Osteochondritis dissecans of the capitellum

Bexkens, R.

Creative Commons License (see https://creativecommons.org/use-remix/cc-licenses):
Other

Citation for published version (APA):

General rights
It is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), other than for strictly personal, individual use, unless the work is under an open content license (like Creative Commons).

Disclaimer/Complaints regulations
If you believe that digital publication of certain material infringes any of your rights or (privacy) interests, please let the Library know, stating your reasons. In case of a legitimate complaint, the Library will make the material inaccessible and/or remove it from the website. Please Ask the Library: https://uba.uva.nl/en/contact, or a letter to: Library of the University of Amsterdam, Secretariat, Singel 425, 1012 WP Amsterdam, The Netherlands. You will be contacted as soon as possible.
Chapter 5

Computed tomography analysis following arthroscopic debridement and microfracture in the treatment of advanced osteochondritis dissecans

Published as:

Decreased defect size and partial restoration of subchondral bone on computed tomography after arthroscopic debridement and microfracture for osteochondritis dissecans of the capitellum.

Bexkens R, van Bergen CJA, van den Bekerom MPJ, Kerkhoffs GMMJ, Eygendaal D.

Abstract

Background: Arthroscopic debridement and microfracture are considered the primary surgical treatment for capitellar osteochondritis dissecans (OCD). Healing of the subchondral bone plays an essential role in cartilage repair, while lack of healing is related to the development of osteoarthritis. To date, it is unknown to what extent healing of the subchondral bone occurs after this technique in the elbow.

Purpose: To analyze defect size changes and subchondral bone healing with computed tomography (CT) after arthroscopic debridement and microfracture for advanced capitellar OCD.

Methods: Between 2009 and 2016, 67 patients underwent arthroscopic debridement and microfracture for advanced capitellar OCD. Fifty-four patients (81% follow-up rate) with CT scans were included (mean ± SD: preoperative, 4.0 ± 1.7 months; postoperative, 29 ± 9.0 months). OCD defect size was assessed by measuring the largest diameter in 3 directions: medial-lateral direction (coronal plane) and anterior-posterior direction and depth (both in sagittal plane). Healing of the OCD was divided into 3 categories: good—complete osseous union or ossification; fair—incomplete osseous union or ossification but improved; poor—no changes between pre- and postoperative scans. Postoperative clinical outcome was assessed with the Oxford Elbow Score (OES) at the same time as the postoperative CT scan.

Results: There were 30 female and 24 male patients (age, 15.7 ± 3.2 years). Defect size decreased (P < .001) in all 3 directions (medial-lateral × anterior-posterior × depth) at 29 ± 9.0 months: preoperatively, 7.9 ± 2.8 × 8.0 ± 3.2 × 4.1 ± 1.5 mm; postoperatively, 3.5 ± 3.3 × 4.0 ± 3.5 × 1.6 ± 1.4 mm. Healing of the subchondral bone was graded as good in 19 defects (35%), fair in 27 (50%), and poor in 8 (15%). The mean postoperative OES score was 40 6 8.4. Neither postoperative defect size nor healing grade correlated with the OES (P < .05).

Conclusion: Arthroscopic debridement and microfracture for advanced capitellar OCD result in improved (ie, decreased) defect size at a mean follow-up of 29 months, both in width and in depth. Healing of the subchondral bone was either good or fair in 85%. Interestingly, CT findings did not correlate with clinical outcomes.
Introduction

Osteochondritis dissecans (OCD) of the capitellum is a commonly seen disorder in young athletes engaged in sporting activities such as baseball, gymnastics, and tennis. OCD in an early stage (stable) in a patient with an open capitellar physis may be treated with immediate rest and analgesics. Surgical treatment is advocated in advanced OCD (unstable) and in cases in which nonoperative treatment has failed. Type of operative treatment is highly based on a surgeon’s experience and preference, including arthroscopic debridement and loose body removal with or without marrow stimulation, fragment fixation, and osteochondral autologous transplantation (OATS).

