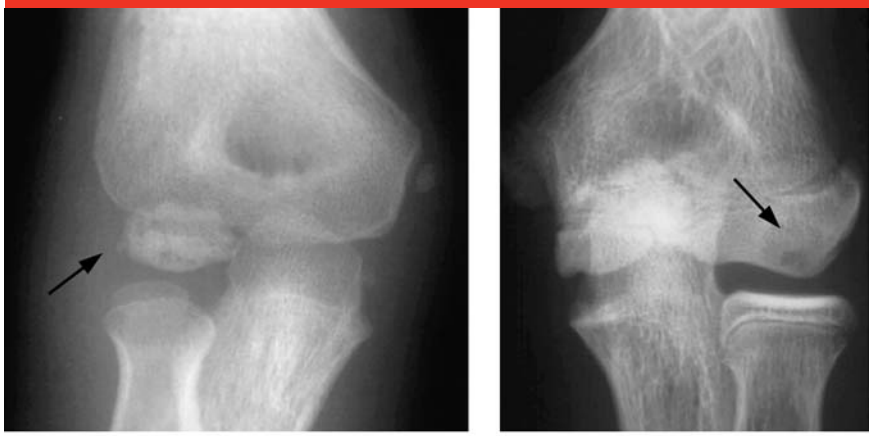
Osteochondritis dissecans (OCD) of the capitellum is a disabling condition that affects immature athletes who undergo repetitive compression of the radiocapitellar joint. This localized lesion involves a segment of articular cartilage with disruption of associated subchondral bone. The exact etiology of the disorder remains unclear, and the natural history of OCD lesions suggests that radiocapitellar degenerative changes occur in up to 50% of patients.[1] Management is determined based on the integrity of the articular cartilage and the stability of the lesion. Many surgical procedures have been described, with varied short-term outcomes. Means of optimal management remains unknown.

Panner disease is another disorder of the immature capitellum and must be differentiated from OCD. Panner disease was initially described in 1927 as a clinical and radiographic entity similar to Legg-Calvé-Perthes disease of the hip.[2] It is an osteochondrosis of the entire capitellum, with fissuring and fragmentation seen on initial radiographs (Figure 1). Unlike OCD, Panner disease is not associated with trauma and is seen almost exclusively in boys aged <10 years.[3] Clinical reports have found it to be a self-limiting disease, with reossification and resolution of

Figure 1



A B

A, AP radiograph of the right elbow in a 6-year-old boy. Note the irregular ossification of the capitellum (arrow), consistent with Panner disease. **B,** AP radiograph of the left elbow in a 14-year-old boy demonstrating a focal osteochondritis dissecans lesion (arrow). (Reproduced from Kobayashi K, Burton K, Rodner C, Smith B, Caputo A: Lateral compression injuries in the pediatric elbow: Panner's disease and osteochondritis dissecans of the capitellum. *J Am Acad Orthop Surg* 2004;12[4]:246-254.)

symptoms with nonsurgical management.[4,5]

Etiology

The etiology of OCD of the capitellum is unknown, but trauma and ischemia are believed to play a significant role.[5-7] No conclusive evidence exists for a genetic predisposition, but several case studies have reported patients with OCD in consecutive generations as well as one case in fraternal twins.[8-11]

Trauma

OCD occurs predominantly in the dominant arm of male throwing athletes and in female gymnasts, which supports the idea that repetitive trauma is the major inciting event.[3,5-7] Overuse with throwing, with or without poor mechanics, can cause fatigue of the medial elbow complex—specifically, of the medial collateral ligament and flexor pronator origin.[12-14] This has been shown to lead to increased compression and shear forces during the late cocking phase across the radiocapitellar articulation, which is the major secondary stabilizer to valgus stress.[12-14] The radiocapitellar articulation has also been shown to experience up to 60% of axial compression forces across the elbow.[15] This may help support a traumatic etiology in female gymnasts, who repetitively load the radiocapitellar joint with their arms in extension.[16]

The findings in OCD mimic the pathophysiology following mechanical trauma to articular cartilage. Tallqvist[17] found that cyclical microtrauma to articular cartilage led to fatigue fracture, resorption, and fragment separation of the subchondral bone in rabbits when fractures failed to heal. As fragments become avascular, the overlying articular cartilage may become progressively more susceptible to increased shear stresses because of failure of the subchondral osseous support. This ultimately leads to separation, fragmentation, and loose body formation.

Schenck et al[18] believed the intrinsic mechanical properties of the radiocapitellar articular cartilage to be responsible for the development of OCD. The authors divided the radial head and capitellum into multiple osteochondral segments and found that the lateral capitellum had softer segments compared with the stiffer mid radial head segments. They concluded that the disparate mechanical properties, or "mismatch," may increase strain in the lateral capitellum, leading to the initiation and localization at the most reported location of OCD lesion.

