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THE QUADRATE LIGAMENT OF THE ELBOW—ITS RELATIONSHIP TO THE STABILITY OF THE PROXIMAL RADIO-ULNAR JOINT

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INTRODUCTION

It has been demonstrated clinically that the proximal radio-ulnar joint is most stable in supination. The purpose of this paper is to present the basic anatomy responsible for this observation. Fifty elbows, both fresh and preserved specimens, were studied. The findings were correlated with 25 clinical cases of dislocations of the radial head and Monteggia fracture-dislocations of the proximal radio-ulnar joint.

The proximal radio-ulnar joint is most stable in supination for the following reasons: (1) The adult radial head is not circular but somewhat oval (Figure 1). With the forearm in supination the greatest diameter of the head comes in contact with the proximal radio-ulnar joint. (2) The height of the margin of the radial head is not of the same width around the head (Figures 2 and 8D). In full supination the broadest portion of the margin of the radial head comes in contact with the proximal radial notch of the ulna and gives the broadest articular contact. (3) In full supination the interosseous membrane is most taut. (4) The orbicular ligament is reinforced by the anterior and posterior components of the radial collateral ligament. (5) In full supination the anterior thicker fibers of the quadrate ligament of Denucé stabilize the radial head more strongly into the proximal radio-ulnar joint.

The quadrate ligament (Figure 3) was first described in 1854 by Denucé and now bears his name. Little attention was given to this structure until 1955 when it was accepted as a functional structure by the *Nomina Anatomica Parisiensia* (N.A.P.). Its function in the past was

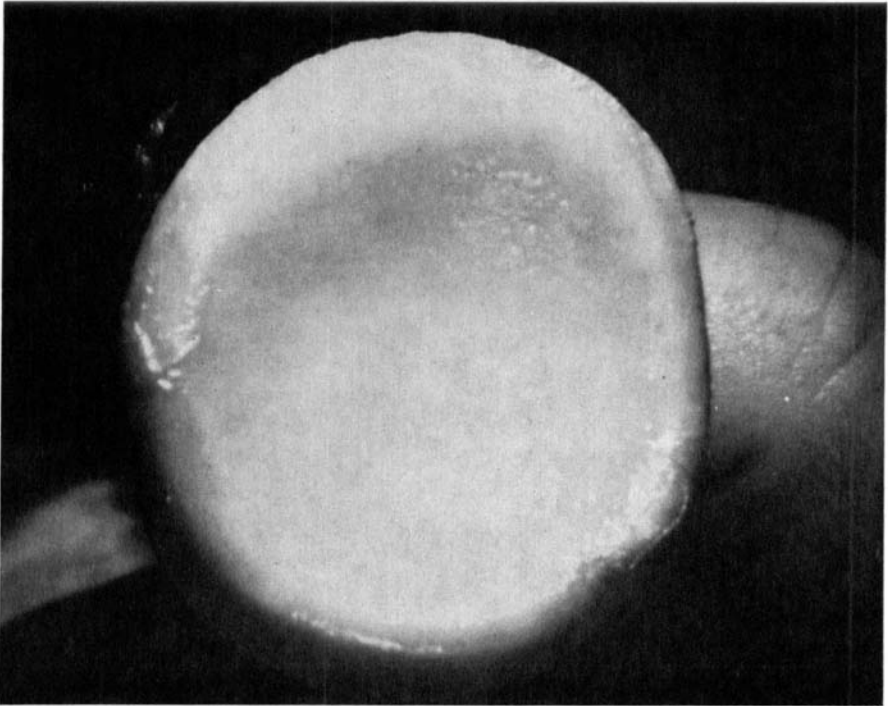


Figure 1. This adult radial head measured 1 inch in its long axis while the short axis was 7/8 of an inch.

described by anatomists as a reinforcement of the inferior aspect of the capsule of the elbow joint. On the basis of our studies the role of the ligament of Denucé is an important structure concerned with the stability of the proximal radio-ulnar joint. These studies have shown its chief role is as an accessory stabilizer of the proximal radio-ulnar joint in full supination and pronation on account of the position of its anterior and posterior fibers in the extremes of rotation.

