Early Results of Single-plug Autologous Osteochondral Grafting for Osteochondritis Dissecans of the Capitellum in Adolescents

Donald S. Bae, MD, Eitan M. Ingall, BA, Patricia E. Miller, MS, and Katherine Eisenberg, BA

Background: Osteochondral autologous transplantation surgery (OATS) has been advocated for unstable osetochondritis dissecans (OCD) lesions of the adolescent capitellum, though limited information is available regarding clinical and radiographic results in North American patients. We hypothesize that single-plug OATS is safe and effective in alleviating pain and restoring function in unstable OCD.

Methods: Twenty-eight patients with unstable OCD treated with single-plug OATS were evaluated. Mean age at surgery was 14.2 years; there were 14 males. Etiology of OCD was presumed to be sports participation, including baseball (n = 5) and gymnastics (n = 11). Indications for surgery included unstable, deep OCD lesions; 2 lesions were uncontained, and 3 patients (11%) had OATS after failed prior surgery. OATS was performed by an anconeus muscle-splitting approach; donor grafts were harvested from the lateral femoral condyle by small arthrotomy. Functional outcomes were quantified using the Timmerman instrument. Median clinical and radiographic follow-up was 6.3 months (range, 5.0 to 27.0 mo) and 5.7 months (range, 5.0 to 26.7 mo), respectively. Furthermore, all patients returned functional questionnaires at a median of 9 months postoperatively (range, 5 to 27 mo).

Results: Of the 26 patients who reported preoperative tenderness, 19 (73%) patients had no tenderness at most recent clinical follow-up ($P = 0.02$). Of 18 patients with restricted elbow motion preoperatively, 13 had achieved full range of motion ($P = 0.10$). Both elbow flexion and extension improved significantly [flexion: median change (interquartile range) = 10 degrees (0 to 10 degrees), $P = 0.009$; extension: 0 degree (−5 to 0 degrees), $P < 0.001$). On postoperative magnetic resonance imaging, 86% ($P < 0.001$) of elbows had restoration of articular congruity and 93% had complete graft incorporation. Objective [median change (interquartile range) = 5 degrees (0 to 15 degrees)], subjective [25 degrees (15 to 40 degrees)], and overall [35 degrees (15 to 45 degrees)] Timmerman scores improved significantly ($P = 0.001$, <0.001, and <0.001, respectively). Of the 13 patients with > 6 months follow-up, 9 patients (69%) had returned to their primary sport ($P = 0.27$) and 100% had returned to general sports participation. There were no postoperative complications. At final follow-up, all donor knees were asymptomatic with full motion and strength.

Conclusion: Single-plug OATS is safe and effective in improving pain and elbow function in adolescents with unstable OCD, with high return to sports rates and little donor-site morbidity.

Level of Evidence: Level IV—case series.

Key Words: elbow, capitellum, osteochondritis dissecans (OCD), osteochondral autologous transplantation surgery (OATS)

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Osteochondritis dissecans (OCD) of the capitellum likely results from repetitive loading to the vulnerable chondroepiphysis, resulting in subchondral bone failure, articular cartilage injury, and ultimately loose body formation.[1–3] Typically seen in adolescent overhead athletes, inadequate or untimely treatment may lead to radiocapitellar joint degeneration resulting in longer-term pain, loss of motion, and functional limitations.[4]

OCD lesions of the capitellum have been classified according to size, stability, and containment; these clinical, radiographic, and arthroscopic characteristics have been used to portend prognosis and guide treatment.[5] Although stable lesions may be treated with rest, surgical treatment in the form of fragment fixation, debridement, drilling, microfracture, and/or osteochondral autologous transplantation surgery (OATS) have been recommended for unstable OCD.[1,6–9]

Comparisons of prior published reports suggest that patients who undergo OATS for unstable OCD lesions have higher return to sports rates, better range of motion, and superior pain relief when compared with the alternative surgical interventions.[10,11] Although there is limited evidence specifying which OCD lesions are best suited to OATS, it is posited that larger lesions with greater depth of bony involvement may benefit from restoration of articular hyaline cartilage and subchondral bone by transplantation.[1,5,7,9–12] OATS has also been used as a

From the Department of Orthopaedics, Boston Children's Hospital, Boston, MA.