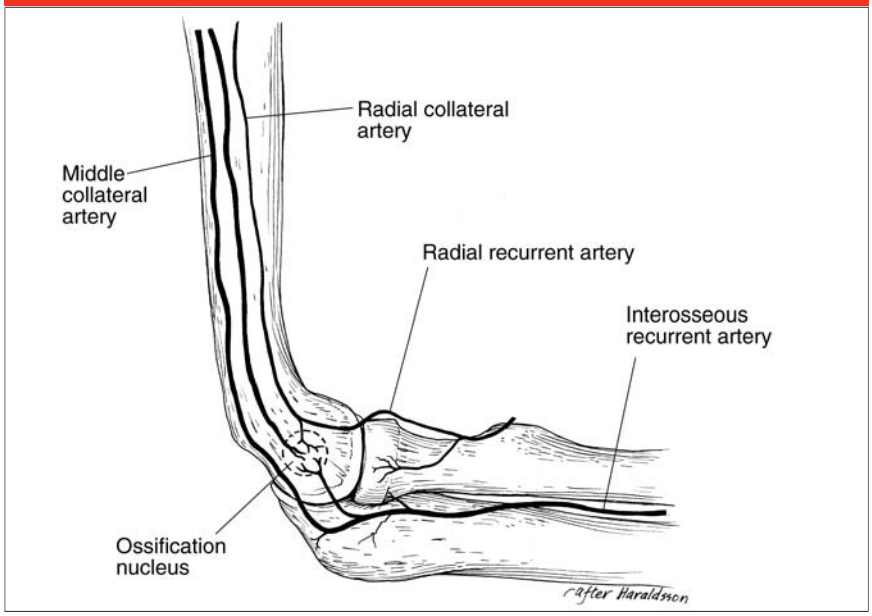
Vascular Anatomy

The vascular anatomy of the distal humerus supports ischemia as a possible contributing factor to OCD of the capitellum. The capitellum is primarily supplied by posterior end arteries that traverse the epiphyseal articular cartilage without metaphyseal collateral contribution[19,20] (Figure 2). Repetitive compression of the tenuous capitellar blood supply may result in subchondral ischemia and the characteristic osteonecrosis seen in OCD. Loss of subchondral support may then lead to articular cartilage fragmentation and loose body formation.[21]

Histopathology

Despite its name, no evidence of inflammation has been observed in histopathologic studies of OCD.[22] In a recent histologic analysis of capitellar lesions, changes similar to those of osteoarthritis were found in the articular cartilage.[23] Kusumi et al[23] used histochemical analysis to detect the presence of matrix metalloproteinase-3 and -13, which are important markers in chondrocyte apoptosis and cartilage remodeling. The authors suggested that the primary pathologic changes in OCD

Figure 2



Blood supply of the capitellum. (Reproduced from Kobayashi K, Burton KJ, Rodner C, Smith B, Caputo AE: Lateral compression injuries in the pediatric elbow: Panner's disease and osteochondritis dissecans of the elbow. *J Am Acad Orthop Surg* 2004;12[4]:246-254.)

were damage to articular cartilage induced by repeated stress following remodeling of articular cartilage and subchondral microfractures. In advanced stages, separation of deep articular cartilage as well as of subchondral bone occurs.

Clinical Presentation

OCD of the capitellum primarily affects athletes aged 11 to 21 years (average, 12 to 14 years).[5-7] OCD is more common in males than females, and it tends to be associated with sports such as baseball, gymnastics, tennis, weight lifting, and cheerleading. The dominant arm is almost always involved, with bilateral involvement occasionally reported.

Patients typically report insidious onset of lateral elbow pain that is increased with activity and relieved with rest. Stiffness and mechanical symptoms, such as locking and catching, are often noted late. Pain at night is rare and should prompt consideration of other pathologic processes.

Physical examination may demonstrate a small effusion or swelling with tenderness over the radiocapitellar articulation. Patients occasionally have a loss of terminal extension of up to 15° to 20°.[7,24,25] Crepitus or pain may be demonstrated on the active radiocapitellar compression test.[6] Passive forearm pronation and supination is done during midrange elbow flexion and extension with an axial load applied to the radiocapitellar joint. The posterolateral rotatory instability test should be done to evaluate for potential elbow instability.

