Resurfacing of Isolated Articular Cartilage Defects in the Glenohumeral Joint With Microfracture: A Surgical Technique & Case Report

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Abstract

Isolated, full-thickness chondral lesions of the glenohumeral joint remain significant problems for athletes, workers, and the elderly. Microfracture has been established as an effective therapeutic solution for such cartilage defects of the knee, because of its low surgical morbidity and ease as a first-line treatment with good clinical outcomes. Although the indications for microfracture and the surgical techniques are similar for cartilage injuries of the shoulder and knee joints, the literature includes no reviews of the use of microfracture in the humeral head or glenoid surface. Overall, microfracture is a minimally invasive, technically simple surgical procedure that provides an excellent option for patients with isolated full-thickness chondral defects.

In this article, we describe the subtleties of microfracture in the glenohumeral joint and outline the clinical course of a typical patient.

Microfracture has been established as an effective therapeutic solution for full-thickness cartilage defects of the knee because of its low surgical morbidity and ease as a first-line treatment with good clinical outcomes. As there is minimal vascular supply to the articular cartilage, defects of any etiology seldom heal spontaneously and often require surgical intervention secondary to a high prevalence of clinical symptoms and functional disability.[1-7] Another reason articular cartilage has a limited capacity to heal on its own—besides there being minimal blood supply—is that there is a virtual absence of an undifferentiated cell population that is able to respond to traumatic or degenerative injury.[8] With regard to the knee, several surgical techniques are being used to address these issues, including simple lavage and débridement, abrasion, drilling, osteochondral autografts, osteochondral allografts, autogenous cell transplantation, and microfracture.[1,2,4,9,10] Recently, the arthroscopic microfracture technique has also been used in attempts to correct chondral lesions in other joints that are arthroscopically accessible. For example, microfracture is now a common procedure used to treat the articular cartilage abnormalities of the ankle and elbow.[11,12] Articular cartilage injuries of the glenohumeral joint are now increasingly recognized and treated.

> "...microfracture is a minimally invasive and a technically simple surgical procedure that provides an excellent first-line treatment option for patients with isolated full-thickness chondral defects.[17]"

The goal with microfracture is to encourage chondral resurfacing by gaining access to the underlying marrow and creating an environment that is ready for tissue regeneration through use of the body's natural vascular response to injury.[4,7,9,13] The basic science behind the microfracture technique has been thoroughly examined.[3,13,14] Blood with marrow elements enters a prepared chondral lesion and organizes into a fibrous clot that consists of mesenchymal stem cells, growth factors, fibrin, and platelets. Cells within the clot undergo metaplasia to initially form granulation tissue.[15,16] Within the first postoperative week, the granulation tissue undergoes fibrosis and then hyalinization and chondrification to ultimately become fibrocartilage over the course of 6 to 12 months if proper rehabilitation and surgical technique are implemented. This resulting fibrocartilagenous tissue ultimately repairs what once was a full-thickness chondral defect.

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Overall, microfracture is a minimally invasive and a technically simple surgical procedure that provides an excellent first-line treatment option for patients with isolated full-thickness chondral defects.[17]

In this article, we explain how to use the microfracture surgical technique in the glenohumeral joint and provide a case report on a patient who underwent microfracture treatment. The authors have obtained the patient's written informed consent for print and electronic publication of the case report.

Indications

The indications for surgical intervention for a focal cartilage defect are more difficult in the glenohumeral joint than in the knee. Secondary to the shoulder having a large arc of motion and being a relatively load-sparing joint, patients seem to tolerate isolated cartilage defects in the glenohumeral joint better than in other joints. Symptoms can be difficult to identify clinically, which can result in this defect's being confused with other intra-articular pathology. There is a symptomatic, isolated high-grade chondral lesion of the glenoid or humeral surface without a significant opposing cartilage abnormality. Typically, patients complain of symptoms such as swelling, locking, the sensation of catching, and activity-related pain deep inside the shoulder.

