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Anatomy, Shoulder and Upper Limb, Elbow Annular Ligament

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Introduction

Three bones and three articulations comprise the elbow joint. The humerus, radius, and ulna interact in a complex, dynamic relationship to constitute three distinct joint articulations[1]:

- The humeroulnar articulation
    - Distal humerus (trochlea) and the proximal ulna (trochlear notch)
- The humeroradial articulation
    - Distal humerus (capitellum) and the proximal radius (radial head)
- The proximal radioulnar articulation
    - The proximal ulna (radial notch) and the proximal radius (radial head)

The elbow joint is both a uniaxial, hinge joint (humeroulnar articulation) and a pivot joint (radiocapitellar articulation). The ligaments surrounding the elbow joint connect one bone to another and provide static stability while allowing the motion to occur. The annular ligament is a critical component of the lateral collateral ligament (LCL) complex. While the major roles of the ulnar collateral ligament (UCL) and the LCL complex include primary support against excessive valgus stress and varus stress, respectively, the annular ligament plays an additionally important role as a primary stabilizing structure for the radial head articulation with the radial notch of the proximal ulna during forearm rotation.

Structure and Function

The annular ligament is a strong fibro-osseous circular structure that has attachments to the anterior and posterior margins of the radial notch of the ulna. The annular ligament forms about four-fifths of a circle. The ligament subdivides into three layers:

- Deep capsular structure
- Intermediate layer (annular ligament proper)
- Superficial structure

Superiorly, the annular ligament is at its widest diameter and is continuous with the fibrous capsule of the elbow joint. Inferiorly, the ligament tapers as it surrounds the head and neck of the radius demonstrating distinct attachment sites to the radial neck via a synovial membrane; this allows the radius to freely rotate during forearm pronation and supination while preventing distal displacement. The anterior portion and posterior portions of the annular ligament become maximally taut when the forearm is in terminal supination and pronation, respectively.

Lateral collateral ligament (LCL) complex

The annular ligament, lateral ulnar collateral ligament (LUCL), and the radial collateral ligament (RCL) together make up the LCL complex of the elbow. The LCL complex originates on the lateral humeral epicondyle near the axis of elbow rotation.

While the annular ligament plays a static stabilizing role against excessive varus stress at the elbow, the annular ligament's primary stabilizing role functions at the proximal radioulnar articulation. The annular ligament stabilizes the radial head as it rotates (supination/pronation forearm motion) and articulates with the radial notch of the proximal ulna.

The proximal, central, and distal band of the interosseous membrane also assists in proximal radial head stabilization. Under transverse displacement, the annular ligament along with the central and proximal band of the interosseous membrane equally contribute to stabilizing the radius. However, during forearm pronation and supination, the central band of the interosseous membrane contributes more to the stabilization of the radial head than the annular ligament and proximal band.[2]

Blood Supply and Lymphatics

The blood supply to the elbow joint derives from peri-articular anastomoses. Collateral and recurrent arterial branches from the brachial, deep brachial, ulnar, and radial arteries anastomose to provide consistent blood flow. The radial, ulnar, and brachial veins provide the elbow joint's venous outflow system.

There are two different sets of lymph nodes at the elbow, the superficial and deep cubital nodes. They are above the medial epicondyle. The superficial cubital nodes drain the medial side of the hand and the forearm. The deep cubital nodes drain the elbow joint itself. The efferent vessels travel more proximal and drain into the axillary lymph nodes before entering the thoracic duct on the left side and the right lymphatic duct on the right side.

Nerves

Anteriorly, the elbow joint is innervated by branches of the median, radial, and musculocutaneous nerves. Posteriorly, the elbow joint receives innervation by branches of the ulnar nerve.

Muscles

The muscles crossing the elbow joint are subdivided into the flexors and extensors.

The primary elbow flexors include the biceps brachii and brachialis muscles. The biceps brachii is the largest of the flexors, and its primary function is as a primary and powerful forearm supinator[3]. The brachialis originates off the anterior humerus and inserts about 1 centimeter distal to the coronoid tip. Additional elbow flexion occurs via the brachioradialis (mobile wad compartment) and pronator teres (flexor-pronator mass). The brachioradialis originates from the lateral supracondylar humerus and attaches at the lateral aspect of the distal radius and assists in elbow flexion. The pronator teres originates off the medial epicondyle of the distal humerus, as well as the coronoid, before inserting on the mid-lateral radial shaft. Thus, pronator teres functions to both assist in elbow flexion and forearm pronation.