Diagnosis

Radiography of the elbow is the diagnostic test of choice. Radiographs are often negative early in the disease process, and views of the contralateral elbow should be obtained for comparison. Supplemental views, such as a 45° flexion AP or oblique view, may help demonstrate the lesion.[21] The classic finding with OCD is a focal lesion in the anterolateral capitellum with rarefaction and irregularity of the articular surface. A rim of sclerotic bone often surrounds the lesion. As the condition progresses, loose bodies may form if the articular surface becomes detached (Figure 3). Healing is normally demonstrated by ossification of the radiolucent area; this may take several years.[11]

Plain radiographs are essential in the diagnosis of OCD lesions; however, additional studies may be indicated, especially for determining lesion stability.[26] CT may be used to better delineate the osseous detail and extent of the lesion. CT arthrography has been demonstrated to more accurately define loose bodies and the articular surface.[27] Ultrasonography also has been used to detect flattening in early stages, but its use is limited due to operator dependence.[28]

MRI has become the most common diagnostic modality after plain radiography. It is useful in assessing the surface of the articular cartilage and has been shown to detect early OCD lesions when no changes were evident on radiographs[29] (Figure 4). In early lesions, T1-weighted images demonstrate decreased signal intensity within the lesion, whereas T2-weighted images remain normal.[21] High signal intensity and cyst formation around a lesion on T2-weighted images has also been found to correlate with lesion instability found on arthroscopy.[30] Pseudodefect is a common finding that is mistaken for OCD on magnetic resonance images[31] (Figure 5). This normal anatomic finding is the cleft that appears at the posteroinferior capitellum as the posterior articular surface meets the nonarticulating capitellum.

Figure 3

Radiographic progression of osteochondritis dissecans of the capitellum. AP radiographs obtained with the elbow in 45° of flexion demonstrating localized subchondral bone flattening without fragments (arrows) (**A**) and nondisplaced bone fragments (arrowheads) (**B**). **C,** AP radiograph demonstrating a displaced fragment (arrow). **D,** AP radiograph demonstrating a loose fragment (arrowheads) and a bone defect (arrow). (Reproduced with permission from Takahara M, Ogino T, Takagi M, Tsuchida H, Orui H, Nambu T: Natural progression of osteochondritis dissecans of the humeral capitellum: Initial observations. *Radiology* 2000;216:207-212.)

Figure 4

A, AP radiograph demonstrating central lucency (arrow) in the capitellum consistent with osteochondritis dissecans in a 15-year-old male baseball pitcher with left elbow pain. Further delineation of the lesion is noted on coronal T1-weighted (arrow) (**B**) and sagittal T2-weighted (arrow) (**C**) magnetic resonance images.

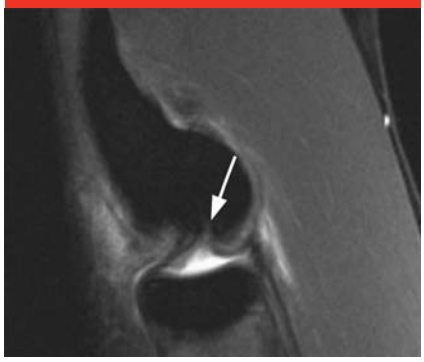
Gadolinium-enhanced magnetic resonance arthrography may provide additional diagnostic accuracy and can improve staging by identifying unstable osteochondral fragments.[29] This is demonstrated by intervening fluid signal on T2-weighted images. However, it is unlikely that all unstable lesions will have these findings.[32] Intravenous gadopentetate dimeglumine–enhanced MRI has been used to evaluate the viability of the attached osteochondral fragments.[32,33] Enhancement may suggest an intact blood supply to the fragment, but this technique has had limited use.

Classification

Minami et al[34] first categorized OCD lesions of the capitellum based on AP radiographs. Grade I lesions demonstrated a translucent cystic shadow in the lateral or middle capitellum. Grade II lesions were characterized by a clear zone or split line between the lesion and the adjacent subchondral bone. Grade III lesions were associated with the presence of loose bodies.

MRI has since been used to improve diagnosis and guide treatment. The classification system developed for OCD lesions of the knee and talus by Nelson et al[35] (Table 1) is commonly used for lesions of the capitellum. A rim of high signal intensity surrounding the lesion on T2-

Figure 5



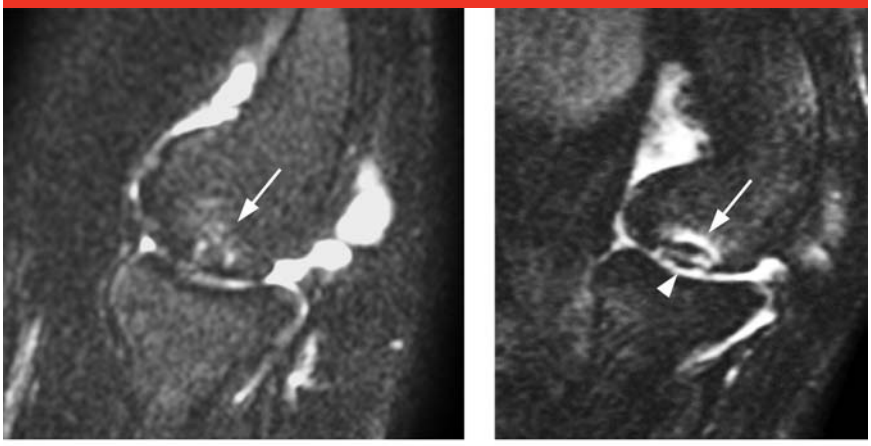
Sagittal T2-weighted fat-suppressed magnetic resonance image demonstrating a normal pseudodefect (arrow) in a 45-year-old man. (Reproduced with permission from Rosenberg ZS, Blutreich SI, Schweitzer ME, Zember JS, Fillmore K: MRI features of posterior capitellar impaction injuries. *Am J Roentgenol* 2008;190:435-441.)