Symptoms that indicate other concurrent shoulder pathology, such as those generated from the acromioclavicular joint, biceps tendon, labrum, or rotator cuff, need to be excluded. Other indications that have been typically considered in the knee are difficult to extrapolate to the shoulder, such as defect size, age under 45, body mass index under 30, and preoperative symptoms lasting longer than 12 months.[18]

Contraindications

There are several contraindications for microfracture as a surgical option in the glenohumeral joint. Absolute contraindications include patients with generalized degenerative joint changes, nonisolated chondral lesions (focal defects with a bipolar reciprocal corresponding defect), and high-grade ligament laxity. In addition, patients with tumors or infection of the glenohumeral joint, inflammatory arthropathy, or systemic cartilage disease are not considered good candidates for microfracture.[18] A size limit is not known, given the paucity of literature on chondral defects in the shoulder. Relative contraindications include patients with concomitant injuries, such as labral, biceps, or rotator cuff pathology. Often, intra-articular chondral defects are incidental findings in the setting of these more common or prevalent diagnoses and should be considered as such without primary treatment of the articular cartilage disease. In addition, cartilage lesions caused by the sequelae of single or multiple dislocations also should be carefully assessed because of the likelihood that symptoms are secondary to instability and not cartilage degeneration. However, cartilage lesions that remain after labral fixation should be considered for microfracture.

Surgical Technique

Microfracture of the glenohumeral joint is a simple surgical technique and is nearly identical to microfracture of the knee joint.[8,19,20] As mentioned, the ideal chondral defect in the shoulder is an isolated full-thickness lesion without reciprocal cartilage damage opposite the defect. Depending on surgeon preference, the patient is placed in either the beach-chair or lateral decubitus position. Anesthesia can be general, regional, or a combination of both. The patient is draped in the usual fashion. The first portal created is the posterior portal, which is typically placed 1 to 1.5 cm medial and 2 to 2.5 cm distal to the lateral edge of the posterolateral acromion and is the same standard portal used for all shoulder arthroscopy.[21]

The anterior portal placement is crucial to the success of the microfracture technique in the shoulder, as it is largely used as the working portal. If the chondral defect is isolated to the anterosuperior glenoid, the anterior portal should be placed more laterally just inferior to the biceps tendon. This allows a more direct approach to the defect, ensuring a perpendicular trajectory to perform the microfracture. If the glenoid defect is located more inferiorly, a lower portal just above the subscapularis can be used, still staying lateral to optimize the trajectory. Posterior glenoid lesions are more difficult to access from the anterior portal, and a posterior 7-o'clock portal (right shoulder) is useful to access this portion of the glenoid. In the case of a posterior defect, the lateral decubitus position affords easier access to this location. Humeral lesions are often more easily accessed with a more medial portal just below the biceps. Most lesions on the humerus are reached through the anterior portal facilitated by internal and external rotation of the arm. Far posterior defects of the humeral head are reached more easily through posterior portals. A 7-mm or larger can-

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Figure 1. Arthroscopic image shows isolated, full-thickness chondral lesion on surface of humeral head.

nula is needed to ensure that the chondral awl can be introduced without difficulty.

After portal placement, a complete diagnostic examination is performed to determine whether any pathology exists other than the chondral defect. In general, all pathology is addressed before microfracture so as to prevent the loss of visualization that occurs with ingress of fat, marrow elements, and blood after penetration of the subchondral plate.

After diagnostic arthroscopy, the chondral lesion is visualized (Figure 1). All loose cartilage and cartilage flaps are débrided with an arthroscopic shaver, ring curette, or basket forceps (Figures 2, 3). The articular defect should be measured with a calibrated probe and its size recorded.[18] The shoulder joint should be taken through a range of motion (ROM), and the points at which the lesion articulates with the opposing joint surface should be recorded to aid with postoperative rehabilitation therapy. At this point, it should be noted whether the lesion is contained by an intact margin of cartilage around the entire circumference of the lesion. A high volume of marrow is needed to form the marrow clot. If the lesion is not contained, sufficient pooling of the marrow clot in the base of the lesion might be compromised.[18] If the defect is mostly contained, the microfracture can begin.