As a primary procedure, arthroscopic debridement and microfracture may be indicated in unstable, shallow OCD defects with an intact lateral capitellar wall. The goal of debridement is to achieve a stable cartilage rim by removing unstable cartilage and underlying avascular bone, as well as to remove any loose bodies present. Subsequently, an awl is used to puncture multiple holes in the subchondral bone to promote revascularization and induce bone and fibrous tissue formation. The importance of subchondral bone integrity in cartilage repair has become clearer during the past few years. Subchondral bone supports the overlying cartilage and distributes mechanical loads across the joint surface. Stiffened and less pliable subchondral bone may transmit increased loads, leading to cartilage damage. In addition, biochemical studies showed that factors released by osteoblasts (eg, growth factors, prostaglandins, and leukotrienes) during subchondral bone remodeling reach the overlying cartilage. Therefore, it is important to know to what extent healing of the subchondral bone occurs after debridement and microfracture for capitellar OCD. Also, knowing to what extent subchondral changes affect clinical outcome would be helpful for the clinician with regard to prognosis after treatment.

The first main objective of this study was to analyze defect size changes and subchondral bone healing with computed tomography (CT) after arthroscopic debridement and microfracture for advanced capitellar OCD. The second main objective was to determine if postoperative defect size and subchondral bone healing correlate with clinical outcome.

Methods

In this retrospective study, we evaluated prospectively collected data of consecutive patients who were treated in our institution between 2009 and 2016. All patients had failed nonoperative treatment for 6 months, consisting of immediate cessation of elbow-stressing activities, initiation of analgesics, and muscle-strengthening exercises.
Included were patients with unstable capitellar OCD who were treated with arthroscopic debridement and microfracture, as well as loose body removal if needed. Also, a CT scan was needed before and after treatment, with the postoperative CT performed at a minimum of 1 year after treatment. Excluded were patients with <1-year follow-up and patients with a CT scan of insufficient quality (ie, inability to assess defect size and subchondral bone healing).

The diagnosis was based on patient history, physical examination, and imaging techniques, including radiographs, CT, and magnetic resonance imaging (MRI). A CT scan was ordered before and approximately 2.5 years after treatment to evaluate the subchondral bone. On the basis of preliminary data involving 25 patients in our cohort, CT scanning has been proven to accurately correlate with intraoperative findings. MRI was occasionally ordered in cases in which lesion stability was undetermined per CT. Arthroscopic debridement and microfracture were indicated if CT scan revealed a fragmented OCD defect with or without loose bodies. There were no restrictions with regard to lesion size. Fragment fixation was considered if the OCD defect consisted of a single large fragment (.10 mm). OATS was considered if debridement with microfracture had failed and the lateral capitellar wall was involved. The latter 2 groups were not included because each consisted of a small sample of patients who were not of interest to the specific purpose of the present investigation. All arthroscopic procedures were performed or supervised by the senior author (D.E.).

Sixty-seven patients underwent arthroscopic debridement and microfracture within this period, of whom 13 patients with <1-year follow-up were excluded (81% follow-up rate). These patients did not wish to have a follow-up appointment approximately 2.5 years after treatment for various reasons: currently no elbow complaints, living far from the hospital, or unreachable by phone or email.

This study was waived for review by the medical ethics committee of our hospital, because data were collected as part of routine clinical care.

**Operative Technique**

The patient was placed in a lateral decubitus position, and a tourniquet was inflated around the upper arm, after which the ulnar nerve, bony landmarks, and portals were marked. Then, 20 mL of saline was injected into the joint from posterior into the olecranon fossa. Arthroscopy was performed with 6 portals: 1 proximal anteromedial, 1 proximal anterolateral, 2 posterior, and 2 posterolateral. A standard 30° wide-angle scope (4 mm diameter) was used to visualize the radiocapitellar compartment and identify the osteochondral defect. After identification, a 4.5- or 2.5-mm shaver or curette was introduced into the posterolateral joint space through the standard softspot or posterolateral portal. All unstable cartilage and underlying necrotic bone were removed. Loose bodies were removed with a grasper. With a microfracture awl (2-mm diameter), 4
to 7 holes were created into the subchondral bone (5-mm depth), depending on the size of the defect. Postoperative treatment consisted of 24 hours of immobilization in loose dressing, followed by an active program under the supervision of a physical therapist. Axial loading was prohibited for 3 months. Gradual return to sports for gymnasts and overhead athletes was allowed at 4 months. Return to other types of sporting activities was allowed after 3 months.

**CT Evaluation**

CT scans of the affected elbow were obtained before and after treatment, with a minimum follow-up of 1 year. The scanning protocol involved high-resolution axial slices with a slice thickness of 0.50 to 0.75 mm and multiplanar coronal and sagittal reconstructions of 1.0 mm.

All scans were analyzed by an orthopaedic surgery resident (R.B.) under the supervision of an orthopaedic surgeon (M.P.J.v.d.B.). Both were blinded to clinical outcomes and not involved in the surgical procedures.