Table 1

MRI Grading of Osteochondritis Dissecans Lesions[35]

Grade	Description
0	Normal
1	Intact cartilage with signal changes
2	High signal breach of the cartilage
3	Thin rim of high signal intensity extending behind the osteochondral fragment, indicating synovial fluid around the fragment
4	Mixed or low signal loose body, either in the center of the lesion or free within the joint

Figure 6



A B

A, Sagittal T2-weighted fat-suppressed fast spin-echo magnetic resonance image of the elbow in a 16-year-old male baseball pitcher with surgically proven stable osteochondritis dissecans (OCD) of the capitellum. Areas of subtle high signal intensity can be seen within the OCD lesion (arrow), but no surrounding rim is evident. **B,** Sagittal T2-weighted fat-suppressed fast spin-echo magnetic resonance image of the elbow in an 18-year-old man with surgically proven unstable OCD of the capitellum demonstrating a rim of high signal intensity surrounding the OCD lesion (arrow). Note the irregularity of articular cartilage overlying the OCD lesion (arrowhead). (Reproduced with permission from Kijowski R, De Smet AA: MRI findings of osteochondritis dissecans of the capitellum with surgical correlation. *Skeletal Radiol* 2005;185:1453-1459.)

weighted images (ie, grade 3) has been demonstrated to differentiate surgically proven stable and unstable OCD[30,36] (Figure 6).

An arthroscopic classification similar to the Ferkel-Cheng classification for lesions of the talus was developed by Baumgarten et al.[25] This classification was later modified by the International Cartilage Repair Society (ICRS). Grade I lesions are stable with a continuous softened area covered by intact cartilage.[37] Grade II lesions are stable on probing but exhibit partial discontinuity. Grade III lesions have complete discontinuity but are not dislocated. Grade IV lesions have an empty defect or a dislocated fragment lying within the bed. Despite its ease of use, arthroscopic classification of OCD lesions can miss subtle changes beneath the articular surface, and it has not been shown to have strong correlations with treatment outcomes.[7,26]

In general, OCD lesions of the capitellum can be classified as stable, unstable but attached, or detached and loose. Recently, Takahara et al[37] further simplified this classification by categorizing lesions as stable or unstable (Table 2). They defined stable lesions as those that heal completely with rest and that are characterized by all of the following: an open capitellar growth plate, localized flattening or radiolucency of the subchondral bone, and good elbow range of motion (ROM) at the time of diagnosis. Unstable lesions are characterized by one of the following: closed capitellar growth plate, fragmentation, or restriction of elbow motion ≥20° at the time of diagnosis. Unstable lesions show improved results with surgery.

Management

Management of OCD of the capitellum is controversial because the healing potential and natural history of these lesions is poorly understood.[4,27,37,38] Management is based primarily on the integrity of the ar-

Table 2

Proposed Classification of Osteochondritis Dissecans Lesions of the Capitellum

Classification	Capitellar Growth Plate	Radiographic Grade	Range of Motion	ICRS Classification
Stable	Open	I	Normal	I
Unstable	Closed	II or III	Restricted	II, III, or IV

ICRS = International Cartilage Repair Society
Adapted with permission from Takahara M, Mura N, Sasaki J, Harada M, Ogino T: Classification, treatment, and outcome of osteochondritis dissecans of the humeral capitellum. *J Bone Joint Surg Am* 2007;89:1205-1214.

ticular cartilage surface and the stability of the lesion.[37,38] Nonsurgical treatment is typically selected for patients with early grade, stable lesions, and it involves activity modification with cessation of sports participation.[4,37,38] The duration of activity modification is dictated by symptomatology, with 3 to 6 weeks of rest followed by return to sport in 3 to 6 months commonly used as a guideline.[6,7] Strengthening and stretching exercises are commonly incorporated after pain has subsided. Using radiographs to determine return to activity is discouraged because radiographic healing lags behind clinical improvement.[11] The use of nonsteroidal anti-inflammatory drugs and bracing for acute symptoms also has been advocated, but this is not supported by clinical evidence.[11]

