Current Reviews in Musculoskeletal Medicine (2022) 15:513–520
https://doi.org/10.1007/s12178-022-09789-w

INJURIES IN OVERHEAD ATHLETES (J DINES AND C CAMP, SECTION EDITORS)

Diagnosis and Treatment of Posteromedial Elbow Impingement in the Throwing Athlete

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Accepted: 8 August 2022 / Published online: 25 August 2022

Abstract

Purpose of Review Posteromedial elbow impingement is a common pathological entity in the throwing athlete. The posteromedial articulation of the elbow is a significant stabilizer to medial elbow forces and valgus stress noted during repetitive throwing. This current review investigates recent literature regarding the relevant anatomy, diagnosis, and treatment of posteromedial impingement in the thrower.

Recent Findings Improvements in advanced imaging have provided accurate and detailed diagnostic capability for the assessment of the throwers' elbow. After failure of conservative measures, arthroscopic treatment of posteromedial elbow impingement with posteromedial osteophyte removal has demonstrated excellent outcomes with a reliable return to play in the competitive thrower.

Summary In addition to a thorough history and physical examination, MRI, MR arthrogram, CT, and dynamic ultrasound imaging modalities are useful in the assessment of a presumed diagnosis of posteromedial impingement. Arthroscopic decompression with posteromedial osteophyte removal provides effective clinical results and return to play. The surgeon should be careful to avoid creating medial ulnar collateral instability by means of over-resection of the posteromedial olecranon.

Keywords Elbow impingement · Elbow arthroscopy · Posteromedial impingement · Valgus extension overload · Thrower's elbow

Introduction

Knowledge of elbow anatomy and throwing biomechanics assists in understanding the unique elbow injuries related to throwing. The mechanics of throwing generate significant and distinctive forces on the elbow that are resisted by articular, ligamentous, and muscular constraints. The valgus torque placed on the elbow and rapid extension of the elbow during throwing results in significant stress along the ulnar collateral ligament, flexor pronator mass, and medial epicondyle; compression at the radiocapitellar joint; and shearing stress in the posterior compartment. This can lead to valgus instability which places greater stress on the posterior compartment. Forces are dissipated in the posterior compartment as the elbow reaches terminal extension with the posterior medial olecranon contacting the olecranon fossa and trochlea. The resultant shear and compressive forces in the posterior compartment can be compounded by poor dynamic muscular control and mechanics as well as ulnar collateral ligament insufficiency. The repetitive traumatic abutment with extension during the throwing motion can result in osteophyte formation at the posterior medial olecranon. This relationship between valgus instability and posterior medial olecranon pathology is of great importance in the throwing athlete as UCL insufficiency can lead to greater forces in the posterior compartment and development of posterior medial osteophyte formation. The purpose of this review is to highlight the contributing anatomy, throwing pathomechanics, current diagnostic strategies, and up to date treatment options

This article is part of the Topical Collection on *Injuries in Overhead Athletes*

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relevant to posterior medial impingement of the elbow in throwing athletes.

Functional Anatomy

The normal elbow joint is stabilized by a combination of joint congruity, capsuloligamentous integrity, and balanced musculature. In full extension, the normal valgus carrying angle is 11–16°. The osseous anatomy allows a variety of movements including flexion-extension and pronation-supination mediated by the ulnohumeral and radiocapitellar joints. These articulations provide primary stability at less than 20° or more than 120° of elbow flexion. In between, stability is provided by the soft tissues, most notably the medial ulnar collateral ligament (UCL) [1, 2]. Overall, 50% of elbow stability is provided by the osseous anatomy, especially in varus stress with the elbow in full extension. The remaining stability is attributed to the muscular and ligamentous structures, including the UCL complex [3–5].