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Reprints: Donald S. Bae, MD, Department of Orthopaedic Surgery, Boston Children's Hospital, 300 Longwood Avenue, Hunnewell 2, Boston, MA 02115. E-mail: donald.bae@childrens.harvard.edu.

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revision procedure for patients who have failed prior surgical intervention. Increasingly, OATS is being used as a first-line surgical intervention for capitellar OCD.

Although OATS has been advocated for treatment of large, unstable, capitellar OCD lesions, limited information is available regarding clinical and radiographic results in North American patients.[1,5,6,9,13–19] Furthermore, most prior studies have reported outcomes achieved with mosaicplasty techniques.[1,8,9] The purpose of this investigation was to characterize the early clinical and radiographic outcomes of a cohort of OCD patients who underwent OATS using a single-plug technique.

METHODS

All patients and data included in this study were obtained from a prospective longitudinal cohort study designed to capture clinical, radiographic, and functional outcomes in patients undergoing treatment for OCD of the capitellum at a single tertiary care institution.

Demographic information is collected upon patient enrollment and includes patient age, sex, hand dominance, and sports participation. Preoperative data are collected at the time of initial patient presentation and throughout the duration of any nonoperative management. Postoperative clinical data are collected at each clinical encounter following surgery, most commonly at 2 weeks, 6 weeks, 3 months, 6 months, and 1-year postoperatively. The clinical data collected includes duration of symptoms, laterality, tenderness, mechanical symptoms, swelling, and elbow range of motion. Full arc of elbow motion is defined as full extension and 135-degree flexion. For the purpose of clinical evaluation, "tenderness" denotes pain elicited by the physician during palpation of the capitellum at the time of physical examination. To assess functional outcomes, objective Timmerman scores are calculated from range of motion data.[18] Finally, donor-site morbidity was evaluated on clinical examination of the knee and through patient reported knee pain during activities of daily living. Range of motion, mechanical symptoms, and knee pain were evaluated at each patient encounter.

Radiographic data are also collected prospectively in this registry. Preoperative plain radiographs and magnetic resonance imaging (MRI) are evaluated when available. OCD lesions are classified according to the International Cartilage Research Society classification and Nelson grade.[20] OCD lesion width and depth are quantified on sagittal and coronal MRI reconstructions. In addition, lesions are classified as contained or uncontained, depending upon the integrity of the lateral column of the distal humerus and presence of intact, adjacent articular cartilage. Postoperative MRIs are evaluated for restoration of the capitellar articular surface and subchondral bone as well as signs of graft incorporation and bony healing.

Self-reported functional outcomes data (subjective Timmerman scores and return to sports) are captured through the use of a survey tool administered through a secure, online portal at each clinical encounter. Subjective Timmerman scores are determined from questions about mechanical symptoms and pain limitation as described by Timmerman and Andrews[21] Overall scores can then be computed from subjective and objective scores. Questions about resumption of sports participation without limitation are also included in this survey; distinction is made between return to preinjury (primary) or other (secondary) sports. Data are also collected from the medical record to indicate physician clearance for the patient to return to sports.

Indications for treatment of OCD at our institution are dependent upon lesion stability, size, and functional status of the patient. For those lesions that are small and stable a trial of nonoperative treatment is attempted. For unstable contained lesions with healthy subchondral bone, debridement or loose body removal with or without microfracture may be indicated. For larger, deep unstable lesions that are uncontained or associated with necrotic subchondral bone, OATS is performed. In addition, those patients who have failed another surgical intervention may be treated with OATS for revision.

