3 Valgus Extension Overload

David C. Gerhardt and E. Lyle Cain

Introduction

The mechanics of baseball pitching and other high velocity throwing sports explain the constellation of elbow injuries which occur in the overhead athlete. Valgus extension overload (VEO) syndrome is a result of repetitive high valgus moments coupled with elbow extension that lead to pathologic shear forces within the posteromedial olecranon and trochlea.

Repetitive near-tensile failure loads experienced by the anterior bundle of the ulnar collateral ligament (UCL) may eventually lead to ligament attenuation or failure. Valgus overload is then accentuated, and subtle valgus laxity may lead to stretch of the other medial structures, resulting in ulnar neuritis, flexor-pronator mass tendinopathy, or medial epicondyle apophysitis in the skeletally immature patient. Overload on the lateral side of the elbow may lead to abnormal compressive forces across the radiocapitellar articulation, resulting in chondromalacia, osteophyte formation, or osteochondral defects in younger athletes. Finally, when a valgus moment is coupled with near terminal extension, posterior shear forces may produce osteophytes at the posteromedial tip of the olecranon, with a corresponding "kissing lesion" in the olecranon fossa and posteromedial trochlea (Fig. 3.1). This is the defining lesion of VEO [1, 2].

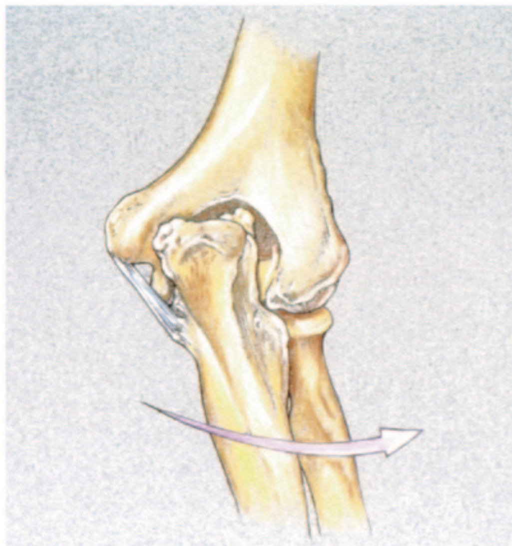

Fig. 3.1 When a valgus moment is coupled with near terminal extension, posterior shear forces produce osteophytes at the posteromedial tip of the olecranon, with a corresponding "kissing lesion" in the olecranon fossa and posteromedial trochlea. (Adapted from [57])

The complex interplay between medial tensile forces, lateral compressive forces, and elbow extension are controlled by both static and dynamic stabilizers that infer varying levels of stability depending on the degree of elbow flexion. Underlying valgus laxity, resulting from injury to the UCL, must be excluded as the etiology of many of the elbow disorders in the throwing athlete, even when the presenting symptom initially appears to be unrelated [1, 2].

E. L. Cain (✉) · D. C. Gerhardt
Andrews Sports Medicine and Orthopaedic Center,
805 St. Vincent's Drive, Suite 100, Birmingham,
AL 35205, USA
e-mail: lylecain@aol.com

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Anatomy and Biomechanics

The bony anatomy of the elbow consists of a modified hinge joint in which the distal humerus, radial head, and proximal ulna/olecranon articulate. Elbow stability is provided by both static and dynamic restraints. Static elbow stability results from the congruent bony articulation and ligament attachments, while dynamic stability is provided by the various muscle-tendon complexes that attach to or cross the joint. Cadaveric and biomechanical studies have helped define the relative importance of each of the individual elbow stabilizers [3–8].

The mechanics of high-velocity throwing can help explain elbow injuries specific to the overhead athlete [2, 9–11]. Valgus forces across the medial elbow have been estimated to reach 64 N m during the late cocking and early acceleration phases of throwing, and compressive forces of 500 N have been documented at the lateral radiocapitellar joint [2, 12]. Angular velocity has been estimated to reach 6000°/s for shoulder internal rotation and 3000–5000°/s for elbow extension during the acceleration phase of throwing [12, 13]. After early and late cocking phases, the acceleration phase initiates and the trunk rotates, the shoulder internally rotates, and the elbow extends to approximately 25° at the time of ball release. The acceleration to ball release occurs over approximately 50 ms. As the elbow extends towards ball release, forces produce a valgus and extension moment, which result in tensile forces across the medial side of the elbow, compressive forces across the lateral side of the joint, and shear forces in the posterior compartment [1, 2, 9, 13, 14]. Because the ulnohumeral joint has a greater role in stability with elbow flexion angles less than 25°, any relative valgus or microinstability during throwing as the elbow moves toward full extension at ball release, forces the posteromedial olecranon tip, olecranon fossa and posteromedial trochlea to be exposed to higher shear forces. This phenomenon has been termed VEO syndrome and forms the basic pathophysiologic model behind the most common elbow injuries in the throwing athlete [1, 2, 14].