The UCL complex consists of the anterior bundle, posterior bundle, and oblique/transverse bundle. Together, these bundles contribute to medial elbow stability in various ways. The anterior band is the most important constraint to valgus instability and is the strongest collateral ligament of the elbow with an average failure load of 260 N [2, 6]. The anterior bundle originates from the inferior edge of the medial epicondyle and inserts on the medial aspect of the coronoid process of the ulna [3, 4, 6, 7]. The anterior bundle can be further divided into its own anterior and posterior bands. The anterior band is the primary restraint to valgus stress up to 90° of flexion. Beyond 90°, the anterior band becomes a secondary restraint [8]. The posterior band resists valgus stress at higher degrees of flexion between 60° and full flexion, while having a secondary role in flexion less than 60° [2, 8].

The posterior and oblique bundles have lesser roles in contributing to elbow stability. The posterior bundle also originates from the medial epicondyle and inserts onto the medial aspect of the trochlear notch of the ulna. It is shorter, wider, and weaker than the anterior bundle [9]. It plays a secondary role in elbow stability with the elbow flexed beyond 90° [2–4]. The oblique bundle, also known as the transverse ligament or transverse band, does not cross the elbow joint. It originates from the medial olecranon and inserts on the inferior medial coronoid process. The oblique bundle is a thickening of the inferior aspect of the joint capsule and does not significantly contribute to elbow stability [9–11].

There is also an essential musculotendinous unit of the medial elbow that provides stability and resistance to valgus stress. This musculotendinous unit is also known as the flexor-pronator mass and originates from the medial epicondyle. The muscles included in the flexor-pronator mass are the pronator teres, flexor carpi radialis, palmaris longus, flexor digitorum superficialis, and flexor carpi ulnaris [7].

Pathomechanics

Throwing is a complex multi segmental process that relies on whole body kinetics. The lower limb, pelvis, and trunk initiate force development while serving as a stable base of support that facilitates the transfer of potential energy through the scapula to the shoulder and elbow [12]. The mechanics of high-velocity throwing generates significant forces on the elbow, which are resisted by osseous, ligamentous, and muscular structures. The overhead throwing motion is divided into 6 phases. Phase 4, the acceleration phase, is the primary phase of interest when discussing forces on the elbow. Acceleration is an explosive phase in which the arm begins at maximum shoulder external range of motion followed by powerful shoulder internal range of motion and rapid elbow extension to generate peak velocity at ball release. During this phase, significant valgus forces are exerted on the medial elbow. The anterior bundle of the UCL bears much of the force with the flexor pronator mass enabling the transmission [7]. The majority of acute elbow injuries while throwing occur during the acceleration phase due to the immense forces placed on the medial elbow.

However, phase 5, the deceleration phase, is also of importance as excess kinetic energy is dissipated as the elbow terminally extends. During deceleration, as the elbow reaches terminal extension, the posterior olecranon contacts the trochlea and the olecranon fossa as subsequent dissipation of the combined valgus force and angular moment occurs. These shear and compressive forces can be amplified by poor mechanics, poor dynamic muscular control, and UCL insufficiency. Repetitive compression and shear during elbow extension results in reactive bone and osteophyte formation at the posteromedial olecranon tip. Furthermore, there may be chondromalacia within the olecranon fossa and posterior medial trochlea known as “kissing lesions” [11]. Subsequently, loose bodies may also form. This collection of pathologic findings can result in symptomatic posteromedial impingement, also known as *valgus extension overload syndrome*, which is specific to overhead throwing athletes [13].

Posteromedial impingement and valgus instability of the elbow have a close association as evidenced by both clinical and biomechanical studies [14–16]. For example, Ahmad et al. investigated the effect of UCL injuries on posterior elbow contact forces. In the setting of UCL insufficiency, posterior elbow contact forces were increased

[14]. Furthermore, the posteromedial articulation of the elbow is a significant stabilizer to medial elbow forces and valgus stress. Therefore, treatment of posteromedial impingement with aggressive osteophyte and bone removal predisposes the elbow to valgus instability and increased risk of UCL injury [15, 16]. In the treatment of posteromedial impingement, only osteophytes should be resected with normal bone preserved [14–18].