After containment of the chondral lesion is confirmed, it is time to create vertical walls around the defect using a curette, arthroscopic elevator, or shaver running in the forward or reverse direction. Curettes are often used to create vertical walls on the far side of the lesion, whereas elevators are often used on the near side. Vertical walls provide an area for the marrow clot, which eventually transforms into a "superclot" facilitating fibrocartilage formation.[7,8,19,20,22] A probe is used to ensure that there is no delamination around the entire circumference. Often, delamination at the calcified cartilage layer is present, but the overlying cartilage appears normal. It is very important to remove this portion of healthy-appearing cartilage, as any delaminated cartilage at the periphery will increase the risk for further delamination, and the superclot will not adhere as well to this damaged cartilage. Once the vertical walls are adequate, special care should be taken to débride the entire layer of calcified cartilage without penetrating the subchondral bone, which will eventually be breached during the actual microfracture component of the procedure (Figures 4, 5). The calcified cartilage layer, which tends to thicken with age, sits between the deep zone of cartilage and the subchondral bone.[18] Its removal leaves a surface that makes it easier for the marrow clot to adhere to the subchondral bone after microfracture. In addition, when the calcified layer is eliminated, chondral nutrition is enhanced through subchondral diffusion, increasing the amount of defect fill.[8,23] The best instrument for removing the calcified layer of cartilage is the curette, as it provides improved manual feedback over the arthroscopic shaver, and it reduces the risk for débriding the area too much and

Figure 2. Arthroscopic image shows débridement, with use of arthroscopic ring curette, of loose cartilage flaps to create stable margin of cartilage on glenoid surface.

Figure 3. Arthroscopic image shows débridement, with use of arthroscopic ring curette, of loose cartilage flaps to create stable margin of cartilage on surface of humeral head.

Figure 4. Arthroscopic image shows intra-operative débridement of layer of calcified cartilage away from underlying subchondral bone.

Figure 5. Arthroscopic image shows self-contained chondral lesion on humeral head just before creation of vertical walls with arthroscopic curette or elevator.

Figure 6. Arthroscopic image shows perpendicular alignment of microfracture awl to subchondral bone surface of humeral head.

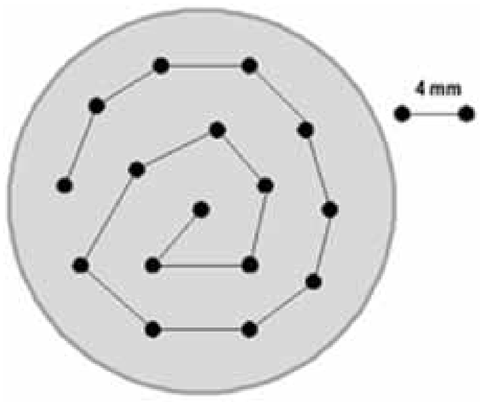

Figure 7. Schematic drawing shows spacing between each microfracture hole as well as spiral pattern of subchondral bone penetration from periphery to center.

for subsequent thinning of the subchondral bone, which may have negative biological and biomechanical consequences.[18,24] Alternatively, a carefully used shaver run in the forward or reverse direction rather than in oscillation mode can successfully remove the calcified layer.

At this point, a clean area of subchondral bone surrounded by vertical walls should be clearly visible. A microfracture awl (Linvatec, Largo, Fla) is used to precisely penetrate the subchondral bone.[3,8,18,19,23-25] Awls are available with tip angulations of 30°, 45°, and 90°. The awl, which has a conically shaped tip, is designed to allow for controlled penetration into the subchondral bone as well as efficient removal after impaction.[18] Each microfracture hole should be made perpendicular to the surface of the subchondral surface (Figure 6).[7,13,18] When penetration is perpendicular, the depth of the awl tip is better appreciated, and the tip is less likely to slip or skive. The first hole should be made in the periphery, subsequent holes in a spiral from periphery to center, and the final hole directly in the center of the lesion. This spiral technique maximizes adherence of the marrow clot to the subchondral surface.[18] Microfracture holes should be approximately 3 to 4 mm apart and should never break into one another (Figure 7). The holes should penetrate to a depth of approximately 2 to 4 mm (about the depth of the awl tip) into the subchondral surface to expose the marrow elements. As discussed, portal placement is paramount to maintain the awl perpendicular to the joint surface. Often, because of the concavity of the glenoid, it is difficult to get the awl tip perpendicular to the joint surface. In such a case, we use the 90° awl and hit the shaft, not the end of the awl, to initiate penetration of the glenoid surface. Having a more lateral portal facilitates this microfracture position. For the humeral head, we recommend a 30° awl, and most lesions can be easily treated with external and internal rotation combined with abduction. The 30° awl is easily impacted at the end of the shaft to ensure control when performing the microfracture.