OCD defects were preoperatively graded according to the Ferkel and Sgaglione classification system,\textsuperscript{11} which was originally used to grade talar OCD but was recently demonstrated to have fair interobserver agreement in grading capitellar OCD as well.\textsuperscript{7}

Three-dimensional sizes of the OCD defects were evaluated by measuring the largest diameter in 3 directions with JiveX Review Client (v 4.7.1.10; VISUS Technology Transfer GmbH): in the medial-lateral direction (coronal plane) and in the anterior-posterior direction and depth (both in sagittal plane). The depth was determined by drawing a circle through the subchondral bone plate of the capitellum on sagittal CT reconstructions. A perpendicular line from the center of the circle to the deepest point of the defect was measured as the depth.\textsuperscript{22} Size measurements were performed twice with a time difference of 2 weeks to assess the intraobserver reliability. The mean of the 2 measurements was used for analysis.

Qualitative assessment of subchondral bone healing was divided into 3 categories according to the classification system described by Kumai and colleagues:\textsuperscript{13,22} good healing—complete osseous union or ossification; fair healing—incomplete osseous union or ossification but improved as compared with preoperative scan; poor healing—no changes between pre- and postoperative scans.

**Clinical Evaluation**

Clinical outcomes were assessed with the use of the Oxford Elbow Score (OES) at the same time as the postoperative CT scan. The OES is a reliable and validated patient-reported outcome measure that is commonly used for elbow assessment after surgical treatment.\textsuperscript{8,9} The OES is a 12-item measure evaluating the following domains: elbow function, pain, and social-psychological effect. The OES ranges from 0 to 48 points.\textsuperscript{8,9}
Return to sporting activities was divided into 4 categories: return to primary sport at the same or higher level, return to primary sport at a lower level, no return because of symptoms, and no return because of other reasons.

**Statistical Analysis**

Baseline characteristics were summarized as absolute numbers with frequencies for categorical data and as mean ± SD for continuous data. Changes in OCD size after treatment were analyzed with a paired \( t \) test. The relationship between postoperative OCD size and clinical outcome (OES score) was analyzed with a Pearson correlation test. The relationship between healing grade (good, fair, or poor) and clinical outcome (OES score) was analyzed with 1-way analysis of variance (ANOVA). In addition, the relationships between CT analysis (postoperative OCD size and healing grade) and the following variables were investigated: sex, age, arm dominance, prior surgery, capitellar physis status, OCD grade, and lateral capitellar wall involvement. For postoperative OCD size (continuous outcome variable [parametric]), a Student \( t \) test was used in case of a dichotomous variable (sex, arm dominance, prior surgery, capitellar physis status, lateral wall involvement), a 1-way ANOVA in case of an ordinal variable (OCD grade), and a Pearson correlation coefficient test in case of a continuous variable (age). For healing grade (ordinal outcome variable), a Mann-Whitney \( U \) test was used in case of a dichotomous variable (sex, arm dominance, prior surgery, capitellar physis status, lateral wall involvement), a Kruskal-Wallis test in case of an ordinal variable (OCD grade), and a 1-way ANOVA in case of a continuous variable (age). A \( P \) value <.05 was considered significant. The intraclass correlation coefficient was calculated to determine the intraobserver reliability for dimension measurements. A value ≥0.80 indicates substantial agreement. Statistical analysis was performed with Stata (v 13.0; StataCorp LP).

**Results**

Fifty-four patients (30 female and 24 male; age, 15.7 ± 3.2 years) were included between 2009 and 2016. Baseline characteristics are depicted in Table 1.