Lastly, valgus extension overload can also lead to injury in the lateral compartment of the elbow. As UCL insufficiency progresses due to repetitive valgus stress, force transfers to the lateral compartment. This places the radiocapitellar joint at risk resulting in synovitis and osteochondral lesions [13, 19].

History

Throwing athletes with posteromedial elbow impingement are typically throwing athletes with repetitive overhead activity. This is most common in baseball pitchers, but has also been reported in softball, tennis, volleyball, javelin, gymnastics, and lacrosse athletes. Symptoms are often preceded by a decrease in performance such as pitch velocity, control, and early fatigue. Isolated posteromedial impingement results in pain localized to the posteromedial aspect of the olecranon. This typically occurs just after ball release in the deceleration phase as the elbow reaches terminal extension. Athletes may complain of limited elbow extension due to impinging posterior osteophytes. Mechanical symptoms of catching, locking, and crepitus are also possible as a result of loose bodies or chondral injury. Posteromedial impingement may also occur concomitantly with valgus instability of the elbow or in a player with previous UCL or flexor-pronator injury as UCL insufficiency allows for greater shear force and posterior impingement [14]. Ulnar nerve pathology manifesting as numbness and tingling in the fourth and fifth digits can also be present along with posteromedial impingement symptoms [11].

Physical Examination

While the primary physical exam should focus on the elbow, a thorough physical exam should evaluate the complete throwing kinetic chain. Physical examination of the elbow may demonstrate tenderness over the posteromedial olecranon with an associated loss of extension and firm endpoint. Furthermore, crepitus may be noted when moving the elbow into extension. The elbow extension impingement test should be performed which involves a controlled thrusting of the elbow into terminal extension. The elbow is placed in the 20–30° of flexion and then quickly and repeatedly brought into terminal extension. This will elicit pain within the posterior compartment of the elbow in athletes with posteromedial impingement. Another specific test to be performed is the arm bar test. With the athlete's elbow extended, shoulder flexed and internally rotated, and hand on the examiner's shoulder, the examiner pulls down on the olecranon to simulate forced extension [11]. The test is considered positive with the reproduction of posterior pain associated with posteromedial impingement.

Given the association between valgus instability and posteromedial impingement, the UCL should be evaluated with the moving valgus stress test, milking maneuver, and/or valgus stress test. Of these 3 tests, the moving valgus stress test is the most sensitive and specific [20]. The athlete can be sitting upright or supine. Placing the athlete supine does stabilize the shoulder and humerus more thoroughly. The shoulder is placed in abduction and external rotation while the examiner holds the thumb with one hand and stabilizes the elbow with the other. The athlete's elbow is then extended and flexed while a valgus stress is applied. A positive test results in pain along the UCL usually at the arc of motion between 70 and 120° of flexion [21]. Pain with the moving valgus stress test at positions near full extension or less than 70° of flexion may indicate chondral injury at the posteromedial trochlea [22]. The flexor pronator mass should also be evaluated. There may be pain with resisted wrist flexion or tenderness to palpation over the medial epicondyle. However, more classic flexor pronator mass injuries result in pain anterior and distal to the medial epicondyle [23]. It is also important to note the presence of ulnar neuritis or ulnar nerve subluxation. The nerve is palpated along its course through the cubital tunnel. Tinel's just posterior to the medial epicondyle should be performed as well. Ulnar nerve subluxation can be palpated at the medial epicondyle as the elbow is moved into flexion from extension. Ulnar nerve instability can also be directly visualized with dynamic ultrasound imaging [24].