History and Physical Examination

A detailed history and physical examination is a crucial part of the evaluation of the overhead athlete. High-level overhead throwing athletes are often acutely aware of the phases of throwing as they impact technique and training. This depth of knowledge coupled with a detailed history of the throwing athlete can help distinguish pathologies within the elbow. In addition to the history, the superficial nature of many structures about the elbow allows the examiner to gather important information from the physical examination. When combining information from the history and the physical examination, it is important to rule out valgus instability due to UCL injury or attenuation as the primary underlying cause of associated pathologic conditions in any thrower presenting with elbow pain.

The duration and preceding timeline of the elbow pain is helpful in distinguishing VEO from other pathologies. For pitchers, any changes in accuracy, velocity, stamina, and strength are key indicators of pathology. The timing of the onset of symptoms as well as the phase of throwing during which pain is experienced is important [12, 15]. In athletes with medial elbow instability, nearly 85 % will experience pain during the acceleration phase of throwing, whereas less than 25 % will experience pain during the deceleration phase [16]. With VEO, the timing of the pain is more commonly at or just after ball release and during the deceleration phase of throwing as the elbow reaches terminal levels of extension [2, 17–19]. Approximately 60 % of patients with UCL injury present after an acute episode, although many report prior medial elbow pain or treatment for flexor-pronator tendonitis or ulnar neuritis [20, 21]. VEO often presents with a slow, insidious onset of pain. Olecranon stress fractures, ulnar neuritis, flexor-pronator tendonitis, and radiocapitellar compression may have a similar pace of presentation and should be considered in the differential diagnosis. Location of the pain is helpful in further delineating the cause of the symptoms. In cases of VEO, patients typically describe pain at the posteromedial aspect of the olecranon consistent with the shearing lesion, which occurs in that location.

The physical examination of the elbow begins with inspection to evaluate the resting position of the arm. The carrying angle is the angle formed between by the axis of the humerus and the axis of the forearm. A normal carrying angle is 11° of valgus in men and 13° of valgus in women [22]. In throwing athletes, carrying angles of greater than 15° can be seen due to adaptive changes from repetitive stress [23]. Further inspection of the elbow is performed systematically to evaluate bony landmarks, including the olecranon tip and the medial and lateral epicondyles, with special consideration given to the posteromedial olecranon tip.

Range of motion (ROM) should be assessed both actively and passively, as loss of motion is a common finding in VEO. Normal motion in the sagittal plane includes flexion from 0° to 140° and forearm rotation of 80° to 90° in both supination and pronation [24–28]. During ROM testing, crepitus, pain, or other mechanical symptoms may represent chondral irregularities, osteophyte formation, or loose bodies. The end-feel to ROM testing in extension can be an important indicator of pathology in the thrower's elbow. The endpoint in extension testing should be a firm sensation of bone engaging bone as the olecranon tip contacts the distal humerus in the olecranon fossa. Not all loss of motion in the thrower's elbow can be attributable to VEO, because anterior capsular and soft tissue contractures may play a role as well. Flexion contractures have been seen in up to 50 % of professional throwers and are not always indicative of posterior olecranon pathology [23].

Palpation of the posteromedial tip of the olecranon process can help localize the pain caused by VEO. In addition to palpation, the examiner can apply a valgus stress to the flexed elbow as it is brought into extension, causing the medial aspect of the olecranon tip to impinge on the medial wall of the olecranon fossa. When this exam maneuver reproduces the patient's pain, it is considered the hallmark of VEO.

The "valgus extension overload test" is performed with the patient in a seated position and the shoulder in slight forward flexion. The examiner repeatedly forces the slightly flexed elbow rapidly into full extension while applying a valgus stress [14] (Fig. 3.2). This maneuver reproduces pain due to impingement of the posteromedial tip of the olecranon on the medial wall of the olecranon fossa. A positive finding often indicates the presence of a posteromedial olecranon osteophyte, which may occasionally be palpable at the time of physical examination [1, 2, 14, 15, 18, 19, 29].

