



Osteochondral autograft plug transfer for treatment of osteochondritis dissecans of the capitellum in adolescent athletes

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Background: Osteochondritis dissecans (OCD) of the capitellum is a condition most commonly seen in adolescents involved in repetitive overhead sports and can profoundly affect ability to return to play and long-term elbow function. Treatment of large, unstable defects in the elbow with osteochondral autograft plug transfer has not been adequately studied.

Methods: We retrospectively identified 11 teenaged patients with large (>1 cm²) capitellar OCD treated with osteochondral autograft plug transfer. Average age at the time of surgery was 14.5 years (range, 13-17 years). Outcome measures obtained included return to play, preoperative and postoperative elbow range of motion, Disabilities of Arm, Shoulder and Hand (DASH; Institute for Work and Health, Toronto, ON, Canada) by telephone interview, and osseous integration on radiographs. All 11 patients were available for evaluation at an average of 22.7 months (range, 6-49 months) postoperatively.

Results: All patients were involved in competitive high school athletics and returned to at least their pre-injury level of play. Average return to play was 4.4 months (range 3-7 months). The average final DASH was 1.4 (95% confidence interval, 0.6-2.1), and the average final sport-specific DASH was 1.7 (95% confidence interval -1.8 to 5.2). Elbow range of motion significantly improved, including improvement in flexion from a preoperative average of 126° to a postoperative average of 141° ($P = .009$) and improvement in extension from a preoperative average of 21° to a postoperative average of 5° ($P = .006$).

Conclusions: Treatment of large, unstable OCD lesions of the capitellum in adolescent athletes allows reliable return to play, is safe, and has good clinical outcomes at short-term follow-up.

Level of evidence: Level IV, Case Series, Treatment Study.

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Keywords: Elbow; capitellar osteochondritis dissecans; osteochondral autograft plug transfer; adolescent athlete; return to play

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Osteochondritis dissecans (OCD) of the capitellum is an uncommon condition most often seen in adolescents involved in repetitive overhead sports and can profoundly affect their ability to return to play and long-term elbow

function.^{3,14} In overhead athletes, a combination of valgus stress across the elbow and weakening of the medial ulnar collateral ligament complex from repetitive activities is believed to result in microtrauma to the radiocapitellar articulation.^{11,22} Repetitive microtrauma to articular cartilage has been demonstrated *ex vivo* to cause the same subchondral fracture, ischemia, and fragment formation seen in OCD.²⁷

Management of the disease is guided by the stability of the lesion and status of the articular cartilage. Plain radiographs are often unremarkable early in the disease process. As a result, magnetic resonance imaging (MRI) is the imaging modality of choice due to its ability to demonstrate a rim of edema around the fragment that distinguishes an unstable from a stable lesion.¹³ Lesion stability is further classified based on a combination of skeletal maturity, MRI imaging, range of motion, and arthroscopic findings.²⁵

Stable lesions are found in patients with open physes, nearly normal range of motion, and an intact cartilage rim on MRI and are initially treated conservatively. Surgery is indicated in the presence of unstable lesions, loose bodies, mechanical symptoms, and stable lesions that have failed 6 months of conservative management.¹¹ Multiple surgical techniques have been proposed, including arthroscopic débridement, with or without microfracture bone marrow stimulation, fragment fixation, and most recently, osteochondral autograft plug transfer.^{1,5,8,9,20,24}

Débridement techniques, with or without marrow stimulation, have shown good short-term to medium-term results, with marginal long-term outcomes.^{2,18,21,24-26} Of particular concern are large defects, defined as greater than 1 cm² in size or encompassing more than 50% of the articular surface, which are a risk factor for early degenerative arthritis if treated with débridement or microfracture.^{2,21,23,25,26} Fragment fixation raises concern for healing given compromised blood flow and has resulted in high reoperation rates.^{5,17,23} Treatment of similarly-sized OCD lesions in the knee with osteochondral autograft plug transfer has proven effective and safe, with minimal donor site morbidity.⁶ Although the literature for capitellar lesions consists of small, retrospective studies, results have been promising, with good to excellent patient outcomes and high rates of return to play.^{1,8,9,17,23,28}

The present study evaluated the clinical and radiographic results of osteochondral autograft transfer (OAT) for unstable OCD lesions of the capitellum in young athletes. Our hypothesis was that patients treated with this procedure for a large, unstable OCD lesion would demonstrate good to excellent long term outcomes with regard to pain relief, Disabilities of the Arm, Shoulder and Hand (DASH; Institute for Work and Health, Toronto, ON, Canada) scores, return to sports, range of motion, and complications.