Unlike OCD in the knee, the relationship between the healing potential of OCD lesions in the elbow and the status of the physis is unclear. Pappas[4] found superior outcomes with nonsurgical management in younger patients. However, Takahara et al[26] and Ruch et al[24] found no correlation between outcome and the status of the physis. In contrast to their early results, Takahara et al[37] recently reported significantly improved radiographic healing ($P < 0.001$) and outcome in terms of pain ($P < 0.01$) and return to sport ($P < 0.05$) in lesions with an open physis compared with a closed capitellar physis. Mihara et al[38] also found greater healing rates in patients with open physes; however, they could not detect a statistical difference when comparing patients with early grade lesions. In persons treated nonsurgically, lesion grade may ultimately be a better predictor of healing and success than physeal status.

Surgical indications include the presence of loose bodies, mechanical symptoms, unstable lesions, and stable lesions that have failed 6 months of nonsurgical management.[5-7,37,39] Takahara et al[37] recently highlighted the importance of lesion stability and recommended surgery for all lesions except those that are classified as ICRS grade I (ie, stable with open physes). Considerable debate continues regarding appropriate surgical management. Surgical goals include stimulation of the healing response and elimination of mechanical symptoms, with decision making being largely dependent on the grade, location, and size of the lesion.[6,25,39] Surgical options include arthroscopic as well as formal arthrotomy for the excision of loose bodies with or without débridement, fragment excision, abrasion arthroplasty, drilling, microfracture, fragment fixation, bone grafting, osteotomy, or osteochondral autograft transplantation (OAT).

Outcomes

Nonsurgical Management

Early results of nonsurgical management of OCD lesions suggest poor outcomes.[1,26,40] Mitsunaga et al[40] found that >50% of patients with stable lesions treated nonsurgically had mild discomfort at a mean follow-up of 13.6 years. Most of these lesions later detached, and the authors recommended excision and curettage of all higher-grade lesions. In a study by Takahara et al,[1] 50% of patients treated nonsurgically had residual elbow symptoms with activities of daily living as well as degenerative changes at an average follow-up of 12.6 years. No patient returned to his or her previous sport. The authors stated that failure to use diagnostic tools such as MRI, ultrasonography, and 45° AP radiographs may have led to underestimation of some lesions that should have been managed surgically.

In a subsequent study, Takahara et al[26] analyzed the outcomes of 24 patients who were treated nonsurgically at a mean follow-up of 5.2 years. They found poor subjective outcome to be independent of lesion grade and reported that radiographic healing and improvement were not associated with the status of the growth plate. Although the status of the physis did not correlate with outcome, poor prognosis appeared to be related to large, advanced lesions as well as to the presence of degenerative changes on presentation.

A recent report supports nonsurgical management when OCD lesions are diagnosed early. Mihara et al[38] evaluated 39 baseball players with a mean age of 12.8 years. At a mean follow-up of 14.4 months, 25 of 30 early lesions were healed, compared with 1 of 9 advanced lesions. Healing was noted in 16 of 17 patients with open physes, compared with

only 11 of 22 patients with closed physes. The authors concluded that spontaneous healing of early lesions is high, particularly in persons with open capitellar physes, and that nonsurgical treatment of these patients is appropriate.

Surgical Management

Open Débridement and Fragment Excision

Long-term results following open débridement and fragment excision have been evaluated in several studies. Bauer et al[41] reported discouraging outcomes at an average of 23 years after diagnosis in 31 patients with a mean age of 20 years. The authors found a 40% recurrence of symptoms and loss of elbow extension, with >60% of examined radiocapitellar joints demonstrating degenerative joint disease. However, most cases appeared to be advanced lesions (20 of 31); loose bodies were present in 20 elbows on presentation.

Takahara et al[1] reviewed 39 patients with an average age of 17.6 years at the time of surgery. Average follow-up was 14.7 years. Twenty-six percent of patients reported good results, and 49% returned to full sports participation. In 2007, Takahara et al[37] reported similar results after adding 16 patients to their original cohort. The results of fragment excision alone were dependent on the size of the capitellar defect, with better results in terms of pain and radiographic findings seen in patients with lesions measuring <50% of the capitellar articular width.

Arthroscopic Débridement and Marrow Stimulation

Numerous investigators have reviewed the short-term results of arthroscopic débridement and abrasion arthroplasty. The available series are retrospective in nature and include patients with variable grade lesions. Although the studies involve only short- to mid-term follow-up, promising results have been seen, with pain relief and objective improvements in elbow ROM. However, these studies do not attempt to correlate the grade of lesion with outcome, with the exception of a report by Byrd and Jones,[42] who found no correlation between grade of lesion and postoperative outcomes or return to sport. Long-term data are needed to fully assess the effectiveness of these treatment options.