The extensors include the triceps brachii and anconeus. The triceps brachii is the largest extensor of the elbow and stabilizes the joint when the hand undergoes fine motor movements. The anconeus is a small muscle that assists in elbow extension as well.

Physiologic Variants

The annular ligament can demonstrate significant anatomic variation in its overall morphology. Multiple MRI-based studies and cadaveric dissection reports demonstrate the annular ligament appearing as a bi-lobed structure. Other studies demonstrate a morphologically broad annular ligamentous structure spanning superior to inferiorly at its

attachment sites. In the instances that the ligament is bilobed, the anterior component remains its own separate, single band, while the posterior component demonstrates a fenestrated morphology. The latter can be seen as its own superior and inferior subdivisions, creating a funnel-shaped appearance.[4]

There may also be variance in the synovial fold of the annular ligament. The synovial fold is its own distinct structure attached to the proximal end of the annular ligament, extending into the radiocapitellar joint capsule and blending with the common extensor tendon; this forms a single enthesis at the lateral epicondyle. One can think of it as the "meniscus" of the elbow joint. This fold can vary in thickness and can be an underlying cause of chronic, recalcitrant elbow pain syndromes.

Surgical Considerations

Although many injuries involving the annular ligament can be managed conservatively with physical therapy, activity modifications, bracing, and non-steroidal anti-inflammatory medications (NSAIDs), there are many indications for surgical intervention.

Radial head instability

Healthcare providers must recognize that, in general, isolated radial head instability is extremely uncommon. In effect, this finding is almost always seen as a long-standing congenital condition or in association with additional forearm trauma (i.e., Monteggia fracture patterns). The latter is extremely important to recognize clinically, as management is nearly always observation alone.

Patients with congenital radial head dislocations will present with a separate chief complaint, and the dislocation may be discovered incidentally. These patients are asymptomatic, and the following factors support congenital dislocation over an acute, traumatic dislocation:

- Bilateral radial head dislocations
- Hypoplastic capitellum and convex radial head
- Other congenital abnormalities
- No history of trauma
- Inability to reduce

In the setting of subacute trauma or chronic subluxation presentations, radial head instability may present with pain, clicking, catching, or locking of the elbow that persists during activity. Chronic instability patients may report as if they feel the elbow is going to "pop out of place" with pronation and supination movements. Overhead athletes may present with pain with throwing or a decrease in velocity.

There have been case reports of a portion of the annular ligament band interposing between the humeroradial interface as the band slips over the radial head during elbow flexion and extension. This "snapping" or "locking" can be thought of as analogous to a bucket handle tear of the meniscus in the knee. Patients are managed based on the severity of symptoms and the degree of severity and disability that is attributable to these mechanical symptoms. Persistent mechanical symptoms may warrant considering surgery to remove the interposed fragment.[5]

Annular ligament reconstruction techniques

The annular ligament is typically reconstructed using any of the previously described reconstructive techniques in the literature.[6]

- Bell-Tawse technique[7][8]
    - Utilizes the central portion of the triceps tendon to create a strip of tissue to pass around the radial neck and through a single drill hole in the ulna

    - Modifications of the original technique have included either an additional ulnar shortening osteotomy or in using the lateral portion of the triceps tendon with a transcapitellar pin for stability

- Two-hole technique[9]
    - Seel and Peterson drilled two holes in the proximal ulna at the original sites of the normal attachment of the annular ligament
- A third technique was described utilizing small bone staples and bone-anchoring devices as an alternative to transosseous drill holes

Rehabilitation protocols depend on the specific surgical technique used for the reconstruction and follow surgeon preference. General rehab phases include early range of motion to mitigate the risks of postoperative stiffness. Patients should return to full range-of-motion by 6 weeks after surgery. Strengthening exercises begin at about 8 to 12 weeks postop. Most patients can return to normal activities by six months to one year. Overhead athletes may take over a year to return to sport.

Clinical Significance

An annular ligament injury is much more common in children due to the skeletal immaturity of the elbow joint during development. The three most common injuries associated with the annular ligament are radial head/neck fractures, nursemaid elbow dislocations, and Monteggia fracture patterns

A radial head/neck fracture occurs during a fall on an outstretched hand or trauma/falls with the elbow in extension and forearm in pronation. Because the annular ligament wraps around the head of the radius, a fracture at this area can lead to damage of the ligament and future could potentially compromise joint stability as a sequela of the original injury.