Materials and methods

Subjects

A retrospective record review of all patients who underwent elbow diagnostic arthroscopy, loose body removal, or débridement (Current Procedural Terminology [American Medical Association, Chicago, IL USA] codes 29830, 29834, 29837, 29838) for a diagnosis of elbow OCD (International Classification of Diseases-9th Edition code 732.7) from January 1, 2007 to December 31, 2013 performed by the senior author (A.B.C.) at a single institution was completed. Inclusion criteria were: (1) OCD defect of the capitellum that was unstable on preoperative MRI or in patients in whom 6 months of conservative treatment had failed, (2) OCD measuring at least 1 cm in area as confirmed by diagnostic arthroscopy, (3) reconstruction of capitellar OCD with osteochondral autograft plug transfer, and (4) a minimum of 6 months of postoperative follow-up.

During the 6-year study period, 11 patients were treated with osteochondral plug transfer for an unstable OCD lesion sized 1 cm² or larger. All patients (100%) were available for evaluation at an average of 22.7 months of follow-up (range, 6-49 months; [Supplementary Table I](#)). Average patient age at the time of surgery was 14.5 years (range, 13-17 years). The group consisted of 10 boys and 1 girl, all of whom were involved in competitive high school athletics. This included 7 baseball players (5 pitchers), 1 basketball player, 1 football and basketball player, 1 lacrosse player, and 1 gymnast.

Diagnosis

All patients underwent MRI evaluation if a capitellar OCD lesion was suspected from the clinical history or preoperative radiographs, or both. All MRIs were reviewed by a fellowship-trained musculoskeletal radiologist. Definitive lesion size and stability were confirmed at the time of diagnostic arthroscopy.

Operative technique

Operative intervention was recommended for all patients with an unstable lesion or the presence of intra-articular loose bodies based on their preoperative MRI and in those with stable lesions in whom at least 6 months of conservative treatment had failed.

The operative reconstruction technique used a stepwise approach and was performed by the senior author (A.B.C.), with donor graft harvest performed by a sports medicine specialist (D.R.D.). The approach was consistent throughout the study period and has been previously described.⁵ An initial diagnostic arthroscopy of the elbow was performed, and lesion size and stability was assessed with a probe ([Fig. 1, A and B](#)). Loose bodies were identified and removed ([Fig. 1, C](#)). Intraoperative decision making was implemented according to the algorithm outlined in [Figure 2](#). For those lesions that were greater than 1 cm² in size and unstable, reconstruction with osteochondral autograft plug transfer was performed. A Kocher approach was used to access the radiocapitellar joint, and the lateral collateral ligament was released from its insertion on the lateral epicondyle to facilitate placement of the graft perpendicular to the joint surface ([Fig. 3, A and B](#)). The exact size of the lesion was determined ([Fig. 3, C](#)), and a

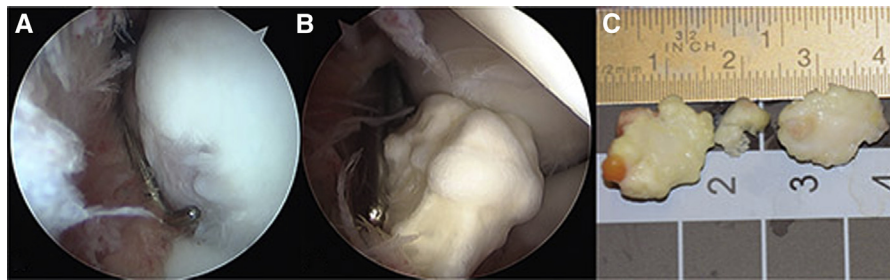


Figure 1 Arthroscopic images from a 17-year-old baseball pitcher with persistent elbow pain and a large osteochondritis dissecans (OCD) demonstrated on preoperative radiographs and magnetic resonance imaging. Diagnostic arthroscopy demonstrated (A) a large OCD and (B) several loose bodies, (C) which were removed.