Fig. 1 Lateral elbow X-ray, with fractured posteromedial osteophyte

Imaging

Imaging is a critical component in the diagnosis of posteromedial elbow impingement. Standard anteroposterior (AP), lateral, and oblique radiographs of the elbow may reveal posteromedial osteophytes and/or loose bodies (Fig. 1). A modified AP radiograph with 140° of external rotation may best show osteophytes on the posteromedial olecranon [11]. Calcification/ossification of the ulnar collateral ligament can also be seen on radiographs. A computed tomography (CT) scan can also be helpful in the evaluation of posteromedial impingement of the elbow. A CT scan with sagittal and coronal reconstructions can best demonstrate bone morphologic abnormalities, osteophyte formation, and loose bodies and help with surgical planning for osteophyte removal [25]. Additional abnormalities including bony hypertrophy of the humerus, ligament ossification, and osteophyte fracture may be identified on CT. Magnetic resonance imaging (MRI), typically with the administration of intra-articular contrast (MRA), is generally the imaging modality of choice in evaluating elbow injuries in throwing athletes. When investigating a throwing athlete with posteromedial impingement, MRA enables the identification of soft tissue and chondral pathology, such as flexor-pronator mass pathology, tendinosis at the medial border of the triceps, synovial plicae, bone edema, and stress fractures of the olecranon, and has particularly high utility in the assessment of UCL pathology/insufficiency (Figs. 2) and 3) [11]. Dynamic ultrasound also has utility in the evaluation of the UCL, facilitating the dynamic evaluation of the UCL while applying a valgus stress to the elbow. This can be completed on both elbows as a means of comparison to determine if there is increased medial gapping in the symptomatic/throwing elbow. Furthermore, ultrasound has utility in the assessment of ulnar nerve pathology, such as dynamically evaluating for ulnar nerve instability or identifying ulnar nerve enlargement through the cubital tunnel [24, 26–30]. Of note, these imaging findings are also common in asymptomatic throwing athletes, thus highlighting the importance of a correlating the history and physical examination to imaging findings to make the diagnosis of posteromedial impingement.

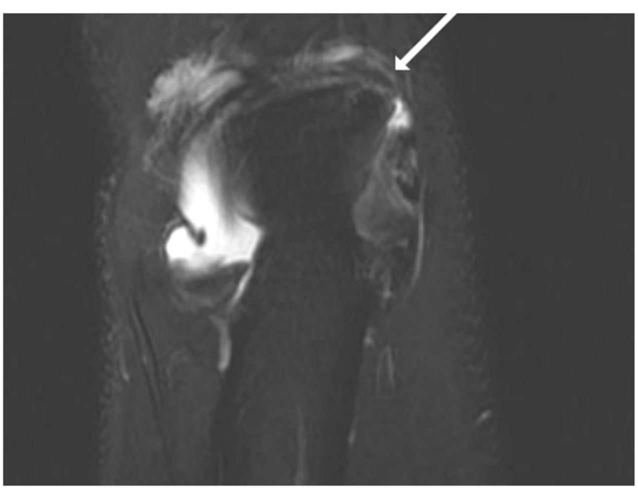

Fig. 2 Coronal view, MR arthrogram, revealing posteromedial osteophyte of olecranon (arrow)

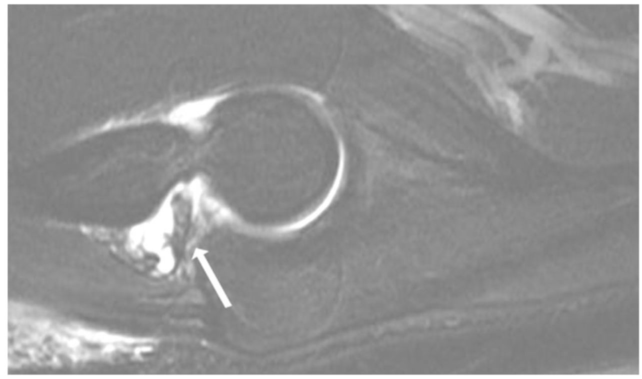

Fig. 3 Sagittal view, MR arthrogram, revealing fragmented posteromedial olecranon osteophyte (arrow)