The ligament extends between the lateral side of the proximal ulnar just distal to the proximal radio-ulnar joint and attaches to the neck of the radius just distal to the articular margin. The radial attachment is in line with the bicipital tuberosity. The ligament of Denucé has an anterior and posterior border. The anterior border is denser and stronger than the posterior border while the central portion of the ligament between the two is thin.

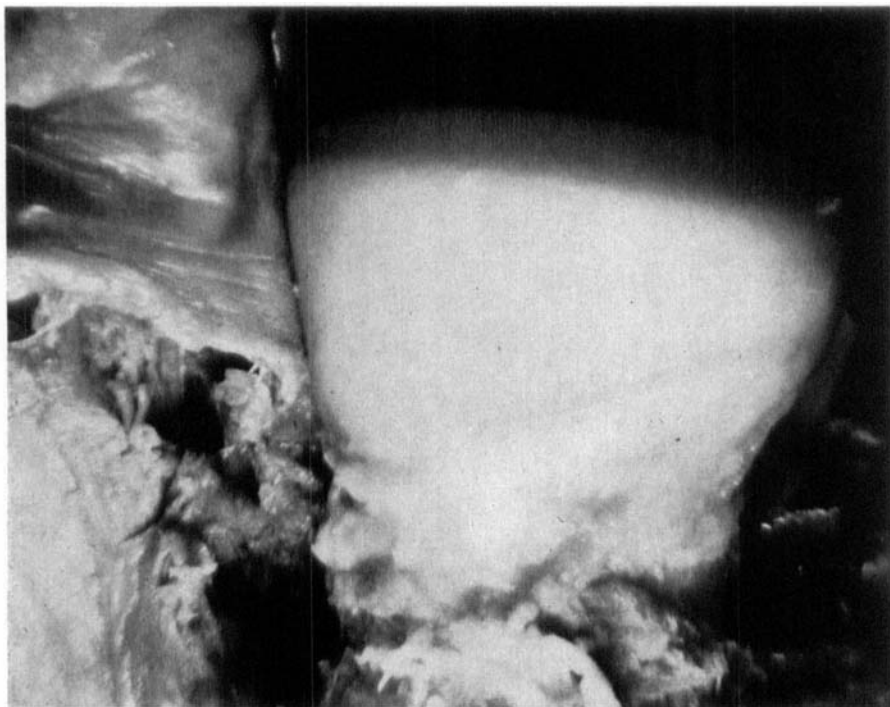


Figure 2. The margin of the radial head is not of the same height around the head.

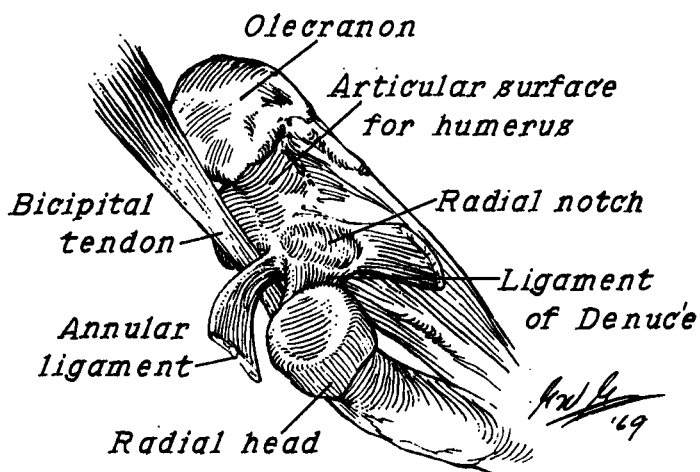


Figure 3. A line drawing of the left elbow joint with particular detail to the ligament of Denucé at the proximal radio-ulnar articulation.