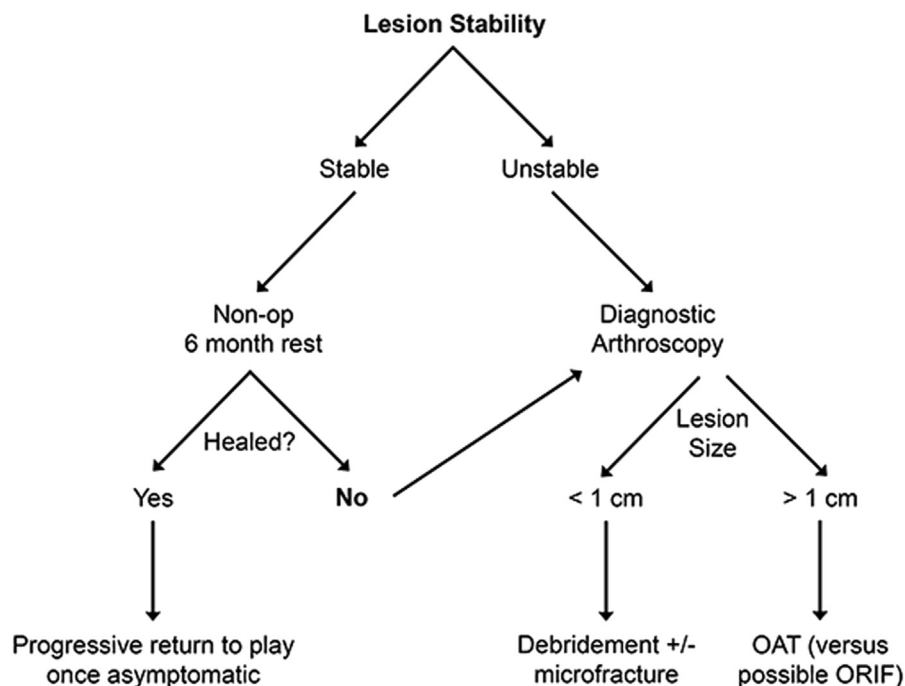


Figure 2 Algorithm used by the senior author for management of elbow osteochondritis dissecans based on lesion stability. *OAT*, osteochondral autograft transfer; *ORIF*, open reduction, internal fixation.

lateral arthrotomy was performed on the ipsilateral knee to gain access to the donor site on the lateral trochlear ridge (Fig. 3, D). A standard plug harvesting system (COR; DePuy Mitek, Raynham, MA, USA) was used to harvest an appropriate size and number of plugs (Fig. 3, D). Whenever possible, single, large plug transfer was performed over mosaicplasty.

The donor site on the capitellum was then drilled to the same depth as the plug, and the plug was press fit into the recipient site flush with the surrounding chondral surface (Fig. 4, A-C). We consider a synthetic bone graft back-fill plug (Tru-Fit Plug; Smith and Nephew, Andover, MA, USA) for harvest sites 10 mm in diameter or for 2 or more donor sites of at least 8 mm in diameter, although this is optional, because the lesions will fill spontaneously. The lateral collateral ligament in the elbow was repaired using a suture anchor technique (G2 suture anchor, DePuy Mitek; Fig. 4, D). Both surgical sites were thoroughly irrigated, and the layers were closed in a sequential fashion. A long arm splint was

placed around the elbow, and an ACE wrap (3M, St. Paul, MN USA) was placed around the knee at the completion of the case.