OATS was performed by 1 of 2 fellowship-trained upper extremity surgeons. After administration of general anesthesia and antibiotic prophylaxis, patients are placed supine with the affected upper limb and ipsilateral lower extremity sterilely prepped and draped. Elbow arthroscopy is performed in the standard fashion to evaluate the OCD lesion, remove loose bodies, and perform limited synovectomy and debridement, when applicable. Following arthroscopy, the elbow is hyperflexed and an anconeus-splitting approach to the capitellum is performed[8] (Fig. 1). The OCD lesion is inspected and intraoperative sizing of the affected area performed. In general, every effort is made to localize and size the area of anticipated osteochondral grafting to restore normal hyaline cartilage and replace the underlying necrotic bone, based upon intraoperative inspection of the capitellum and preoperative MRI. This is particularly true of uncontained lesions, in which restoration of lateral column integrity is important for radiocapitellar stability.[5] An OATS recipient site chisel (Single Use Osteochondral Autograft Transfer System; Arthrex, Naples, FL) is used to remove diseased cartilage and bone and prepare a single cylindrical recipient site. Typically recipient chisels are placed orthogonal to the joint surface; for lateral uncontained lesions, recipient chisels may need to be directed obliquely to avoid lateral cortical breakout. Donor grafts are harvested from the non–weight-bearing surface of the lateral femoral condyle by a small, lateral, parapatellar arthrotomy. An appropriately sized donor-site plug is harvested and press fit into the recipient elbow site. All OATS procedures are performed using a single-plug technique; grafts range from 6 to 10 mm in diameter.

Inclusion criteria for this study required the patient (1) be enrolled in the registry described above and (2) underwent OATS with (3) minimum clinical, radiographic, and survey follow-up times of 5 months, respectively. Thirty-two patients with unstable OCD treated with single-plug OATS from 2010 to 2016 were identified in the registry; 28 met these criteria and were included in

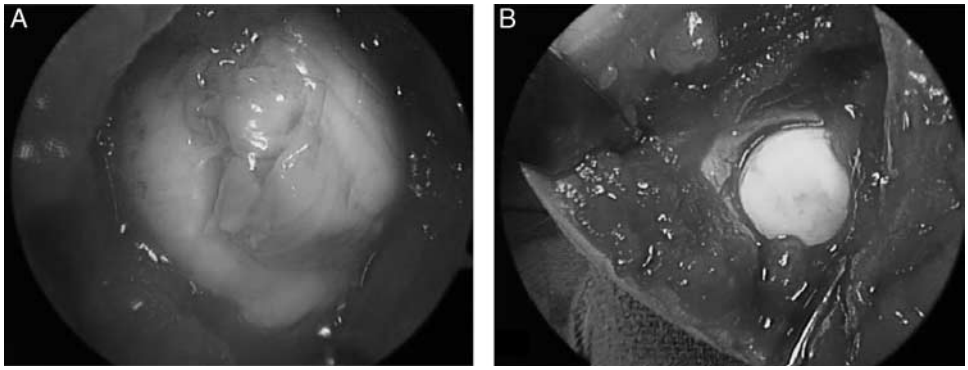

FIGURE 1. Clinical photos depicting the use of single-plug osteochondral autologous transplantation surgery for capitellar osetochondritis dissecans (OCD). A, Intraoperative photograph demonstrating a grade III OCD lesion of the capitellum. There is obvious articular cartilage incongruity and fragment instability. B, Intraoperative photograph after single-plug graft placement, with press-fit stability and restoration of articular congruity. Images courtesy of Children's Orthopaedic Surgery Foundation.

the study. One was excluded due to lack of postoperative imaging, and 3 did not respond to follow-up surveys. In the case of patients who underwent a trial of nonoperative management or who underwent prior surgical treatment before OATS (ie, debridement or microfracture), preoperative data were used from the clinical encounter most immediately preceding OATS. In the case of patients who required revision surgery after the OATS procedure, only clinical data pertaining to the period of their OATS follow-up was used.

At our institution, patients are cleared for sports participation at 6 months postoperatively if they have resolution of tenderness on examination, restoration of elbow motion and strength, and radiographic evidence of healing. Return to sports data was therefore stratified and only reported for patients who have had sufficient clinical follow-up time of ≥ 7 months (ie, have had 1 follow-up appointment beyond that where they would be cleared for sports). For all patients in the cohort, restrictions on contact sports participation or heavy lifting are reported.

Median clinical, radiographic, and survey follow-up times were 6.3 months (range, 5 to 27 mo), 5.7 months (range, 5 to 27 mo), and 9 months (range, 5 to 27 mo), respectively.

Continuous characteristics were summarized by mean and SD; those variables that deviated from normality were summarized by median and interquartile range (25th percentile to 75th percentile). Binary and categorical characteristics were summarized by frequency and percent. Changes from preoperative to postoperative status were assessed using the Wilcoxon signed-rank test for continuous characteristics and McNemar test for binary characteristics. This investigation was approved by the Committee on Clinical Investigation of our Institutional Review Board.