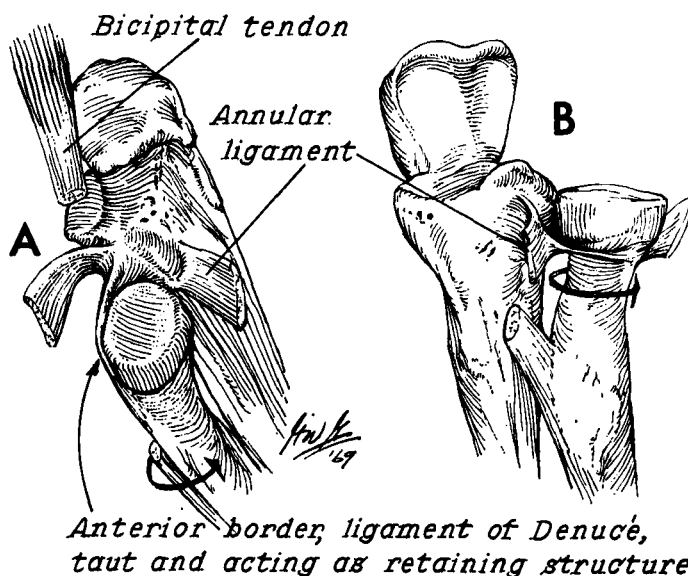


Figure 4. (A) Note when the orbicular ligament is divided the radial head can dislocate posteriorly. (B) When the forearm is supinated, it is the anterior border of the quadrate ligament which becomes taut and draws the radial head snugly against the radial notch of the ulna.

Normal Functional Anatomy of the Ligament of Denucé

In full supination of the forearm the anterior border becomes taut around the neck of the radius drawing it snugly against the proximal radio-ulnar notch (Figure 4B). The posterior border slackens; whereas in full pronation the posterior fibers become taut, drawing the radial head into the sigmoid notch of the ulna while the anterior fibers become slack.

MATERIAL AND METHODS

Fifty elbows were dissected and set in 2 main groups. The extensor musculature and supinator were separated from their origin and were reflected distally to expose the joint capsule, orbicular ligament, interosseous membrane and the proximal one half of the radius and ulna.

Group 1. The principal stabilizer of the proximal radio-ulnar joint is the orbicular ligament. Dislocation of the radial head did not occur in this first group when the ulna and the orbicular ligaments were intact and Denucé's ligament divided.

However, with the ulna intact our anatomical studies indicated that when the orbicular ligament reinforced by the anterior and posterior components of the radial collateral ligaments were severed, the radial head dislocated posterior, radial,

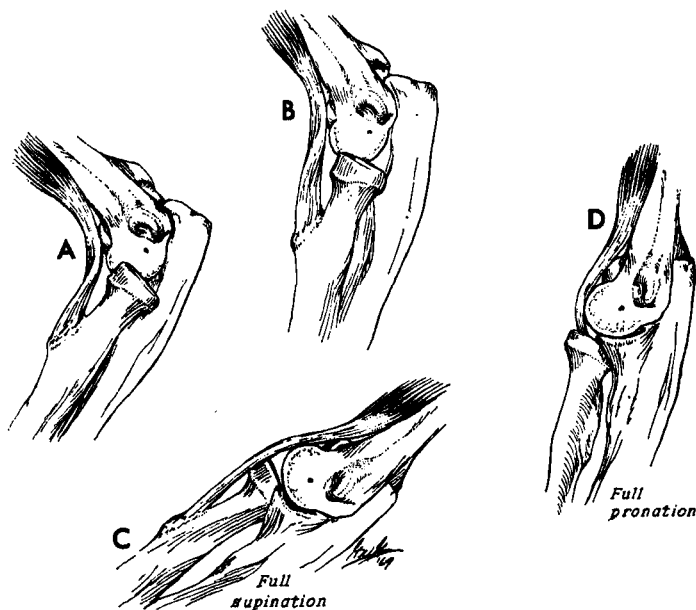


Figure 5. Left elbow. A posterior dislocation of the radial head is best reduced and maintained in extension and full supination (A, B and C). It can also be reduced in full pronation in extension (D).

or postero-radial in 90 per cent of the specimens (Figure 4A). Anterior dislocation was not demonstrated in any of these specimens. In a few, there was complete stability at the proximal radio-ulnar joint with the orbicular ligament divided and in these specimens the ligament of Denucé appeared short and square in outline.