Fig. 3.2 The valgus extension overload test. The examiner repeatedly forces the slightly flexed elbow rapidly into full extension while applying a valgus stress. This maneuver reproduces pain due to impingement of the posteromedial tip of the olecranon on the medial wall of the olecranon fossa

Not all proximal olecranon pain is synonymous with VEO. Pain noted with palpation of the lateral border of the olecranon tip, rather than the medial border, should raise suspicion for an olecranon stress fracture. Additionally, while palpating the ulnar nerve proximal to the cubital tunnel, the examiner should palpate the distal medial aspect of the triceps tendon, as anomalous bands of the distal triceps insertion have been described as a cause of pain, ulnar nerve impingement, and "snapping" as they move across the medial epicondyle [30].

The diagnosis of VEO with posteromedial impingement is made only when the patient history, physical examination, and imaging studies suggest the presence of posteromedial olecranon pain with an intact, functional UCL. Underlying instability of the UCL must be excluded as the root cause of posteromedial overload.

Imaging Studies

Imaging of the elbow plays an integral role in developing an accurate diagnosis in the throwing athlete. Specialized radiographic views, computed tomography (CT), and magnetic resonance imaging (MRI) all provide pertinent information.

Standard radiographs of the elbow, including anteroposterior (AP), lateral, oblique, and axial views are often the initial imaging study. The oblique axial radiograph with the elbow in 110° of flexion helps demonstrate posteromedial olecranon osteophytes [14]. Comparison to the normal elbow may be performed if needed. Radiographs are helpful in evaluating for olecranon osteophytes, but may show additional pathology such as calcification within the UCL (an indirect sign of prior injury), osteochondritis dissecans of the capitellum, or intra-articular bodies. Valgus AP stress views can be obtained if injury to the UCL is suspected; this is performed with a valgus stress radiography machine (Telos, Weiterstadt, Germany). AP views with 0, 5, 10, and 15 dN of valgus stress applied to each elbow at 25° of flexion is recommended [2]. An increase in medial joint space widening with increasing stress, as compared with the uninjured side, is suggestive of medial ligamentous injury [31]. However, standard normal values are not well established, especially since uninjured baseball pitchers have been found to have increased laxity in the throwing elbow compared with the nondominant arm [21, 32].

CT is not routinely performed but may be helpful to evaluate the olecranon osteophyte size, osteophyte fragmentation, intra-articular bodies, overall elbow morphology, and olecranon stress fracture [33]. CT with intra-articular contrast may also be helpful to assist in the evaluation of the UCL [32, 34], especially in patients who are unable to undergo MRI. It is important to note that normal radiographic imaging studies do not rule out the presence of an olecranon osteophyte. Imaging of the olecranon tip and trochlea is difficult and the diagnosis of olecranon impingement is made primarily by history and physical examination, but may be confirmed with radiographs and/or CT imaging modalities.

MRI with intra-articular gadolinium contrast is the preferred imaging modality for evaluation of the UCL and may be helpful to determine the presence of olecranon osteophytes and the sequelae of VEO. MR arthrography is much more sensitive than MRI without intra-articular contrast for the detection of partial tears of the UCL [34]. MRI also identifies a reproducible pattern of pathology in throwing athletes. Marrow edema and/or chondral abnormalities within the posterior trochlea and anteromedial olecranon, synovitis in the posteromedial recess, and marginal osteophytes at the trochlea and olecranon suggest posteromedial elbow impingement [35]. MRI is also superior for identification of intra-articular bodies (both chondral and ossific), osteochondritis dessicans of the capitellum, synovial plicae, and radiographically occult stress fractures of the olecranon tip, olecranon process, posteromedial trochlea, and sublime tubercle [12, 35].

Treatment

Treatment initially consists of active rest and rehabilitation. Throwing is avoided and the athlete is treated with rehabilitation exercises for the elbow and shoulder. Return to gradual interval throwing is allowed as symptoms resolve. In the athlete who fails to obtain symptom relief after an extended rehabilitation program elbow arthroscopy may be considered.