Postoperative care

All patients followed the same postoperative protocol. After initial immobilization in a long arm splint, patients returned for a wound check at 2 weeks and were placed in a hinged elbow brace. Progressive range of motion was performed in the brace for the next 4 weeks, beginning from an initial 30° extension block. Pronation and supination were initiated at the start of postoperative week 4. At the 6 week visit, full range of motion was allowed, and all braces were removed. Strengthening and throwing exercises were not initiated until 3 months to allow complete lateral collateral ligament healing. Postoperative radiographs were obtained at the 2-, 6- and 12-week postoperative visits to assess plug integration. Return to play was determined by a combination of patient

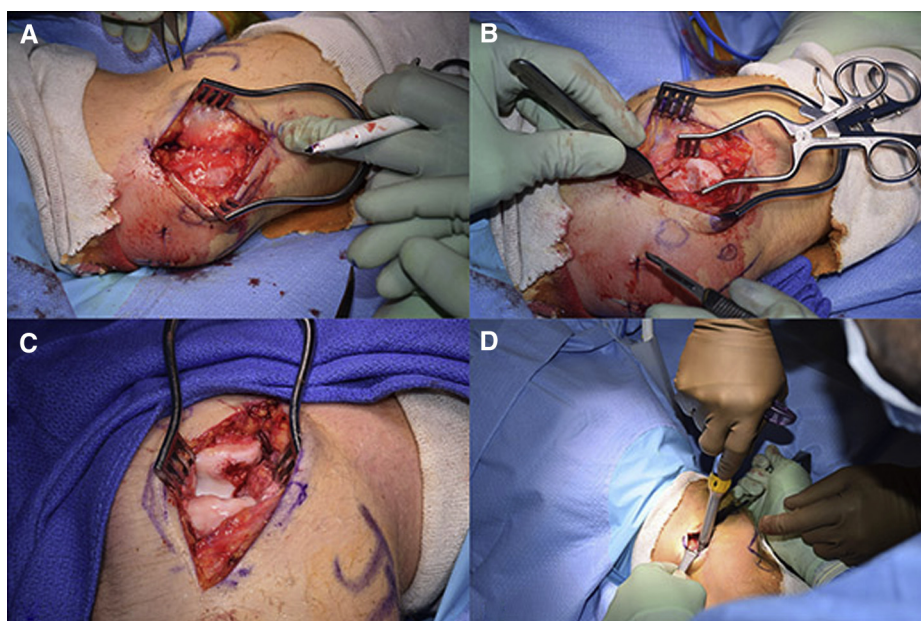


Figure 3 Intraoperative photos of osteochondral plug transfer for the elbow osteochondritis dissecans confirmed by diagnostic arthroscopy depicted in Figure 1, A-C. (A and B) A lateral (Kocher) approach to the elbow is used. (C) The osteochondritis dissecans is identified and prepared. (D) An appropriately-sized osteochondral plug is harvested from the patient's knee.

symptoms, range of motion, plug integration, and lateral collateral ligament healing.

Study procedures

A retrospective record review was completed for all included patients to determine patient-related and injury-related variables. All preoperative imaging and radiologists' interpretations were reviewed to confirm the presence of an OCD lesion. Patient records and athletic training records were reviewed to determine return to play for each included athlete. Return to play was defined as when the senior author released the patient to return to game play (when in-season) or practices (when out of season).

All patients were contacted by telephone to administer the DASH and Sport Specific DASH outcome measure questionnaires. Patients were additionally asked to confirm their postoperative and final levels of play achieved. DASH scores were calculated using the metrics provided by the Institute for Work and Health. The date of DASH and telephone survey administration was used to calculate the length of final patient follow-up.

Plain elbow radiographs were obtained as a routine part of postoperative care in all patients. Existing radiographs were reviewed by a musculoskeletal radiologist to determine osseous integration of the osteochondral plugs. Similar to the technique described by Shimada et al,²³ osseous integration or union was defined as bridging or continuity of the bony trabeculae on 3 radiographic views, including anteroposterior, lateral, and oblique view in 45° of flexion. The amount of postoperative time required for radiographic evidence of osseous integration to occur was recorded for each patient.