Division of the posterior border of the quadrate ligament, in this small group of 10 per cent, produced posterior or postero-radial dislocations of the radial head.

All dislocations in this group could be reduced by full extension of the elbow (thus unlocking the radial head from the capitellum) and rotation of the forearm into full supination or full pronation when the ligament of Denucé was intact (Figure 5). When the posterior fibers of the ligament were severed, reduction could be accomplished only in full supination. If the anterior border was severed, reduction occurred only in full pronation.

To produce an anterior dislocation of the radial head with an intact ulna three conditions had to be met: (1) the orbicular ligament had to be severed; (2) the posterior border of Denucé's ligament had to be divided; and (3) the oblique cord of Weilbrecht and the proximal $\frac{1}{4}$ of the interosseous membrane had to be divided (Figure 6A). With an intact ulna, anterior dislocation of the radial head could not be produced unless the above structures were severed.

We repeated several of Evans' excellent hyperpronation experiments. In the specimens in which there was an anterior dislocation of the radial head without a fracture of the ulna the orbicular ligament was found to be ruptured along with a

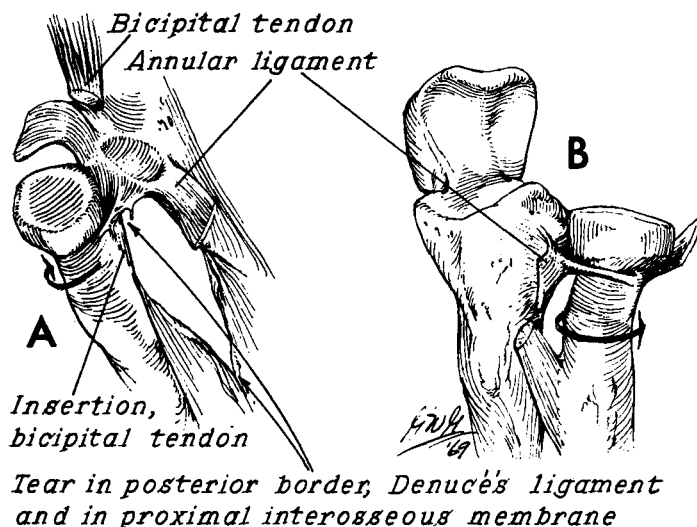


Figure 6. (A) Left elbow. To produce an anterior dislocation of the radial head, the orbicular ligament, the posterior border of the Denucé ligament, and the proximal $\frac{1}{3}$ to $\frac{1}{2}$ of the interosseous membrane (including Weitbrecht's oblique cord) must be severed. (B). Reduction of an anterior dislocation occurs in full supination and is accomplished through the intact anterior border of the quadrate ligament.

rupture of the posterior border of Denucé's ligament and the proximal $\frac{1}{3}$ to $\frac{1}{2}$ of the interosseous membrane (Figure 7).

The anterior dislocation of the radial head created either by dividing the three essential structures or produced by hyperpronation were reduced by fully supinating the elbows flexed at 90 degrees. In these cases apparently the intact anterior fibers of Denucé's ligament reduced and stabilized the joint (Figure 6B).

Group II. Twenty elbow specimens were used to study Monteggia fractures under varying conditions.

Group A. In five specimens the orbicular ligament was severed leaving the ligament of Denucé intact and the ulna osteotomized at the junction of the proximal and middle third. By forceful angulation an anterior or posterior dislocation was produced.