| Table 1: Baseline Characteristics (\( N = 54 \)) a |
|-----------------|-----------------|-----------------|
| **Age, y, mean ± SD** | 15.7 ± 3.2 |
| **Sex** |                |
| Male | 24 (44) |
| Female | 30 (56) |
| Right side | 40 (74) |
| Dominant side | 43 (80) |
Table 1: Baseline Characteristics (N = 54) (continued)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Count (Percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior surgery</td>
<td>15 (28)</td>
</tr>
<tr>
<td>Sporting activities</td>
<td></td>
</tr>
<tr>
<td>Gymnastics</td>
<td>18 (35)</td>
</tr>
<tr>
<td>Tennis</td>
<td>8 (15)</td>
</tr>
<tr>
<td>Volleyball</td>
<td>4 (7.7)</td>
</tr>
<tr>
<td>Field hockey</td>
<td>4 (7.7)</td>
</tr>
<tr>
<td>Baseball</td>
<td>3 (5.8)</td>
</tr>
<tr>
<td>Others (e.g., water polo, judo)</td>
<td>15 (28.8)</td>
</tr>
<tr>
<td>Capitellar physis status</td>
<td></td>
</tr>
<tr>
<td>Open</td>
<td>8 (15)</td>
</tr>
<tr>
<td>Closed</td>
<td>46 (85)</td>
</tr>
<tr>
<td>OCD classification</td>
<td></td>
</tr>
<tr>
<td>I: cystic lesion with intact roof</td>
<td>0</td>
</tr>
<tr>
<td>IIA: cystic lesion with communication to the surface</td>
<td>2 (4)</td>
</tr>
<tr>
<td>IIB: open articular surface lesion with nondisplaced overlying fragment</td>
<td>2 (4)</td>
</tr>
<tr>
<td>III: nondisplaced fragment with lucency underneath</td>
<td>13 (24)</td>
</tr>
<tr>
<td>IV: displaced fragment</td>
<td>37 (68)</td>
</tr>
<tr>
<td>Lateral capitellar wall involvement</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>10 (19)</td>
</tr>
<tr>
<td>No</td>
<td>44 (81)</td>
</tr>
</tbody>
</table>

aData are reported as n (%), unless otherwise indicated. OCD, osteochondritis dissecans.

CT Analysis

CT scans of the affected elbow were obtained at 4.0 ± 1.7 months preoperatively and 29 ± 9.0 months postoperatively.

Defect size decreased in all directions after arthroscopic debridement and microfracture ($P < .001$) (Table 2). The intraobserver reliability of defect size measurements was substantial (intraclass correlation coefficient = 0.90).

Healing of the subchondral bone was classified as good in 19 defects (35%), fair in 27 defects (50%), and poor in 8 defects (15%) (Figure 1).

Table 2: Three-dimensional OCD Size at Baseline and After Debridement and Microfracture (N = 54)

<table>
<thead>
<tr>
<th>Direction</th>
<th>Preoperative</th>
<th>Postoperative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medial-lateral direction: coronal plane, mm</td>
<td>7.9 ± 2.8</td>
<td>3.5 ± 3.3</td>
</tr>
<tr>
<td>Anterior-posterior direction: sagittal plane, mm</td>
<td>8.0 ± 3.2</td>
<td>4.0 ± 3.5</td>
</tr>
<tr>
<td>Depth: sagittal plane, mm</td>
<td>4.1 ± 1.5</td>
<td>1.6 ± 1.4</td>
</tr>
</tbody>
</table>

aData are reported as mean ± SD, unless otherwise indicated. OCD, osteochondritis dissecans.

bFor each postoperative value, $P < .05$. 
Clinical Outcomes

The postoperative OES score was 40 ± 8.4 at a follow-up of 29 ± 9.0 months. Thirty-one patients (60%) returned to their primary sport at the same or higher level. An additional 3 patients (6%) returned at a lower level. Thirteen patients (25%) did not return to sporting activities because of elbow symptoms, and 5 (9%) did not return for other reasons (eg, changing interests and lack of time). Two patients did not participate in sports.

Associations Between CT Analysis and Clinical Outcomes

Postoperative defect size did not correlate with the OES for all directions: in the medial-lateral direction in the coronal plane ($P = .28$) and in the anterior-posterior direction ($P = .12$) and depth in the sagittal plane ($P = .13$). OCD defects with good subchondral bone healing had a mean OES score of 39; defects with fair healing, a score of 40; and defects with poor healing, a score of 43. There was no difference in OES score among healing grades ($P = .43$).

Associations Between CT Analysis and Patient- and OCD-Related Factors

Neither patient-related factors (sex, age, arm dominance, prior surgery, capitellar physis status) nor OCD-related factors (OCD grade and lateral wall involvement) were associated with postoperative defect size or healing grade ($P < .05$).

Discussion

The present investigation is the first, to our knowledge, that evaluated CT imaging after arthroscopic debridement and microfracture in the treatment of capitellar OCD. The most important finding of this investigation is that defect size significantly improved in all directions after treatment at a mean follow-up of 29 months. Healing of the subchondral bone was good or fair in 85% of OCD defects and poor in only 15%. Neither postoperative
defect size nor subchondral bone healing correlated with clinical outcomes. Additionally, there were no prognostic factors found (eg, skeletal immaturity, OCD grade, lateral wall involvement) for either postoperative defect size or healing of an OCD defect.