Baumgarten et al[25] examined 16 patients with arthroscopic Ferkel-Cheng grade 3, 4, or 5 lesions over a 4-year period. Grade 3 lesions had a fixed osteochondral fragment, and grade 4 and 5 lesions showed a loose but undisplaced fragment and a displaced fragment with loose bodies, respectively. Thirteen patients returned to sport, and 8 of the 16 patients demonstrated slight capitellar flattening. Ruch et al[24] followed 12 patients with unstable elbow lesions (mean size, 2.5 cm) for a mean of 3.2 years. Improved extension was seen postoperatively, with all elbows demonstrating capitellar remodeling. Mechanical symptoms resolved in 11 patients. However, only three patients returned to sport, and six demonstrated an enlarged radial head at follow-up. Byrd and Jones[42] examined 10 patients, 7 of whom demonstrated grade IV or V lesions based on the American Sports Medicine Institute classification system of OCD lesions. At 4-year follow-up, only 4 of 10 patients had returned to sport, and 2 demonstrated degenerative radiographic findings. Brownlow et al[43] followed 29 patients for a mean of 6.4 years. Twenty-three patients returned to sport, with 38% demonstrating degenerative joint disease and loose bodies at follow-up. Rahusen et al[44] found that 12 of 15 patients with unstable lesions returned to sport following débridement.

Arthroscopic débridement and abrasion arthroplasty display reliable short-term results, with good pain relief and improved elbow extension. The long-term results are mixed, however, with recurrence of loose bodies and variable return to sport. These short-term studies demonstrate radiographic progression of degenerative changes over time. Although no significant correlation was found between early radiographic changes and return to sport, studies with longer-term follow-up are needed to examine this relationship.[37]

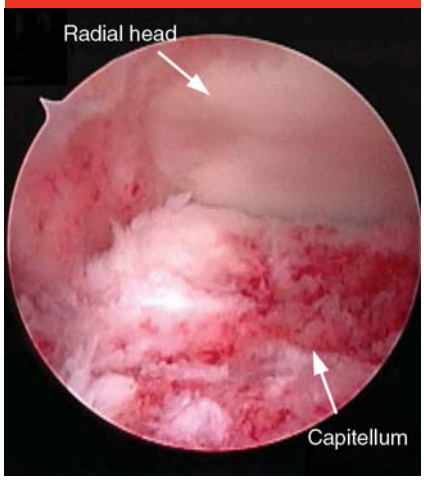
Some authors advocate drilling and microfracture techniques following débridement of OCD lesions (Figure 7). As in the knee and talus, multipotent marrow cells are released, and a fibrocartilaginous filling of the defect is generated. Bojanić et al[45] reported short-term outcomes for symptomatic advanced capitellar OCD lesions despite nonsurgical management in three elite gymnasts. At 12-month follow-up, all patients demonstrated full ROM and were pain free. All three patients returned to full national team participation within 5 months postoperatively. Postoperative MRI demonstrated that the defects were filled with hyaline-like tissue.

Fragment Fixation

Fragment fixation may be performed with a myriad of techniques, including Herbert screws, dynamic staples, pullout wiring, bioabsorbable implants, and bone peg fixation[6,37,46-48] (Figure 8). Reliable results have been found in several small series of advanced lesions; however, some authors have expressed reservations about this technique because of the possible poor healing potential of the fragment.[39]

Harada et al[46] evaluated dynamic staples inserted in a unicortical manner with iliac crest bone graft in four patients followed for a mean of 7.5 years. They reported a 100% union

Figure 7



Arthroscopic view through the proximal anterolateral portal in a left elbow demonstrating a capitellar osteochondritis dissecans lesion after arthroscopic débridement and abrasion arthroplasty.

Figure 8

Osteochondritis dissecans fragment fixation techniques. AP radiographs of the elbow demonstrating dynamic staples (**A**) and bone pegs (arrows) (**B**). (Panel A reproduced with permission from Harada M, Ogino T, Takahara M, Ishigaki D, Kashiwa H, Kanauchi Y: Fragment fixation with a bone graft and dynamic staples for osteochondritis dissecans of the humeral capitellum. *J Shoulder Elbow Surg* 2002;11:368-372. Panel B reproduced with permission from Takahara M, Mura N, Sasaki J, Harada M, Ogino T: Classification, treatment, and outcome of osteochondritis dissecans of the humeral capitellum. *J Bone Joint Surg Am* 2007;89:1205-1214.)

rate, with all patients demonstrating full ROM and painless activities of daily living. Three of four patients returned to competitive baseball. Takeda et al[47] used pullout wires in 11 patients. All patients achieved union at an average follow-up of 57 months, with 10 patients demonstrating excellent results with return to competitive pitching. Minimal degenerative changes were noted in three elbows, however. Kuwahata and Inoue[48] examined seven patients treated with Herbert screw fixation and cancellous bone graft. At a mean follow-up of 32 months, pain was resolved in all patients and all returned to sports, with an average increase in ROM of 18°.