RESULTS

Detailed data on the 28 patients who underwent OATS during the study period are presented in Table 1. Summary characteristics of this cohort are presented in Table 2. Etiology of OCD lesion was presumed to be repetitive loading of the radiocapitellar joint during sports participation, most commonly baseball (n = 5) or gymnastics (n = 11). A summary of OCD lesion characteristics and graft dimensions can be found in Table 3.

Preoperatively, 93% of (26/28) patients had reproducible tenderness to palpation of the capitellum. Eighteen (64%) had limitations with elbow flexion-extension, and 14 (50%) had mechanical symptoms of locking or giving-way. Further preoperative and postoperative clinical data are reported in Table 4. There were no postoperative complications of infection, neurovascular compromise, or iatrogenic distal humeral fracture.

Clinical, radiographic, and patient reported data were compared preoperatively and postoperatively. Results of these comparisons are presented in Table 5. Notably, of the 18 patients who had limited range of motion preoperatively, 13 achieved full range of motion postoperatively ($P = 0.10$). Median flexion arc of motion increased significantly as did the distribution in extension arc of motion. On postoperative MRI, a significant number of patients demonstrated complete restoration of articular congruity with radiographic evidence of complete graft incorporation and bony healing ($P < 0.001$) (Fig. 2). Improvements in subjective, objective, and overall Timmerman scores from the preoperative to postoperative period each achieved statistical significance ($P < 0.001$, 0.001, and <0.001, respectively) (Table 2).

Of those 13 patients who were followed for >6 months postoperatively, 9 patients (69%) had returned to their primary sport ($P = 0.27$) and all (100%) had returned to general sports participation. Twenty-five of 28 patients (89%) had been cleared for full sports participation at the time of their most recent follow-up visit ($P < 0.001$). The 3 patients with sports restrictions were only restricted from contact sports. All donor knees were asymptomatic with full motion and strength, with no effusion or patellofemoral instability.

There was 1 revision surgery for recurrent elbow pain after return to competitive sports, including volleyball and