Treatment

Nonoperative Treatment

When a thorough clinical examination, relevant x-rays, and advanced imaging studies (such MRI, MRA, and/or CT) indicate a diagnosis of posteromedial impingement, nonoperative treatment is initiated. This includes a period of complete cessation from throwing, activity modification, modalities, physical therapy exercises including stretching and strengthening, nonsteroidal anti-inflammatory drugs (NSAIDs), corticosteroid injections, possibly the adjunctive use of orthobiologics, and a gradual return to throwing on a progressive throwing program. During the progressive throwing program, it is important to assess pitching mechanics and correct any errors in throwing technique. A return to play plan should be supervised by the patient coaches and team medical staff including an experienced physical therapist and athletic trainer, and individualized for each player.

Operative Treatment

Should nonoperative treatment fail, operative intervention is considered. The concurrent presence of UCL insufficiency is a contraindication for isolated arthroscopic treatment with posteromedial osteophyte resection. Posteromedial osteophyte resection in the setting of UCL insufficiency, even with partially torn ulnar collateral ligaments, may set up the patient for the development of valgus instability necessitating reconstruction in the future. Overly aggressive removal of posteromedial osteophytes must be avoided, as an increase in stress on the medial ulnar collateral ligament can be created in this setting. Surgical options include arthroscopic posteromedial osteophyte removal versus a limited incision arthrotomy.

Arthroscopic treatment will employ the surgeon's preference for patient positioning. Supine, prone, and lateral decubitus positions have been described and utilized. The use of the modified supine position for elbow arthroscopy allows for convenient positioning if a concurrent UCL reconstruction is anticipated. The patient is placed with the shoulder in 90° of forward flexion and the elbow flexed approximately 90° with the forearm, wrist, and hand suspended with a mechanical traction device (Fig. 4). Alternatively, the lateral decubitus position can be utilized but requires that the patient is repositioned with repeat sterile prepping and draping after arthroscopy is performed prior to medial ulnar collateral ligament reconstruction.

Following insufflation and then the completion of anterior compartment arthroscopy, a proximal anteromedial or anterolateral portal is established. This is the initial viewing portal. An arthroscopic valgus stress test may be performed at 60 to 70° of flexion visualizing for instability of 3 mm of greater at the ulnohumeral joint, indicating medial ulnar collateral ligament insufficiency (Fig. 5). Posterior compartment elbow assessment is initiated with a posterolateral portal. A careful synovectomy is performed prior to the diagnostic arthroscopy. The central, lateral, and medial olecranon is evaluated for osteophytes and the presence of a posteromedial osteophyte confirmed. The radiocapitellar joint is evaluated for loose bodies. The posteromedial aspect of the humeral condyle and trochlea is evaluated for chondral defects that correlate with impinging osteophytes. A transtriceps portal is established, associated loose bodies are removed, and chondral defects are addressed by means of arthroscopic chondroplasty. These "kissing lesions" are addressed by means of arthroscopic removal of all loose chondral flaps. Rarely, full-thickness grade 4 chondral lesions are addressed with microfracture or anterograde drilling of the lesion to stimulate a fibrocartilage healing response [11]. Accessory posterolateral portals may be established to assist with ulnar nerve retraction or as working portals. The posteromedial olecranon osteophyte is then inspected under arthroscopic visualization (Fig. 6). This may be performed with a motorized bur or a small osteotome. Intraoperative lateral radiographs may be obtained in order to assess appropriate bone removal. The pathologic extent of the osteophyte is removed but it is very important that the normal olecranon is left intact (Fig. 7). The optimal amount of olecranon resection remains a matter of debate [15, 31].

Fig. 4 Modified supine positioning for elbow arthroscopy

Rehabilitation includes immediate passive and active range of motion to obtain flexion, extension, and supination. Flexor pronator strength is restored. Plyometric exercises with neuromuscular training are initiated prior to starting a progressive throwing program at 6 weeks after surgery. Typical for return to activity is 3 to 4 months after surgery.