In a large retrospective review, Takahara et al[37] reported significantly improved outcome in terms of pain in 12 patients treated with fragment fixation versus in 55 patients treated with open fragment excision alone ($P < 0.05$). Results were not stratified according to grade of lesion. Follow-up for fragment fixation was a mean of 2.9 years, compared with 9.6 years in the excision group. Based on their results, the authors recommended bone peg fixation for all ICRS grade II lesions and fragment fixation with bone grafting for all ICRS grade III lesions. The authors admit, however, that arthroscopic techniques were not evaluated and that they may provide good results in terms of pain and return to sport in persons with OCD lesions without the need for fragment fixation.

Osteotomy

Closing wedge osteotomy for the management of capitellar OCD has been used in Japan to unload the radiocapitellar joint. This technique is reserved for early grade lesions and is technically demanding.

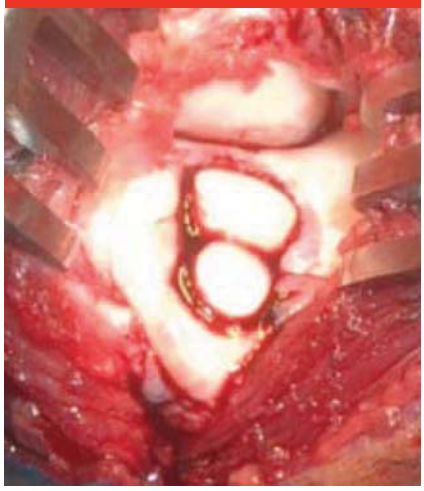
In 14 patients, Yoshizu[49] performed a 10° closing wedge osteotomy 2 cm proximal to the lateral epicondyle, with the apex medial to the capitellum. All patients demonstrated remodeling at 3 months postoperatively. Kiyoshige et al[50] evaluated seven baseball pitchers with a mean age of 14 years. Following closing wedge osteotomy, six patients returned to contact sports, and all seven demonstrated capitellar remodeling within 6 months. A mean increase in ROM of 12° was seen, and no advanced degenerative joint disease was noted.

Osteochondral Autograft Transplantation

OAT was recently introduced as another treatment option for capitellar OCD. Indications include large Baumgarten grade 4 and 5 lesions, ICRS grade IV lesions, lesions involving >50% of the articular surface area, disruption of the lateral buttress, and radial head engagement.[25,37,39] Contraindications include degenerative changes in the lateral (radiocapitellar) compartment and radial head and capitellar deformity.

The procedural steps of OAT are adapted from those performed in the knee and ankle. Cylindrical osteochondral grafts are harvested from the donor site—typically the lateral femoral condyle—and the plug is in-

Figure 9



Bone plugs inserted during osteochondral autologous transplantation of the capitellum in a 12-year-old male baseball player. (Reproduced with permission from Takahara M, Mura N, Sasaki J, Harada M, Ogino T: Classification, treatment, and outcome of osteochondritis dissecans of the humeral capitellum. *J Bone Joint Surg Am* 2007;89:1205-1214.)

serted perpendicular to the subchondral bone (Figure 9). The restricted surgical field and the lateral location of these lesions often make insertion of the grafts technically demanding, which may result in incongruent graft placement.[51] Several authors have advocated the use of oblique osteochondral plugs, but no results are yet available.[51] Donor site morbidity is another potential complication, but a recent report found no adverse effects on donor knee function following OAT.[52]

Early results demonstrate reasonable outcomes with OAT. In a study by Yamamoto et al,[36] 16 of 18 patients returned to sports participation by a mean of 3.5 years postoperatively. All patients had a good to excellent outcome. Iwasaki et al[53] reported good to excellent results in 18 of 19 male teenage athletes at a mean follow-up of 45 months postoperatively; 17 patients returned to their previous competitive level of sport. Loose body formation and degenerative changes were absent in all patients at follow-up. Shimada et al[54] demonstrated excellent results in 8 of 10 patients, with 100% graft incorporation and a mean increase to 64.2% radiocapitellar joint congruency.

Short-term results appear promising with OAT, but questions remain. The effect on outcomes of different morphologic characteristics between donor and recipient articular cartilage must be assessed, such as the flatter curvature and thicker articular cartilage found in the femoral condyle. This may affect load distribution at the radiocapitellar articulation and predispose the patient to degenerative joint disease. Further research is needed on the characteristics of chondral metabolism in the transplanted graft.