For comparison of the preoperative and postoperative elbow range of motion, statistical analysis was completed using paired *t* tests. For comparison of radiographic healing time between a single plug transfer and mosaicplasty, an unpaired *t* test was used. For all statistical tests, $P < .05$ was considered significant.

Statistical analysis was performed using SPSS 22 software (IBM, Armonk, NY, USA).

Results

Clinical outcomes

Average return to play for the entire cohort was 4.4 months postoperatively (range, 3-7 months). All athletes returned to a level of play equal to or higher than preinjury. Three patients graduated from high school and received Division I college scholarships in their respective sports. Of the 5 pitchers, 4 returned to pitching, with 1 transitioning to a nonpitching position. The average time to return to throwing for pitchers was 4 months and to return to play was 6 months. The football player returned to his previous level of play as a quarterback at 3 months.

The average overall DASH score was 1.4 (95% confidence interval, 0.6-2.2), and the average sport-specific DASH score was 1.7 (95% confidence interval, -1.8 to 5.2). There was a statistically significant improvement in elbow flexion from a preoperative average of 126° to a postoperative average of 141° ($P = .009$). There was also a statistically significant improvement in elbow extension from a preoperative average of 21° to a postoperative average of 5° ($P = .006$). Of the 8 patients who reported locking symptoms before surgery, none reported recurrence postoperatively.

There was 1 postoperative complication, which consisted of a superficial wound infection that required operative irrigation at débridement at 5 weeks. This was

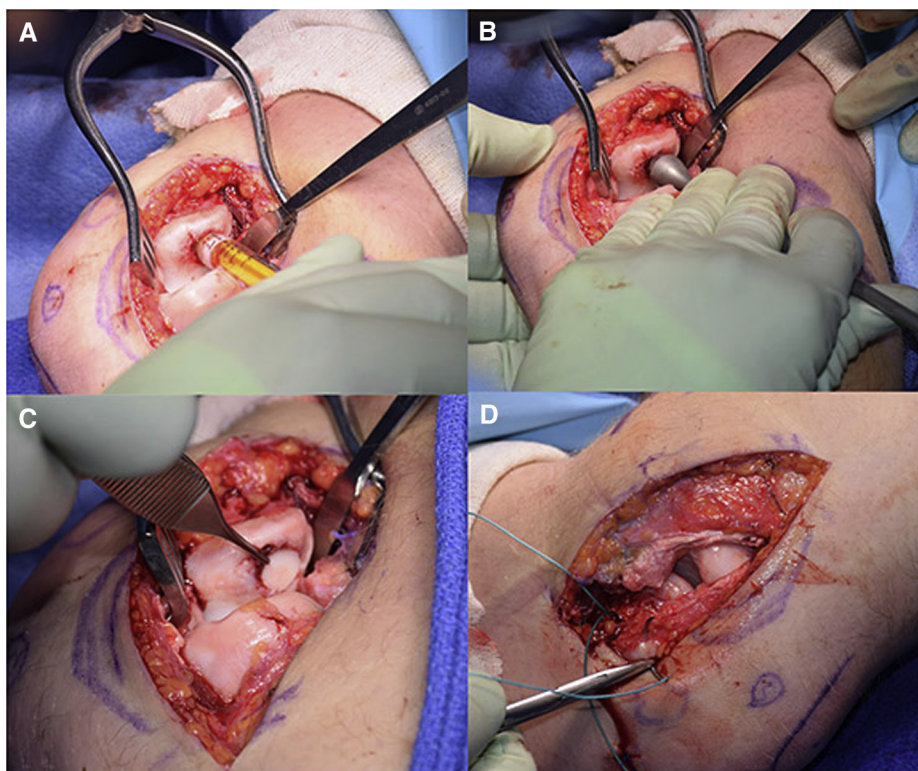


Figure 4 Intraoperative photos of osteochondral plug transfer. (A) The harvested plug is placed into the prepared osteochondritis dissecans defect in the capitellum in a parallel fashion. (B and C) A tamp is gently used to assure the plug surface conforms to the surrounding cartilage. (D) The lateral collateral ligament complex is repaired.

followed by 2 weeks of intravenous vancomycin and 6 weeks of oral clindamycin. The infection subsequently resolved and did not adversely affect the patient's eventual return to play at 4.5 months after the index operation.