After the chondral lesion is penetrated with microfracture holes, currettage or shaving should be used to remove any bony remains on the rims of the holes.[18] At this point, the irrigation pump pressure is reduced

Figure 8. Arthroscopic image shows several microfracture holes on surface of humeral head just before reduction of irrigation pump pressure.

Figure 9. Arthroscopic image shows marrow elements flowing from microfracture holes in humeral head after reduction of irrigation pump pressure.

to permit visualization of marrow elements or blood flowing from each hole into the glenohumeral joint space (Figures 8, 9). Presence of fatty droplets indicates that the appropriate subchondral depth has been reached, at which point the arthroscopic instruments can be removed from the joint space. Drains are not used after microfracture, because it is important to prevent clot components from being removed, either by suction or direct contact with a drain during postoperative movement of the joint.[18] In addition, we do not advocate using intra-articular injections or continuous pain pump catheters in the glenohumeral joint for postoperative pain management because of the potential for chondrocyte toxicity from local anesthetics.[17]

Postoperative rehabilitation is key to the success of any microfracture, but there are some distinct differences concerning the shoulder and the knee. Typically, continuous passive motion (CPM) is used to facilitate ROM in the knee. Motion is key to producing synovial fluid, which is necessary for the nutrition of the forming clot and ultimately for the differentiation into fibrocartilage. However, in the shoulder, secondary to decreased joint volume (synovial lining) and increased ROM, we do not use CPM to stimulate fluid production. We believe patients can adequately move the shoulder enough after surgery to produce an appropriate amount of synovial fluid to help the restorative process. In addition, as the shoulder is a relatively load-sparing ball-and-socket joint, strict weight-bearing restrictions are not needed. We allow patients to begin gentle strengthening and lifting exercises as tolerated. Heavy overhead lifting is restricted for 3 months. Full activity is expected around 4 months, but overhead competitive athletics are restricted for 6 months.

Case Report

A left-hand–dominant man in his early 40s presented to the senior author's clinic with a 10-year history of low-level pain in the right shoulder. The patient denied any history of distinct injury or trauma and said he had not sought medical attention for this problem in the past and had not had any interventions, including physical therapy or injections, but had used nonsteroidal anti-inflammatory drugs for pain relief. Initially, he

Pearls

- Use relative lateral cannula placement for glenoid lesions.
- Use relative medial cannula placement for humeral lesions.
- Use arthroscopic elevator to create vertical walls.
- Use curette to remove calcified cartilage layer.
- Awl should be perpendicular to joint surface.
- Range of motion is paramount after surgery to stimulate fibrocartilage growth.

Pitfalls

- Careless débridement can lead to additional cartilage injury or initiate a more generalized healing response in disrupted subchondral bone.
- Uncontained defects or absence of vertical walls can lead to suboptimal lesion geometry and poor clot retention.
- Awl holes closer than 4 mm can lead to convergence of holes and subchondral fracture.
- Penetration may not be to appropriate depth, with very little of bleeding or marrow visualized.

Figure 10. Preoperative radiograph shows minor glenohumeral narrowing.

Figure 12. Preoperative magnetic resonance imaging shows early chondral wear on humeral head with minor rotator cuff tendonitis.

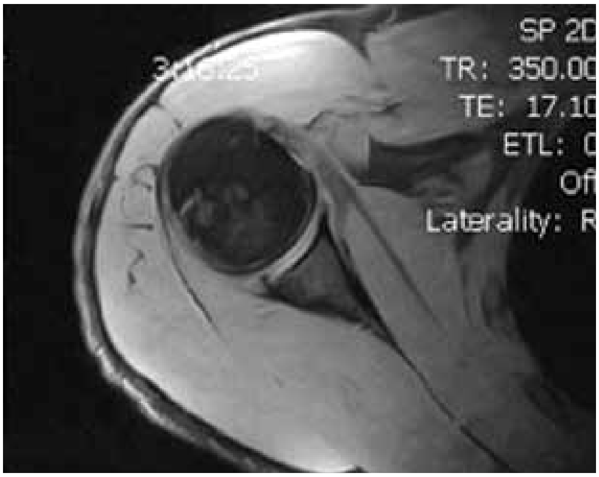

Figure 11. Preoperative magnetic resonance imaging shows early chondral wear on humeral head with minor rotator cuff tendonitis.