TABLE 1. Cohort Data Summary

									Preoperative			Postoperative				
ID	Sex	Age (y)	Primary Sport	OCD Lesion Grade	Lesion Saggital Width (mm)	Lesion Saggital Depth (mm)	Graft Diameter (mm)	Graft Depth (mm)	Objective Timmerman	Tender	Mechanical	Objective Timmerman	Tender	Mechanical	MRI Healing	Return to Primary Sport
1	F	14.81	Gymnastics	2	10.00	9.00	10.00	11.00	100	Yes	No	90	Yes	No	Yes	Other
2	M	18.89	Basketball	3	11.90	6.70	10.00	12.00	95	Yes	Yes	100	No	No	Yes	Yes
3	M	14.69	Football	4	13.20	6.20	10.00	10.00	70	Yes	No	100	No	No	Yes	Yes
4	F	14.92	Dance	3	6.90	6.10	6.00	10.00	85	Yes	Yes	100	Yes	No	Yes	Other
5	F	15.18	Gymnastics	3	8.11	7.10	8.00	12.50	100	Yes	No	100	No	No	Yes	Other
6	M	14.46	Baseball	4	7.00	6.10	8.00	12.00	75	Yes	No	100	No	No	Yes	Yes
7	F	17.94	Hockey	4	7.90	6.10	15.00		40	Yes	Yes	100	Yes	Yes	No	Other
8	M	14.27	Tennis	2	9.10	7.60	10.00	10.00	90	Yes	Yes	100	No	No	Yes	Cleared
9	F	16.64	Gymnastics	3	7.40	6.10	8.00	12.00	100	Yes	Yes	100	No	No	Yes	Yes
10	M	15.44	Baseball	3	13.38	6.68	8.00	11.00	100	Yes	No	100	No	No	Yes	Yes
11	M	15.48	Hockey	3	9.50	7.00	10.00	14.00	90	No	Yes	100	No	Yes	Yes	Yes
12	M	15.58	Lacrosse	4	15.17	5.43	10.00	15.00	85	Yes	No	85	No	No	Yes	Yes
13	M	15.47	Gymnastics	3	8.69	5.13	8.00	13.00	85	Yes	Yes	100	No	No	Yes	Yes
14	F	13.01	Gymnastics	2	9.38	5.53	6.00	12.00	100	Yes	No	100	Yes	No	Yes	Yes
15	F	14.31	Gymnastics	2	9.00	5.00	8.00	10.00	100	Yes	No	100	No	No	Yes	Yes
16	M	14.86	Hockey	3	11.90	9.40	10.00	15.50	100	Yes	Yes	100	Yes	No	Yes	Yes
17	F	16.24	Gymnastics	4	11.49	5.81	8.00	10.00	100	Yes	Yes	100	No	No	Yes	Yes
18	M	13.96	Lacrosse	3	6.30	7.00	8.00	10.00	100	Yes	No	100	No	No	No	Yes
19	F	14.78	Gymnastics	3	8.80	5.30	8.00	10.00	85	Yes	No	100	No	No	Yes	Yes
20	M	14.97	Baseball	3	7.87	5.66	10.00	11.00	90	Yes	Yes	100	No	No	Yes	Cleared
21	F	13.78	Gymnastics	4	15.70	5.00	6.00	12.00	85	No	Yes	85	No	No	Yes	Cleared
22	M	13.81	Baseball	4	8.70	4.60	8.00	13.00	85	Yes	Yes	85	Yes	Yes	No	Restrictions
23	F	12.77	Field hockey	2	12.60	8.60	8.00	14.00	75	Yes	No	100	No	No	Yes	Cleared
24	M	14.33	Football	3	7.48	12.29	8.00	12.00	90	Yes	Yes	100	No	No	Yes	Cleared
25	F	11.82	Gymnastics	2	10.40	3.40	8.00	10.00	85	Yes	No	90	No	No	Yes	Cleared
26	F	13.05	Gymnastics	3	9.30	5.10	8.00	12.00	100	Yes	No	100	No	No	Yes	Cleared
27	F	13.10	Baseball	4	14.00	7.30	10.00	10.00	85	Yes	Yes	100	No	No	Yes	Cleared
28	M	14.22	Lacrosse	3	8.20	4.00	8.00	12.00	85	Yes	No	90	Yes	No	No	Restrictions

F indicates female; M, male; MRI, magnetic resonance imaging; OCD, osetochondritis dissecans.

TABLE 2. Patient and Lesion Characteristics (N = 28)

Demographics	Median	IQR
Age (mean ± SD) (y)	14.2	± 3.15
Sex (% male)	14	50
Race [n (%)]		
White	25	89
Black or African American	1	4
Asian	2	7
Laterality [n (%)]		
Right	20	71
Left	7	25
Bilateral	1	4
Revision procedure	4	14

IQR indicates interquartile range.

rowing. This patient underwent surgical debridement and chondroplasty, though the OATS graft was noted to be well incorporated at the time of the secondary procedure.

DISCUSSION

A host of treatment options have been proposed for adolescents with capitellar OCD, depending on the characteristics of the lesion. Patients with open distal humeral physes and small, stable lesions may be offered trial of rest and activity modification.[6,12,18,22] Rest is appropriate first line for younger patients with stable lesions, though healing is not universal and may require 12 to 18 months of activity modification.[6,22,23] In more advanced lesions with unstable but in situ osteochondral fragments, internal fixation may lead to symptom resolution, healing, and return to sports.[2,6,15,17,24,25] Nobuta et al[2] reported complete resolution of symptoms in 25 of 28 patients with reduction and fixation. Hennrikus et al[17] described a cohort of 26 Nelson grades II and III lesions and reported healing in 77% of patients after internal fixation. However, fixation does not lead to successful healing in all patients. Indeed, Kosaka et al[26] reported that 50% of patients in their cohort who received peg fixation required revision surgery.

TABLE 3. OCD Lesion and Graft Characteristics

	Median	IQR
Lesion characteristics		
Contained [freq. (%)]	26	93
Dimensions (mm)		
Length	9.2	8.6-10.8
Width	9.2	8.1-11.9
Thickness	6.1	5.3-7.0
Grade [n (%)]		
2	6	21
3	14	50
4	8	29
Graft dimensions (mm)		
Diameter	8	8-10
Depth	12	10-12

IQR indicates interquartile range; OCD, osetochondritis dissecans.