Radiographic outcomes

Osseous integration of the graft site was complete in all patients at the 12-week postoperative visit. Five of 11 patients demonstrated graft site union on radiographs obtained at the 6-week visit (Fig. 5, A-D). Although the average time to radiographic healing was shorter for single-plug transfer (8.4 weeks) than for mosaicplasty (10.5 weeks), this was not statistically significant ($P = .356$). The average duration of postoperative radiographic follow-up for the entire cohort was 8.8 ± 3.5 months (range, 5.0-15.1 months).

Discussion

OCD of the capitellum is a relatively rare condition most commonly found in adolescents involved in sports that result in repetitive compression of the radiocapitellar joint and has the potential to cause significant elbow disability. Sports such as baseball and gymnastics are believed to cause microtrauma or ischemia, leading to disruption of

articular cartilage and an associated segment of subchondral bone. Patients are often young, active athletes and are eager to return to activity. Inadequate or ineffective treatment has the potential to not only interfere with return to sports but also lead to irreversible degenerative changes in the elbow. Multiple surgical techniques have been proposed, including fragment excision, open or arthroscopic fragment fixation, arthroscopic débridement, with or without marrow stimulation, and most recently, OAT.^{1,3,4,9,12,17,18,21,22,28} Currently, a clear consensus on surgical management does not exist.

Fragment fixation, with or without bone grafting, has only been examined in small series, largely due to concern about the healing potential of loose or displaced fragments. Shimada et al²³ demonstrated that 50% (4 of 8) of patients with a lateral lesion that encompassed greater than 33% of the articular surface required a second operation for failure of healing. In addition, depending on the fixation used, a second procedure may be required for hardware removal.

When débridement is combined with techniques such as subchondral drilling or microfracture, the goal is to release pluripotent stem cells from the bone marrow, forming a fibrin clot that later remodels into fibrocartilage. Fibrocartilage lacks the same mechanical properties of native hyaline cartilage and has shown poor long-term survivorship.⁷ Consequently, débridement techniques, with or without marrow stimulation, have shown good short-term