Group B. In this group of five specimens, the ulna was osteotomized high at the level of or just proximal to the radial tuberosity; the orbicular ligament, Denucé's ligament and the interosseous membrane were left intact (Figure 8A). With the forearm in supination and by angulating the osteotomy site posteriorradially, the radial head dislocated posteriorly, leaving the intact orbicular ligament as an obstacle to reduction (Figure 8B). The radial head pulled out from the inferior aspect of the orbicular ligament without rupturing it. In addition the quadrate ligament is intact (Figure 8C). By pronating the forearm, the posterior irreducible dislocation was converted to an irreducible anterior dislocation with the ulna abnormally rotated to 90 degrees at the osteotomy site (Figure 8D).

Group C. The ulna was osteotomized at different levels in five specimens with



Figure 7. Right elbow. A hyperpronation experiment (Evans type), the proximal forearm viewed from posterior reveals an anterior dislocation of the radial head with a rupture of the articular ligament (OL), the posterior border of the quadratus ligament (arrow), and the interosseous membrane (IM).

the orbicular ligament and the quadratus ligament intact in all. When the ulna was osteotomized proximal to the origin of the interosseous membrane, only posterior dislocation of the head of the radius by posterior angulation of the ulna was noted (Figure 9).

With the osteotomy made in the middle third of the ulna, angulation of the osteo-

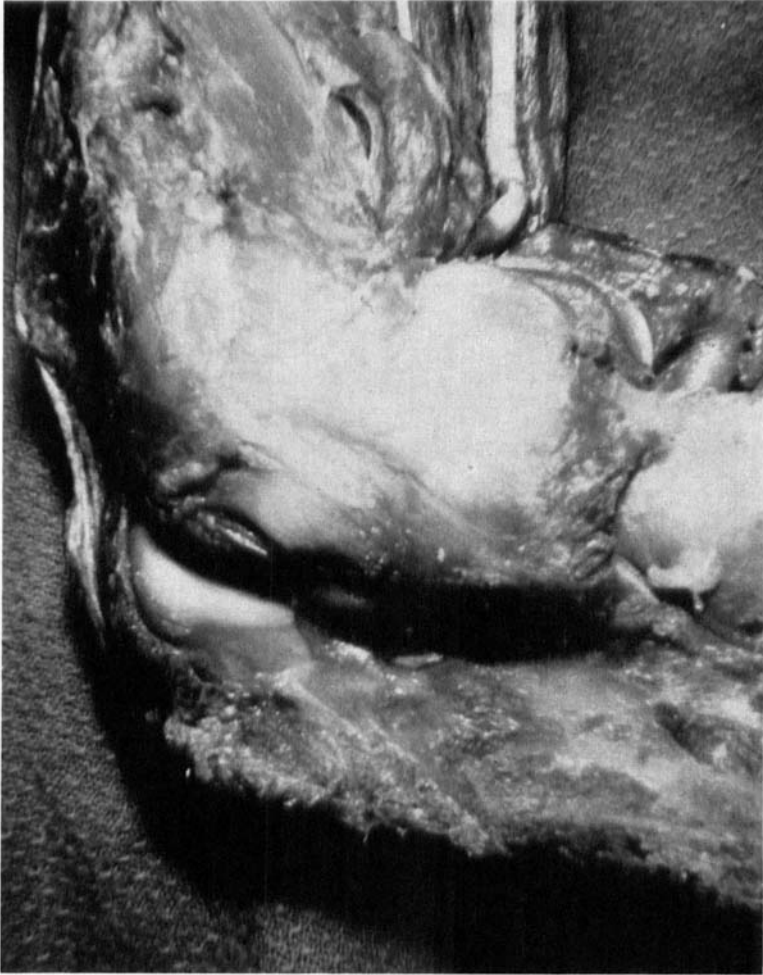


Figure 8A. Right elbow. The orbicular ligament is intact.

tomy failed to produce a dislocation of the radial head in either direction, unless the proximal portion of the interosseous membrane was incised. Pronounced posterior angulation at the osteotomy site produced marked widening of the proximal interosseous space resulting in a posterior dislocation of the radial head even though the integrity of the orbicular ligament and Denucé's ligament was maintained (Figure 10). There is some doubt in the author's mind that this type occurs clinically.