Nonoperative management can be successful and has been documented in the cases of olecranon osteophyte formation in 17 world-class javelin throwers, all of whom eventually returned to competition. However, these patients were identified retrospectively and, thus, the number of athletes with olecranon osteophytes who were unable to return to play is unknown [36]. Nonoperative management including rest, nonsteroidal anti-inflammatories, local modalities, and strengthening exercises for the rotator cuff and flexor-pronator mass with a focus on throwing technique may allow the thrower to become asymptomatic, but will not be curative in regards to the structural pathology such as the posteromedial olecranon osteophytes and chondral lesions.

Elbow arthroscopy is indicated for the treatment of posteromedial olecranon impingement in the thrower secondary to VEO syndrome after failure of adequate conservative treatment. Elbow arthroscopy also allows for the treatment of concomitant pathology including loose body removal, osteochondral lesions (i.e., capitellum), excision of anterior osteophytes, chondromalacia of the radial head, partial synovectomy, lysis of adhesions, and evaluation of valgus instability secondary to UCL insufficiency [1, 14, 17, 19, 21, 29, 37–39].

Fig. 3.3 Elbow arthroscopic positioning. The patient is supine with the arm in 90° of abduction and the elbow in 90° of flexion suspended by an overhead arthroscopic traction device

Surgical Technique

Elbow arthroscopy has been described in lateral decubitus, prone or supine positions [37, 40–45]. Our experience is predominantly with the patient in the supine position. The patient is supine with the arm in 90° of abduction and the elbow in 90° of flexion suspended by an overhead arthroscopic traction device (Fig. 3.3). Elbow flexion and extension is controlled by adding or subtracting weight on a pulley system. The tourniquet is routinely set at 250 mm Hg, and a pressure sensitive arthroscopic pump is helpful in preventing overdistension of the elbow and fluid extravasation into the soft tissues. Both a standard 4.0 mm arthroscope and 2.7 mm small joint arthroscope are routinely utilized. A 70° arthroscope is also useful for evaluation of the space along the medial and lateral gutters of the elbow capsule.

A detailed knowledge of elbow anatomy is imperative for proper portal placement and to minimize the risk of neurovascular complications. Prior to injection and incision, all bony landmarks and portal locations are marked (Fig. 3.4). The elbow joint is then distended using a saline injection into the lateral soft spot [46, 47]. The anterolateral portal is established by placement of an 18 gauge spinal needle into the anterior capsule to confirm intra-articular placement, followed by careful skin incision. A hemostat is used for blunt dissection to the anterolateral joint capsule before penetration of the capsule with a 4.0 mm blunt trocar and sheath.

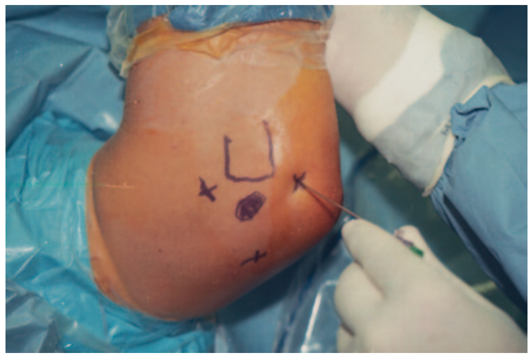

Fig. 3.4 Bony landmarks and portal locations are marked

The anterior compartment diagnostic arthroscopy is then begun. An anteromedial portal may be established using an 18 gauge spinal needle for portal localization. The anteromedial portal is useful as a working portal to address loose bodies, injury to the coronoid process, capitellum or radial head, or osteophyte formation within the coronoid fossa. All compartments must be thoroughly visualized in order to avoid missing critical pathology. During the evaluation of the anterior compartment, concurrent evaluation of UCL stability can be performed by placing a valgus stress on the elbow at 70° of flexion. Opening of greater than 1–2 mm suggests UCL insufficiency [48].