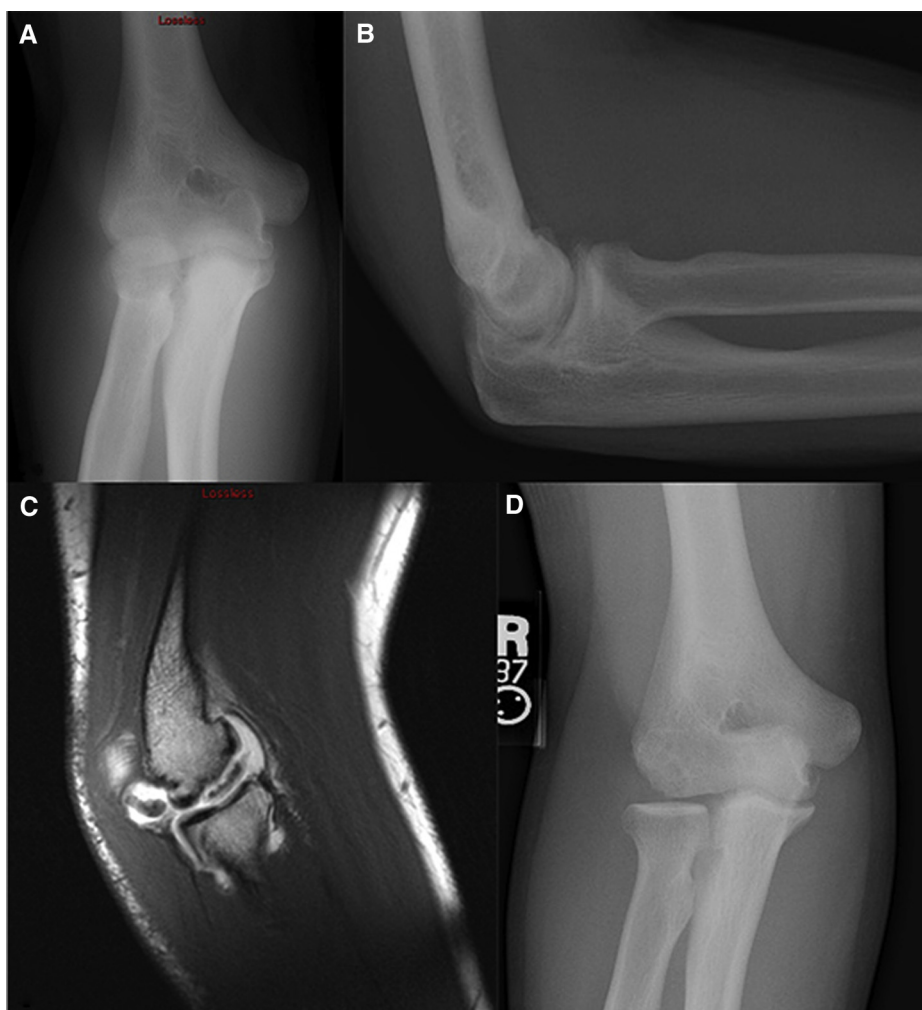


Figure 5 Preoperative (A) anteroposterior and (B) lateral X-ray images and (C) a sagittal T2-weighted magnetic resonance image of a 16-year-old pitcher with right elbow pain and loss of full elbow extension demonstrated a 20×15 mm osteochondritis dissecans with large loose bodies. The patient underwent right elbow arthroscopy with débridement and removal of loose bodies, followed by an open osteochondral autograft transfer procedure with two 4-mm plugs and two 6-mm plugs harvested from the ipsilateral knee. (D) Radiographs obtained at 3 months postoperatively demonstrated excellent incorporation of the graft.

to medium-term outcomes, with marginal long-term outcomes. A recent study of 18 patients found that 38% continued to experience persistent catching, 58% reported pain, and 33% had degenerative changes in the radio-capitellar joint after arthroscopic débridement of capitellar OCD.⁴ Similarly, Miyake et al¹⁸ reported that fragment excision was a risk factor for progression to radiographic degenerative arthritis in patients with lesions larger than 50% of the articular surface and open physes. In a series by Ruch et al,²¹ only 3 of 12 patients (25%) treated with débridement were able to return to competitive sports at an average follow-up of 3.2 years. Takahara et al²⁶ reviewed 39 patients treated with open débridement ranging from 3 to 25 years postsurgery and found 46% had pain with daily activities and that all patients with large lesions demonstrated poor outcomes.

The location and size of the lesion on the humeral capitellum are also important prognostic factors and can

influence treatment decisions. Outcomes of débridement appear to be less favorable in patients who have defects involving more than half of the articular surface, defects that are more than 1cm in diameter, and defects that violate the lateral margin of the capitellum.^{24,25} A recent systematic review reported that uncontained lesions located on the lateral capitellum require more aggressive surgical management than those located centrally or medially.¹⁶

OAT or mosaicplasty involves harvesting viable subchondral bone and cartilage plugs from a low weight-bearing portion of a joint and transferring them to the site of the cartilage injury. Aligning the plugs flush with the native cartilage is key, and when performed, results in normal contact pressures with the joint.¹⁵ The use of OAT in the elbow evolved from its initial success in the knee.^{9,28} Long-term outcomes after OAT have proven superior to microfracture in the treatment of osteochondral defects within the knee.⁷ Given the particularly poor outcomes seen

with débridement and microfracture techniques for large OCD lesions in the humeral capitellum, it has been proposed that OAT be used for lesions greater than 1 cm in size or 50% of the total capitellar articular surface.⁵

The results of the present study are consistent with what has been previously published on OAT for OCD of the humeral capitellum. In the largest study to date, Kosaka et al¹⁷ reviewed 32 patients, 19 of whom were treated with OAT. The OAT patient population was not stratified, and the return to play rate for all patients was 81%. Iwasaki et al^{8,9} reported in 2 separate studies that 15 of 19 male athletes (78%) and 6 of 8 pitchers (75%) were able to return to their previous level of play after mosaicplasty for OCD of the elbow. Shimada et al²³ demonstrated excellent outcomes and return to sport in 26 patients treated with autografts harvested from a costal donor site. Yamamoto et al²⁸ examined 18 baseball players treated with OAT at an average of 3.5 years and showed 81% had returned to their previous level of play.