Studies reporting on postoperative imaging after microfracture in the treatment of capitellar OCD are scarce and limited to radiographs and MRI. Wulf and colleagues evaluated 10 patients who underwent microfracture for unstable OCD by means of radiographs and MRI at 27-month follow-up. Radiographic findings improved according to the grading system described by Takahara and colleagues. Additionally, minimal to no degenerative changes were observed preoperatively, and these did not alter after treatment. Note that radiographic evaluation included an anteroposterior view in full extension, while a view in 45° of elbow flexion may better depict an OCD defect. MRI evaluation showed significant improvement in objective scoring with a method described by Roberts and colleagues for assessing the incorporation of the articular surface after OATS. The authors reported normal or near-normal bone intensity in all patients and subchondral cortical irregularity in 70% of patients. Thickened cartilaginous signal intensity, suggestive for a completely filled articular defect, was seen in 80%. These findings are supported by a case report of Bojanić and colleagues, who published MRI results in 2 cases after microfracture for capitellar OCD. A few studies with relatively large sample sizes reported on radiographic findings after debridement alone, without additional microfracturing. Although acceptable radiographic results were reported in the majority, a small group of patients (2.8%) developed early osteoarthritic lesions. Ueda and colleagues reported progression to mild osteoarthritis in 37%.

In the current study, we focused on bony repair after microfracture because subchondral bone plays a crucial role in cartilage repair and in the pathogenesis of osteoarthritis. Because of this unique approach, the results of our investigation are, to a limited extent, comparable with the current literature. In our cohort, subchondral bone healing of the OCD was evaluated according to CT, analogous to a previous ankle OCD study, and was good or fair in 85%. This is consistent with Wulf and colleagues, who reported complete filling (subchondral bone and/or fibrous tissue) in 80% based on MRI after microfracture. Lewine and colleagues reported complete resolution in 50% per MRI after bone marrow stimulation. Unfortunately, no distinction was made between microfracture and drilling.

The present study is the first to demonstrate that defect size of capitellar OCD, both in width and in depth, significantly improves (ie, decreases) after arthroscopic debridement and microfracture. Since none of the aforementioned studies specifically reported on postoperative defect size, no direct comparison can be made regarding this aspect. However, a similar study conducted by Reilingh and colleagues, who analyzed OCD defect size of the talus after microfracture, reported significant improvement in terms of the depth of the defect but no difference in width.
Interestingly, neither subchondral bone healing nor postoperative defect size correlated with clinical outcomes, as also reported in the investigation of Reilingh and colleagues.\(^2\) This counterintuitive finding indicates that even if a CT scan demonstrates a completely filled defect, this may not correlate with clinical outcome and vice versa. We hypothesize that a larger sample size would possibly lead to a significant correlation between clinical outcome and CT analysis. Also, it should be noted that the follow-up in the ankle OCD study was shorter, and caution should be taken when comparing different joints.

Additional analysis of our cohort revealed no prognostic factors (e.g., skeletal immaturity, OCD grade, lateral wall involvement) for subchondral bone healing on CT images. Apart from 1 study that reported no correlation between patient age and OCD resolution on MRI,\(^1\) the relationship between potential prognostic factors and OCD healing based on advanced imaging techniques (CT and MRI) has not been investigated yet. As several studies demonstrated a positive correlation between skeletal immaturity and clinical outcomes after surgical treatment for capitellar OCD,\(^4,17,24\) we hypothesize that OCD is more likely to heal in a skeletally immature patient. It is theorized that in this group, endochondral ossification at the capitellar physis may be an advantage in the healing process of OCD, although this was not investigated in the present study.

The strengths of this study include complete radiologic and clinical follow-up after debridement and microfracture. Additionally, a relative high number of patients (N = 54) were included. However, this study should be interpreted by taking into account some limitations. First, defect size was measured 2-dimensionally, while an OCD defect is a 3-dimensional structure. Second, the use of MRI in postoperative assessment may have provided more information about the quality of the cartilage as compared with CT. Third, some patients were lost to follow-up (19%). Fourth, this study lacks preoperative subjective elbow assessment, although this was not essential for the study’s purpose.

Although CT is the ultimate imaging modality to evaluate subchondral bone, this inherently means that patients were exposed to radiation.

**Conclusion**

Arthroscopic debridement and microfracture for advanced capitellar OCD result in improved (i.e., decreased) defect size at a mean follow-up of 29 months, both in width and in depth. Healing of the subchondral bone was good or fair in 85%. Interestingly, CT findings did not correlate with clinical outcomes.
References