The low incidence of OCD of the capitellum makes prospective evaluation of nonsurgical and surgical management challenging. Further analysis of the long-term results of surgical modalities is necessary to define the indications for each procedure.

Authors' Preferred Treatment

Initial treatment consists of activity modification and/or sport cessation, the use of nonsteroidal anti-inflammatory drugs, and, occasionally, bracing for acute symptoms. Elbow arthroscopy is indicated in patients who fail 3 months of nonsurgical treatment as well as in those who have a detached lesion with intervening fluid signal on MRI or who have mechanical symptoms on presentation. OCD lesions with stable overlying cartilage on examination are treated with drilling. Lesions with unstable cartilage caps or loose bodies are managed with débridement of the osteochondral fragment and marrow stimulation techniques to generate a fibrocartilaginous healing response. OAT is indicated for large lesions that make up >50% of the articular surface or that engage the radial head as a result of loss of the lateral buttress.

Diagnostic arthroscopy of the affected elbow may either be performed in the the lateral decubitis position with the involved side up, the elbow flexed at 90°, and the arm supported by a padded bolster, or in the supine position with the arm balanced in double suspension through sterile fingertraps as advocated by Takahara et al.[37] We prefer to use proximal anterolateral and anteromedial portals for the inspection of the anterior compartment and the anterior capitellum. The direct lateral portal (ie, posterolateral "soft spot") and the ancillary lateral portal are used to visualize the posterior radiocapitellar region. The posterior and posterolateral portals are used to gain access to the posterior compartment and posterolateral gutter where loose bodies may be found.

Once the portals have been established and the joint is examined, synovectomy, débridement, and removal of loose bodies are performed to improve visualization before initiating management of the OCD lesion. The entire joint is systematically explored, and the lesion is examined and graded to determine appropriate treatment.

An open approach is used in the presence of a large OCD fragment in the patient who requires fragment fixation, osteochondral autograft, or osteochondral allograft. A lateral or posterolateral approach is used when formal arthrotomy is required, and approach selection is guided by the location of the lesion. Using a lateral approach, a longitudinal incision is made, extending from the lateral epicondyle distally and obliquely over

the radial head to the proximal ulna. The fascia is split between the anconeus and the extensor carpi ulnaris muscles. The joint capsule is exposed and then incised anterior to the radial head to protect the lateral ulnar collateral ligament. The annular ligament is preserved. Depending on the location of the lesion, proximal release of the lateral collateral ligament may be necessary. This is later repaired using suture anchors. For anterior lesions, a small proximal release of the ligament of up to 2 to 3 mm is usually sufficient.

For more central lesions, complete release may be required. We prefer a posterolateral approach for posteroinferior lesions, and we perform the arthroscopy in the supine position. The arm is released from double suspension, an arm board is rotated under the brachium, and the elbow is hyperflexed. A 4- to 6-cm posterolateral oblique skin incision is made along a line from the posterior edge of the lateral epicondyle to the posterior aspect of the radioulnar joint. The skin and subcutaneous tissues are incised and the investing fascia of the anconeus is identified. The anconeus fascia is split in line with the muscle fibers to the level of the underlying radiocapitellar capsule. Capsulotomy is performed, and the lesion is easily seen with the elbow hyperflexed.

Summary

OCD of the capitellum primarily affects adolescent overhead athletes and gymnasts. It must be clearly differentiated from Panner disease. The etiology of OCD is multifactorial and likely results from microtrauma in the setting of cartilage mismatch and vascular susceptibility. Multiple diagnostic modalities aid in diagnosis, including plain radiography, MRI, magnetic resonance arthrography, and ultrasonography. Management is based on the size, location, and grade of the lesion, with attempts made to address subchondral bone loss and articular cartilage damage. Early, stable lesions should be treated with rest; surgery should be considered for unstable lesions.

Controversy exists regarding the appropriate surgical management of lesions with partially detached fragments (ie, ICRS II, III). Most investigators advocate arthroscopic débridement with marrow stimulation techniques. Good short-term results also have been observed with fragment fixation and bone grafting, but concerns persist regarding the healing potential of advanced lesions. OAT appears to be promising and is indicated for higher-grade lesions measuring >50% of the width of the articular surface. Despite technical advances, clinical outcomes and return to sport remain variable. Longer-term follow-up studies are necessary to fully assess these surgical treatments, and patients and family members must be counseled to maintain realistic expectations.

References

Evidence-based Medicine: Levels of evidence are described in the table of contents. In this article, there are no level I or III studies. References 35 and 37 are level II studies. References 1, 2, 4, 10, 13, 14, 16, 21, 24-26, 30, 34, 36, 38, and 40-54 are level IV studies. References 8, 9, and 22 are level V expert opinion.

Citation numbers printed in **bold type** indicate references published within the past 5 years.

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