TABLE 4. Preoperative and Postoperative Clinical Outcomes

Preoperative	Median	IQR
Symptoms [freq. (%)]		
Mechanical	14	50
Tenderness	26	93
Outcome measures		
Range of motion		
Flexion	130	125-135
Extension	0	0-6
Timmerman score		
Subjective	65	55-75
Objective	90	85-100
Total	150	140-170
Postoperative		
Symptoms [freq. (%)]		
Mechanical	3	11
Tenderness	7	25
Outcome measures		
Range of motion		
Flexion	135	135-135
Extension	0	0
Timmerman score		
Subjective	90	85-95
Objective	100	100-100
Total	190	180-195

IQR indicates interquartile range.

For larger grade IV lesions, loose body removal and/or debridement, microfracture, and other marrow stimulation techniques have been advocated. A 6-year follow-up study by Brownlow et al[27] showed clinical improvements in 28 of 29 patients treated with arthroscopic debridement and loose body removal. However, many patients reported continued mechanical symptoms postoperatively, and pain

TABLE 5. Statistical Reporting of Outcomes

Outcome	Median	IQR	*P**
Change in range of motion			
Flexion	5	0-10	0.009
Extension	0	−5 to 0	< 0.001
Change in Timmerman score			
Subjective	25	15-40	< 0.001
Objective	5	0-15	0.001
Total	35	15-45	< 0.001
	%	95% CI	*P***
MRI healing	86	66-95	< 0.001
Articular congruity	89	71-97	< 0.001
Graft incorporation	93	75-99	< 0.001
Return to sports (patients with ≥ 7 mo clinical follow-up, N = 13)			
Primary sport	69	39-90	0.27
Any sport/activity	100	—	—
Restrictions			
Any	11	3-29	< 0.001
Heavy lifting	0	—	—
Sports	0	—	—
Contact sports	11	3-29	< 0.001
Tenderness at follow-up	25	11-45	0.02
Mechanical symptoms at follow-up	11	3-29	< 0.001

CI indicates confidence interval (95% exact); IQR, interquartile range; MRI, magnetic resonance imaging.

*P-values < 0.05 indicate significant difference from 0 at the 5% level.

**P-values <0.05 indicate significant difference from 50% at the 5% level.

FIGURE 2. A, Preoperative T2-weighted sagittal magnetic resonance imaging (MRI) depicting an unstable, in situ osetochondritis dissecans lesion. Note is made of the breach of the articular cartilage and high signal within the affected subchondral bone. B, T2-weighted sagittal MRI taken 6 months after single-plug osteochondral autologous transplantation surgery, depicting graft incorporation and restoration of articular congruity. Images courtesy of Children's Orthopaedic Surgery Foundation.

did not fully resolve in the majority of patients. Baumgarten et al[28] reported on a cohort of 16 patients treated with chondroplasty and loose body removal. They reported significant improvement in flexion and extension contracture. Seven of 9 patients returned to baseball and 4 of 5 returned to gymnastics. Lewine et al[16] published results of 21 patients treated with drilling and/or microfracture and reported that two thirds of patients returned to their primary sport. These return to sports rates are consistent with the experience at other US and Japanese centers.[6,29]

OATS has been more recently proposed as an alternative treatment for large, unstable, and uncontained OCD lesions of the capitellum. Theoretical advantages include replacement of the abnormal OCD lesion with healthy hyaline cartilage and subchondral bone. Initial reports regarding the clinical results of OATS in Japanese baseball players have been very encouraging, with healing and return to sports rates of over 90%.[8,30] Yamamoto et al[1] reported on 18 adolescent baseball players treated with OATS. Elbow motion, radiographic appearance, and Timmerman scores improved considerable postoperatively, with high (16/18 patients) return to baseball rates. Similarly Iwasaki et al[8] published promising results in a series of 19 adolescent baseball players, of which 18 were pain free and 17 returned to sports.