Anterior dislocations could not be produced with the orbicular ligament intact.

Group D. In this group of five specimens the orbicular ligament was incised and the ulna was osteotomized at varying levels from the level of the ulna notch to the mid-shaft with the interosseous membrane intact. Dislocations of the radial head

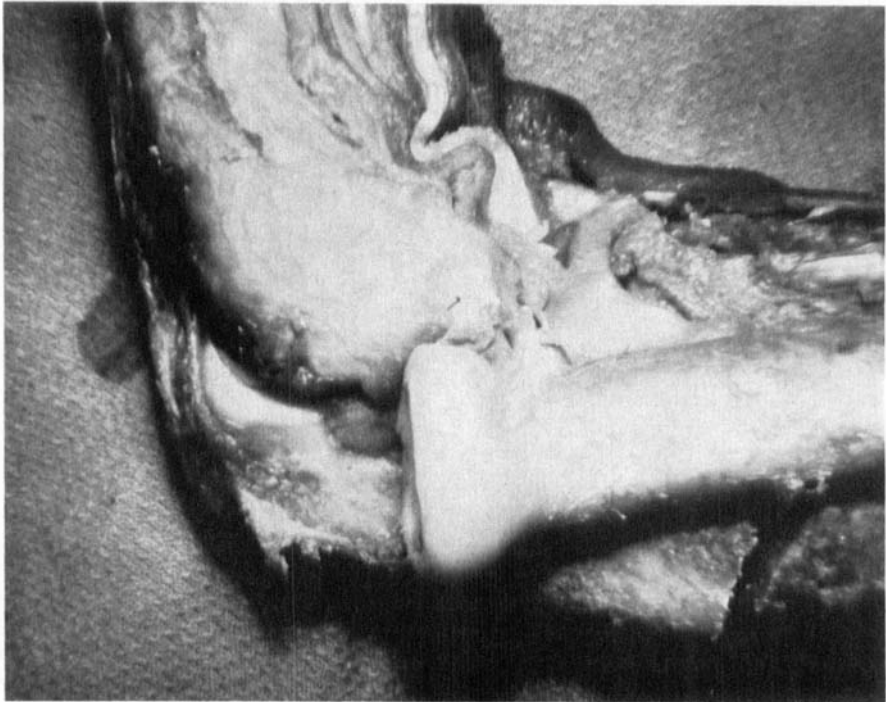


Figure 8B. A posterior Monteggia fracture-dislocation has been produced with an intact orbicular ligament which is an obstacle to reduction.

were constantly produced with angulation of the ulna. With anterior angulation of the ulna, anterior dislocation of the radial head was noted, while with posterior ulna angulation posterior dislocation of the radial head was produced.

CLINICAL MATERIAL

Twenty-five clinical cases of dislocations of the radial head and Monteggia fracture-dislocations were reviewed with particular attention to the method of obtaining and maintaining the reduction.

All of the Monteggia lesions in children were reduced by closed methods in either flexion (Figures 11 A and B) or in extension depending on the type fracture-dislocation. All of the radial head dislocations were reduced and were maintained in full supination.