In pediatric patients, a radial head subluxation, also known as a nursemaid elbow, occurs due to a sudden pull on an extended arm, or when lifting a child by the wrist. This injury occurs almost entirely in the pediatric population since the annular ligament is much weaker in children compared to adults. The classic symptoms of a radial head subluxation in pediatric patients consists of a history of the child refusing to use the arm. The child may hold the extremity with the elbow in extension. On exam, there is typically pain localized to the dorsal aspect of the proximal forearm with variable amounts of swelling. Often there may only be subtle decreases in flexion and extension range of motion (ROM), but supination is significantly limited. The annular ligament is frequently interposed between the radial head and the capitellum. Treatment includes closed reduction using either hyperpronation or a combination of flexion and supination maneuvers. The prognosis in these patients is typically excellent in the long-term.[10]

Monteggia fracture-dislocations are relatively rare injuries in the pediatric population. Although forearm fractures in kids account for up to 30% of all fractures, Monteggia fracture-dislocations constitute only about 1% of all pediatric forearm fractures. These injuries encompass a proximal one-third of the ulna (olecranon) fractures with an associated radial head dislocation. Mechanisms of injury include a fall on an outstretched hand with excessive forearm pronation and less commonly, direct trauma on the dorsal surface of the proximal forearm. These injuries commonly require surgical intervention given the high incidence of long-term elbow dysfunction following either missed injury or following suboptimal clinical management. Surgical management consists of open reduction internal fixation (ORIF) of the proximal ulna. Upon restoration of ulnar length and stability, the radial head can be reduced with a restoration of the anatomic relationship between the radial head, capitellum, and the annular ligament.

The prognosis in children is usually good with early intervention and treatment. However, several studies in the literature have focused on the long-term clinical and radiographic outcomes following surgical management of pediatric patients with delayed/missed diagnosis of Monteggia fracture-dislocations. The most commonly performed procedure includes an open reduction with ulnar osteotomy with or without annular ligament reconstruction.[11] Nakamura et al. reported good long-term outcomes when performing open reduction if the patient is less than twelve years of age or within three years after the initial injury.[12]

Questions

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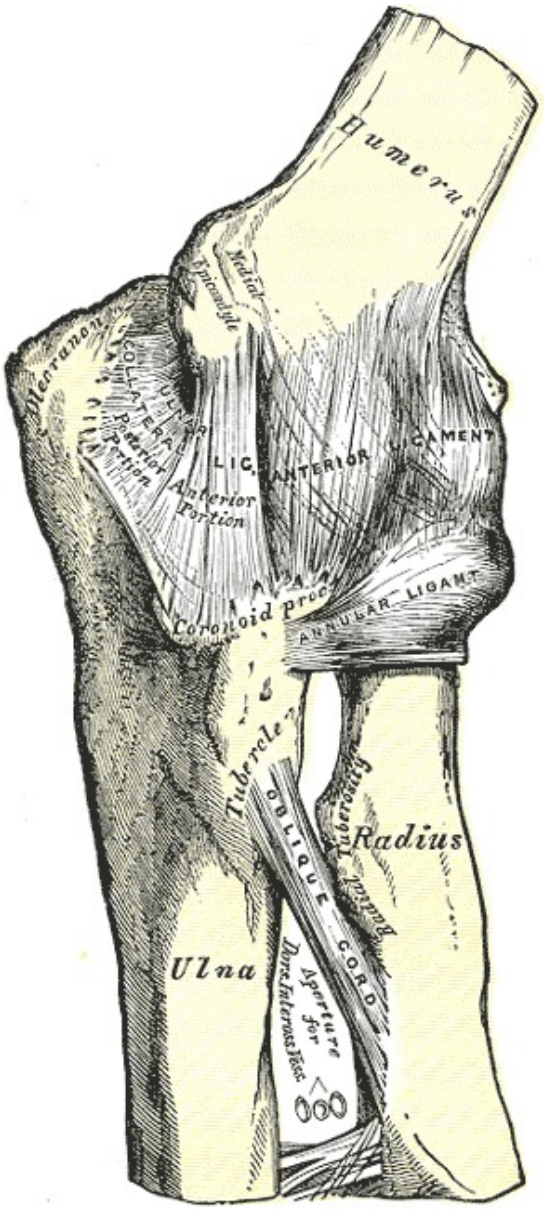
Figures



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