A lateral soft spot portal is then established for the 2.7 mm arthroscope. A second lateral portal may be placed approximately 1 cm distal to the

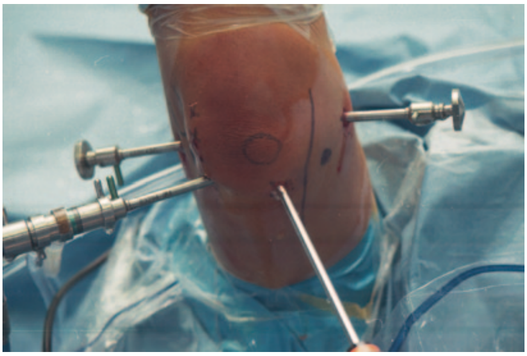

Fig. 3.5 The accessory straight posterior portal through the triceps tendon. Care is taken to avoid the ulnar nerve

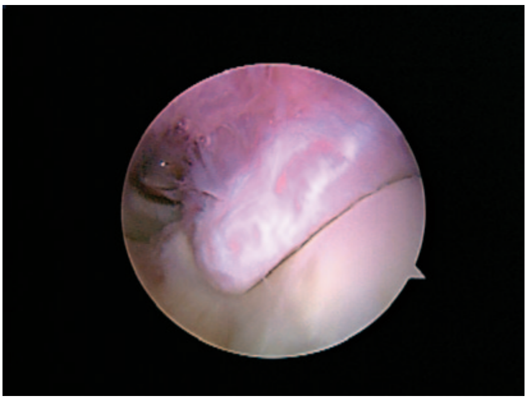

Fig. 3.6 Soft tissue and synovitis is debrided from the olecranon tip and olecranon fossa so that the entire bony margin of the olecranon tip can be visualized

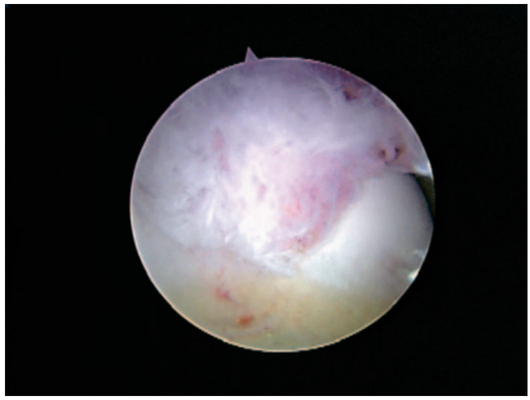

Fig. 3.7 Olecranon tip with bony hypertrophy pre-resection

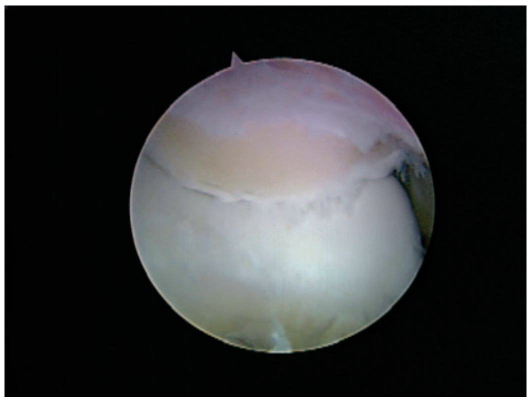

Fig. 3.8 Olecranon tip post resection of osteophytes

direct lateral portal for instrumentation of the lateral compartment. The posterior compartment is then viewed by transitioning the 2.7 mm arthroscope from the lateral portal to the posterior compartment. The elbow is extended to 30° of flexion by adding traction weight to increase the posterior working space. A posterolateral portal is established and the 4.0 mm arthroscope is then introduced into the posterior compartment. An accessory straight posterior portal can then established through the triceps tendon with care taken to avoid the ulnar nerve (Fig. 3.5). The posterior portals as are kept as far apart as possible to allow triangulation in the posterior compartment. Viewing from the posterolateral portal, a shaver is introduced through the straight posterior portal to clear synovitis and soft tissue from the olecranon tip and olecranon fossa so that the entire bony margin of the olecranon tip can be visualized (Fig. 3.6).

Arthroscopic evaluation of the posterior compartment in throwers with VEO is of paramount importance as subtle olecranon osteophytes may not be visualized well on X-ray, but the margin of cartilage and bony hypertrophy is easily seen after adequate soft tissue debridement of the olecranon tip. The chondral injury on the posteromedial trochlea can also be easily identified and addressed. Loose cartilage margins and olecranon osteophytes are then excised with a sharp osteotome and 5.5 mm acromionizer burr. A small sharp osteotome is used to complete the osteophyte removal along the articular margin (Figs. 3.7 and 3.8). The small bone fragments are

Fig. 3.9 Lateral radiograph obtained intraoperatively demonstrates adequate bone removal

then removed with a grasper. The exact amount of olecranon osteophyte that can safely be excised is unknown. Typically ~3 mm of bone is resected [49–51]. This allows visualization into the articular space of the ulnohumeral joint and allows full elbow extension without impingement. A lateral radiograph is obtained intraoperatively to assess for adequate bone removal and to assure that no bone debris remains in the soft tissues around the elbow (Fig. 3.9). A compressive dressing is applied, and the arm is iced and elevated postoperatively [1, 2, 17, 19, 29, 38, 39, 47].