Surgical Outcomes

Andrews and Carson investigated the effectiveness of elbow arthroscopy for posteromedial impingement. Patient satisfaction scores increased to 83% from 50% preoperatively. Those requiring the removal of the loose body only had improved clinical outcomes [32]. Later, in 1995, Andrews and Timmerman evaluated the results of arthroscopic or open surgical treatment of posteromedial olecranon impingement and 72 professional baseball players. The most common surgical indications included intra-articular loose bodies and posteromedial olecranon osteophytes. They noted a 25% rate of persistent valgus instability after olecranon osteophyte resection that necessitated UCL reconstruction. There was a 42% reoperation rate overall, either in the form of repeat arthroscopic debridement or UCL reconstruction [33]. Similarly, Fideler et al. reviewed the outcomes after posteromedial decompression, revealing a 10% incidence of subsequent UCL reconstruction with 26% of athletes being unable to return to their preoperative level of play [34]. Overall, this highlights the necessity of evaluating for concurrent UCL pathology when considering posteromedial osteophyte resection.

In 2000, Reddy et al. reviewed 187 elbow arthroscopies for posteromedial impingement, loose body formation, and osteoarthritis in elite baseball players. The authors reported 87% good to excellent with an 85% return to the same level of play after surgery [35]. In a relatively recent study in 2011, Cohen et al. evaluated the results of arthroscopic posteromedial olecranon decompression after unsuccessful conservative treatment in 9 overhead throwing athletes. After arthroscopic debridement and posteromedial osteophyte resection, followed by an appropriate rehabilitation and throwing program, the authors reported excellent