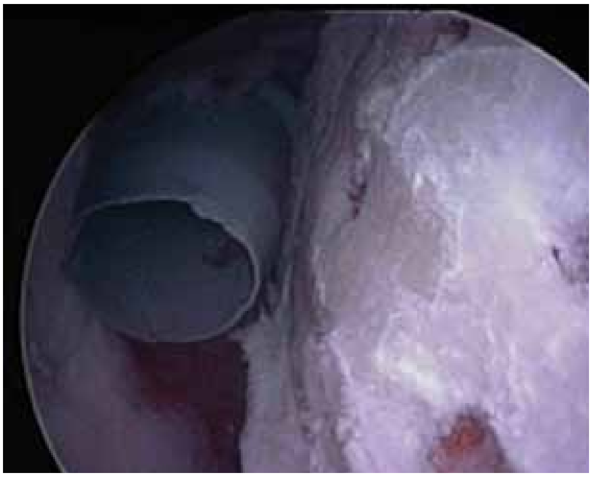

Figure 13. Arthroscopic image shows accurate placement of microfracture holes in surface of humeral head.

was given an injection and treated with physical therapy, which only mildly reduced symptoms. On physical examination, the patient had full ROM to 180° of forward elevation, 55° of external rotation, and internal rotation to T7. Circumduction of the shoulder elicited mild crepitus in the glenohumeral joint, and the patient had pain with Neer and Hawkins maneuvers but full strength in the rotator cuff musculature. Radiographs at this time showed mild glenohumeral narrowing (Figure 10). Magnetic resonance imaging showed early chondral wear on the humeral head with mild rotator cuff tendonitis (Figures 11, 12).

During surgery, the patient was found to have minor labral fraying, mild subacromial bursitis, and a 25×25-mm focal chondral defect (Figure 13) on the humeral head. Labral débridement, soft-tissue subacromial bursectomy (no acromioplasty), and humeral microfracture were performed. After surgery, the patient's pain decreased from a mean of 3/10 to no pain, 0/10 (visual analogue scale scores), and his American Shoulder and Elbow Surgeons score, indicating overall shoulder function, improved from 62 to 100. He regained full ROM and full strength and was completely satisfied with the procedure.

Conclusions

Microfracture is an advanced surgical method used to treat isolated, full-thickness articular cartilage damage caused by acute injury or degeneration. Because of the molecular and cellular features of articular cartilage, de novo healing of such defects is rare, and microfracture has proved to be a successful minimally invasive first-line surgical option to stimulate healing. Although indications for microfracture and surgical techniques are nearly identical for cartilage injuries of the shoulder and knee joints, the literature includes no reviews of the technique and nuances of microfracture as specifically related to the glenohumeral joint.

Recently, several short-term outcomes studies on the effects of microfracture in the glenohumeral joint have been published. In 2010, Frank and colleagues[26] reported on 13 patients who underwent microfracture for isolated chondral defects of the humeral head and/or glenoid surface. There were statistically significant improvements in visual analog scale, simple shoulder test, and ASES scores at an average of 27.8 months after surgery, and 92% of patients claimed they would repeat the procedure. Millet and colleagues[27] reported on 25 shoulders at an average of 47 months after microfracture of the glenohumeral joint. The authors reported significant improvements in patients' postoperative ability to work and participate in sports as well as in pain relief and ASES scores. The authors noted that smaller lesions of the humerus had the best results while bipolar lesions produced the worst results.

Long-term clinical studies with large patient populations are needed to evaluate the effectiveness of microfracture in the shoulder joint. In addition, should microfracture fail, higher-level cartilage procedures (osteochondral allografting, carticel) can be used with good success in patients who warrant further treatment.[28,29]

Authors' Disclosure Statement

The authors report no actual or potential conflict of interest in relation to this article.

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