Postoperative Management

The postoperative rehabilitation for elbow arthroscopy and osteophyte excision is focused on early ROM [52, 53]. The primary initial goal is to return to full motion; however, full elbow extension is often more difficult to obtain than with routine diagnostic elbow arthroscopy because of posterior osseous pain and synovitis. Gentle ROM is initiated on the day of surgery with the elbow in a soft dressing. The first 7–10 days are spent concentrating on active and active-assisted elbow ROM and wrist strengthening exercises. By 10 days after surgery, ROM is typically 15–100° flexion or better, and 5–10° to 115° flexion by 2 weeks postoperative. In most cases, full ROM (0–145°) returns by 3–4 weeks after surgery. The risk of an elbow flexion contracture may be minimized by early aggressive rehabilitation [52, 53].

Strengthening of the dynamic stabilizers of the arm is an important part of the rehabilitation process; these include forearm and wrist flexors such as biceps brachii, brachioradialis, and brachialis. These dynamic stabilizers play an integral part in controlling the valgus and rapid extension forces across the elbow during the throwing motion. Isometric strengthening is initiated during the first 10–14 days, followed by isotonic strengthening during weeks 3–6. Strengthening of the shoulder is started by week 6, with plyometrics and endurance exercises focused on the thrower's needs. In most cases, an interval-throwing program may begin at 10–12 weeks after surgery, with a return to competition after symptom-free completion of the throwing program [52–55].

Results

Multiple authors have retrospectively analyzed the results of arthroscopic posteromedial osteophyte excision in throwers, but no prospective, randomized data is currently available. Andrews and Timmerman reported the results of elbow surgery in 64 professional baseball players over a 5-year period [20], the most common procedure being arthroscopic debridement of posteromedial olecranon osteophytes (58 %). Loose bodies were found in 27 % of patients, and the authors noted poor sensitivity of both plain radiographs (27 %) and CT-arthrography (59 %) for the preoperative diagnosis of loose bodies. 73 % of players were able to return to the same or higher level of play, however, 19 (32 %) required subsequent surgical procedures, including 41 % of patients initially treated with arthroscopic excision of an olecranon osteophyte [20]. The authors reported that in the high demand overhead athlete these surgical procedures are often palliative treatments but may result in temporary relief of symptoms and successful return to play.

Reddy and colleagues [56] reported a large series performed at the Kerlan-Jobe clinic, in which the results of 187 arthroscopies were reviewed. The most common diagnoses were posterior impingement (51 %), loose bodies (31 %), and degenerative joint disease (22 %) [56]. Ninety-two percent of 104 patients contacted had results rated as good or excellent at an average follow-up of 42 months, with the biggest improvement seen in pain scores when osteophytes were excised. Forty-seven of 55 baseball players (85 %) were able to return to the same level of competition. The complication rate was 1.6 % [56].

Summary

Posterior elbow pain is a common problem in the throwing athlete due to adaptive bony and soft tissue changes in response to VEO syndrome. A thorough patient history and physical examination with appropriate diagnostic imaging are required to correctly identify the etiology of the elbow pain. It is important to recognize that VEO may occur in combination with other injuries in the elbow and specifically, an injury to the UCL with resultant micro or macro instability must be ruled out as the underlying cause. Osteophytes on the posteromedial olecranon that do not respond to rest and rehabilitation may require surgical excision, a procedure that may be performed arthroscopically with a low complication rate. The amount of olecranon tip that can safely be resected without placing additional stress on the UCL is thought to be less than 3 mm. Removing the least amount of olecranon tip while still adequately addressing the impingement lesions may offer the lowest risk of overloading the ulnar collateral ligament. With proper attention to anatomical landmarks for portal placement and meticulous surgical technique, arthroscopic evaluation and treatment of posterior elbow pain can be safely accomplished in the throwing athlete with minimal risk. Return to previous level of competition can be expected in a high percentage of cases; however, the incidence of additional future surgical procedures is as high as 30–40 %.

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