We believe an established algorithm is the key to treatment of this challenging disorder. The primary strength of this study is a similar group of athletes treated with a consistent technique by a single surgeon with 100% follow-up. Our return to play rate is higher than what has been previously published. Earlier studies, such as Iwasaki et al,^{8,9} recommended multiple smaller plugs to fill the defect using a mosaicplasty technique. In contrast, we favor the use of larger, single plugs whenever possible. Literature on the use of OAT within the knee has shown that larger plugs result in greater graft stability and more predictable and rapid graft healing.⁶ This is supported by the trend we saw toward earlier radiographic graft incorporation in the single-plug group. An additional study with greater patient numbers and more frequent 2-week intervals between X-ray imaging would likely be required to detect if a true difference exists.

In addition, meticulous graft harvest and placement technique to restore the contour of the capitellar articular cartilage is of paramount importance to the success of this procedure. In our hands, this requires release and anatomic repair of the lateral collateral ligament complex. This raises 2 concerns, because ligament healing delays the rehabilitative process and also presents the potential for posterolateral rotatory instability. Of note, no patients within our series have presented with symptoms of posterolateral rotatory instability or elbow stiffness due to prolonged immobilization.

One patient in our series experienced a complication. This consisted of a superficial elbow infection that required operative treatment and 8 weeks of antibiotic therapy. The patient's rehabilitation was not compromised, and he returned to play at 4.5 months without limitations. Other potential complications, including graft donor site morbidity, persistent pain, reduced elbow range of motion, and loss of graft fixation, were not seen in the course of this study. Although the possibilities of limited donor site material and graft site morbidity are valid concerns, the amount of graft required for capitellar reconstruction is

minimal compared with what is typically required for osteochondral defects within the knee, and 2 separate studies have demonstrated no long-term negative effects.^{10,19} Of note, no patients within our study reported donor site complaints at the time of final follow-up.

Lesions in which the lateral shoulder of the capitellum has been compromised, resulting in loss of graft support and ability to restore the articular contour, may represent a relative contraindication to OAT.^{5,17,23} Shimada et al²³ proposed a possible solution to this problem with cylindrical costal osteochondral autograft from the rib costochondral articulation. The authors admit this is a more technically demanding procedure than OAT harvest from the knee, with potential complications including damage to the visceral pleura and resulting pneumothorax. We would argue this should remain a secondary graft source to be used in the setting of an unstable lateral capitellar wall.

This retrospective study has several limitations, primarily a relatively small patient number. OCD of the capitellum is a rare condition, and the small number of patients decreases the power of the study, subjecting the results to type II errors. The retrospective nature of the study introduces the potential for bias. All study patients underwent surgical intervention, so there is no control group for comparison. In addition, only postoperative DASH scores were obtained, so there are no preoperative levels for statistical comparison.

A larger study with longer follow-up period could evaluate whether the results were maintained into adulthood and the procedure prevented the development of degenerative arthritis within the elbow. Also, given the rarity of the disease, patients came from a wide geographic area and many had matriculated to college, making final follow-up over the phone a necessity.

Despite these study limitations, this is a large series of patients for this rare condition with long-term follow-up and 100% return to high level of sports participation. This study supports the use of OAT reconstruction of capitellar OCDs in high-level adolescent athletes.

Conclusions

Treatment of large, unstable OCD lesions of the capitellum by OAT in adolescent athletes is safe, allows reliable return to play, and has good clinical outcomes at short-term follow-up.

Disclaimer

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Supplementary data

Supplementary data related to this article can be found at <http://dx.doi.org/10.1016/j.jse.2015.03.014>.

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