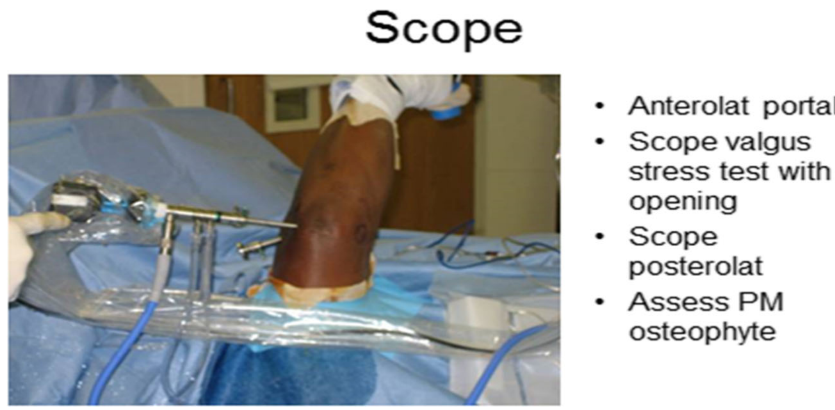

Fig. 5 Arthroscopic posterior compartment assessment via posterolateral portal

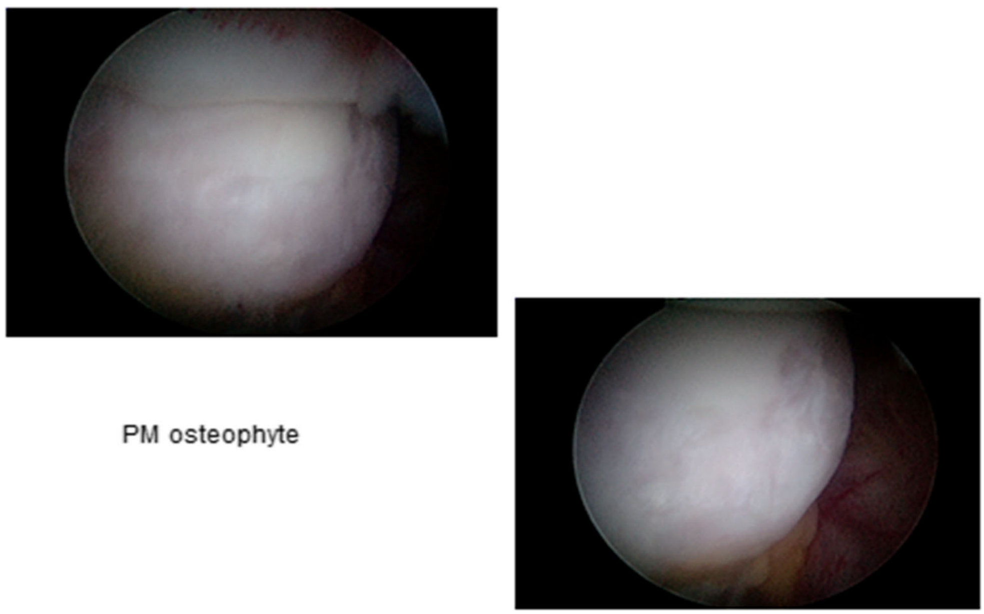

Fig. 6 Posteromedial osteophyte noted at diagnostic arthroscopy

results at a mean 68-month follow-up [36]. Koh and Altchek, in a recent paper in 2018, evaluated 36 athletes with posteromedial olecranon impingement that required arthroscopic debridement with a mean 51-month follow-up. They noted a statistically significant improvement in Andrews and Timmerman elbow scores with a 97% return to the prior level of activity, including all professional athletes [37]. In another recent study in 2018 by Matsuura et al., 15 male high-level, adolescent baseball players with posteromedial elbow impingement were carefully selected and treated with arthroscopic debridement of posterior elbow compartment synovitis and posteromedial osteophyte excision with a mean follow-up of 27 months. The authors noted that all players were able to return to play and an average 3.4 months and all returned to their prior level of play. There was no necessity for later UCL reconstruction at final follow-up for any of the players [38]. There is conflicting literature to suggest how much of the olecranon should be removed at the time of surgery. There is

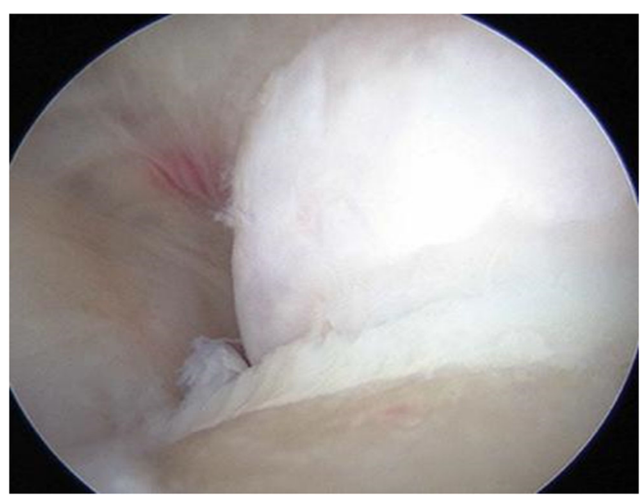

Fig. 7 Status post arthroscopic posteromedial osteophyte resection with a motorized bur

certainly debate as to whether any amount of the normal olecranon should be removed. Kamineni et al. performed a biomechanical study showing a resection of both 3 and 6 mm of the posterior medial olecranon led to a significant increase in strain of the anterior bundle of the UCL [15]. Levin et al. have also noted that removing more than 4 mm of the posteromedial olecranon put significant strain on the UCL [31].

Conclusion

In conclusion, posteromedial elbow impingement is a common diagnosis in the throwing athlete. With failure of a comprehensive conservative treatment regimen, arthroscopic decompression with posteromedial osteophyte removal provides effective clinical results and return to play. The surgeon should be careful to avoid creating medial ulnar collateral instability by means of over resection of the posteromedial olecranon.

Funding Dr. Griffith received funding from the MLB.

Declarations

Conflict of Interest Robert Bowers declares that he has no conflict of interest.

Gary Lourie declares that he has no conflict of interest.

Timothy Griffith declares that he has no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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