The majority of adults required open reduction to stabilize the ulna. The radial head component was reduced in full supination once the ulna was fixed. There was one exception:

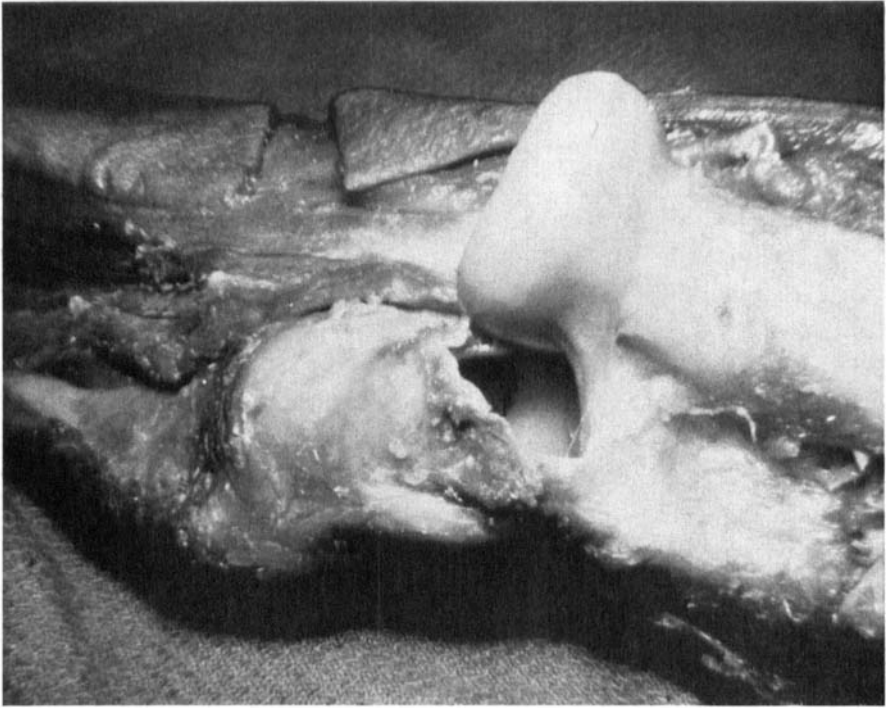


Figure 8C. The irreducible dislocation occurred when the radial head dislocated through the inferior aspect of the articular ligament. Note that the Denucé ligament is intact.

A 56 year old male was admitted to the Jacobi Municipal Hospital, New York, with a Monteggia lesion of the right arm on September 17, 1968. Closed reduction was unsuccessful. An open reduction was performed and a Leinbach screw was used to fix the ulna fracture one week later. A small fragment of the radial head was found loose in the joint and was removed. In supination the radial head was noted still to be dislocated posteriorly. Full pronation yielded the reduction of the radial head.

The probable explanation for this exception was that the anterior border of the ligament of Denucé was detached with the small fragment of the radial head leaving just the posterior border intact. The radial head was reduced utilizing the posterior border of the ligament in full pronation. This was confirmed at surgery subsequently, when after union of the ulna was obtained and the arm mobilized in order to gain maximum rotation of the forearm the radial head was removed.