A recent meta-analysis by Westermann et al[11] identified 24 studies on surgical treatment of OCD with data on 492 patients of a mean age of 14.3 years. With microfracture and debridement, 71% of patients returned to prior level of sports participation compared with 64% of those who underwent fixation. Notably, OATS yielded a 94% rate of return to primary sport participation ($P < 0.01$). This meta-analysis did not find a significant difference in either elbow range of motion or Timmerman scores between surgical interventions. Westermann and colleagues' analysis was corroborated by a second systematic review of the OATS literature, also noting a 94% return to primary sports.[10] Although these authors have highlighted prior hypotheses[9] that having fewer plugs may lead to faster osseous union, they concluded that this supposition could not be reliably evaluated given the available data. Indeed, none of the studies included in either of these systematic reviews were exclusively evaluating single-plug OATS from a lateral femoral condyle donor site.

Despite these favorable results, a number of challenges remain. OATS is a technically demanding procedure, and much of the published information on the results of OATS is based upon mosaicplasty technique. As mosaicplasty requires the harvest and precise placement of multiple osteochondral grafts, technical refinements to facilitate the ease of capitellar reconstruction would be of interest to practicing surgeons. In addition, mosaicplasty requires more extensile open approaches, longer surgical time, and potential donor-site morbidity, particularly when multiple osteochondral grafts are needed. Furthermore, the majority of published reports describe the results obtained in Asian patients, in whom there may be differences in clinical presentation, lesion size and severity, and other clinical characteristics. Additional work in North American patients is warranted to corroborate the generalizability of the initial OATS reports. Finally, most prior reports have focused on adolescent baseball players, in whom OATS was the primary treatment. Additional investigation to delineate the anticipated results in other athletes and in revision OCD reconstruction is warranted.

To this end, we present the early clinical, radiographic, and functional outcomes of single-plug OATS in North American patients. At most recent clinical follow-up, 93% of patients had elbow motion within 5 degrees of normal, and 75% were without capitellar tenderness. Articular congruity was successfully restored in over 85% of patients, with excellent graft incorporation and bony healing rates. At most recent follow-up, ~90% of patients were cleared for full sports participation. Indeed, ~70% of patient had successfully returned to their primary sport—including baseball and gymnastics—less than a year after surgery. Of note, 3 of the patients who did not return to their primary sport had the OATS procedure in the setting of failed prior surgical intervention for their OCD lesion.

The significant increase in subjective Timmerman scores indicates patient reported improvement in activities and quality of life. Furthermore, this improvement was seen across the cohort, regardless of lesion grade or containment. Finally, there were no intraoperative or postoperative complications reported, nor any pain or functional limitations from the knee donor site. These findings highlight the appeal of the single-plug technique.

These results are particularly encouraging considering that 2 patients in this cohort (7%) had uncontained lesions, both of which went on to successful radiographic healing. Furthermore, 3 patients (11%) of the cohort underwent OATS as a secondary, revision procedure after prior failed surgical treatment for their OCD. Historically, large uncontained lesions—particularly after failed prior procedures—have been associated with more guarded prognoses after revision surgery.[2,5,16,18] The high healing and return to sports rates in this cohort suggest that single-plug OATS may provide superior clinical outcomes compared with internal fixation or microfracture for adolescent capitellar OCD, particularly for unstable, deep, and uncontained lesions.

Despite these encouraging results, there are a number of limitations to the current investigation. Longer-term evaluation of larger number of patients is needed to monitor the durability of the graft reconstruction, particularly given the high rate of return to repetitive overhead or weight-bearing sports. The current study, however, evaluated similar numbers of patients as prior published reports, and enrollment of additional patients continues through our OCD registry. Second, no knee imaging or validated functional outcome instruments were routinely collected postoperatively. Prior reports have suggested little morbidity from osteochondral graft harvest, though further study is needed to ascertain the long-term effect, if any, on the knee.[7,31] Finally, this study only evaluates the use of single-plug OATS for unstable capitellar OCD. No conclusions can be drawn regarding the indications for osteochondral grafting in grades I and II OCD, or for the comparative efficacy of this technique compared with mosaicplasty, particularly with larger capitellar lesions.

Despite these limitations, we conclude that single-plug OATS is safe and effective in the treatment of unstable capitellar OCD in adolescents. With careful patient selection and meticulous surgical technique, single-plug OATS provides high healing and return to sports rates with minimal donor-site morbidity in adolescent athletes.

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