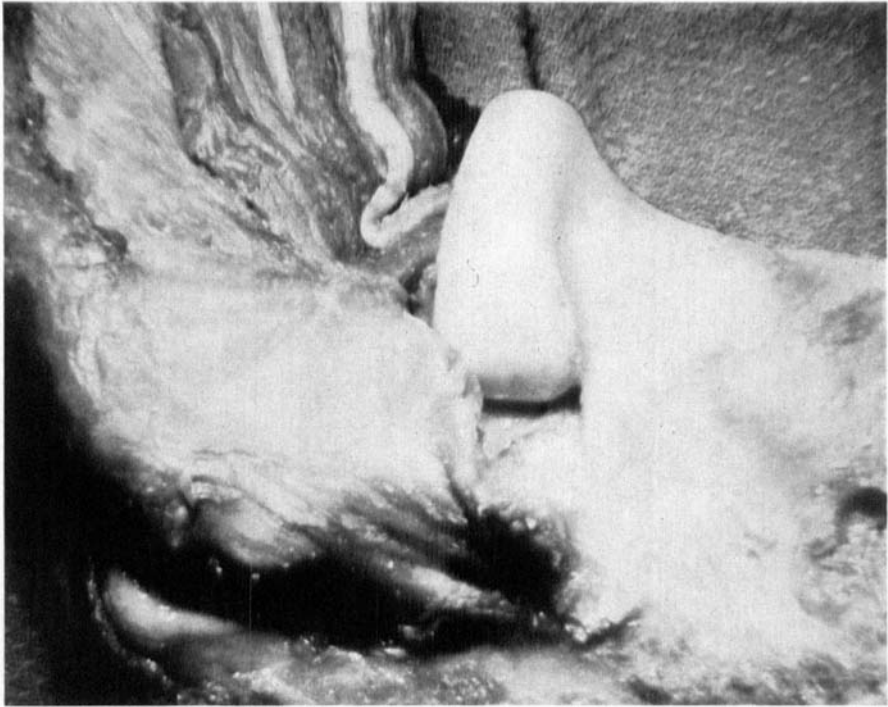


Figure 8D. The same specimen can be converted into an irreducible anterior Monteggia by pronation of the forearm. The orbicular ligament and capsule are still interposed between the radial head and capitellum.

It revealed the fragment of radial head was from the region where the anterior border of the ligament attached.

DISCUSSION

Our anatomical studies continue directly from the initial experiments of Evans (1949), in which he related anterior Monteggia fractures to hyperpronation of the forearm. Evans emphasized the importance of supination in reduction of these fracture-dislocations. The importance of supination is further supported by the additional laboratory experiments with the functional studies of Denucé's ligament noted in this report. It is the intact anterior border of this ligament with the forearm in full supination that draws the radial snugly into the proximal radio-ulnar joint. Earlier reports of Henderson (1931) and Wilson (1933) indicated the importance of supination postoperatively, in treat-



Figure 9. Group C. Right arm. A posterior Monteggia lesion can be produced with an intact orbicular ligament when the ulna is osteotomized proximal to the interosseous membrane.

ment of Monteggia fractures. Naylor (1942) initially utilized traction with pronation to gain reduction but found it impossible to maintain it. He too found it necessary to place the forearm in full supination to maintain the reduction.

Schubert (1965) described a case of dislocation of the radial head in one newborn. The dislocation was postero-radial. It was reduced well in full supination with the arm held in extension and immobilized in this position for 2½ weeks. The infant had an uneventful recovery. He noted the bilateral case of Cockshott & Omolulu (1958) of a six day old female baby with bilateral dislocation of the radial head which seemed to reduce in full supination and dislocated in pronation.

Furthermore, it is well-known that the so-called "pulled elbows" in



Figure 10. Group C. Right arm. Similarly, posterior Monteggia fracture-dislocation with an intact orbicular and Denucé ligaments but with the ulna osteotomized in its middle third. To produce it the entire proximal interosseous membrane had to be divided.

young children reduce in 90 degrees of flexion and full supination. It is believed, therefore, that it is the ligament of Denucé which on the extremes of supination draws the radial head through its thickened anterior border into the proximal radio-ulnar joint by wrapping around the neck and holding it firmly to this joint.

In addition, one may question whether some congenital dislocations of the radial head of childhood are not the end result of an accidental dislocation of the newborn which was not recognized. In support of this speculation a 30 per cent incidence of dislocations of the radial head (anterior and posterior) in cases of Erb's palsy is reported by Aitken (1952). It is possible that, in addition to the current concept of these



Figure 11 A.

dislocations due to "muscular imbalance in prolonged immobilization in an extremely abnormal position", some of the radial head dislocations in Erb's palsy may be due to an unrecognized accidental dislocation in the newborn. We are currently attempting to substantiate this viewpoint by examination of the newborn with observation and roentgenograms of the upper extremities which do not respond to the Moro reflex.

SUMMARY

The quadrate ligament of the elbow, the significance of which is still debated, is an important stabilizer of the proximal radio-ulnar joint. Its anterior and posterior reinforced borders play an important role in the reduction of dislocations of the radial head in Monteggia lesions, dislocations of the radial head, and "pulled elbows".

A Monteggia lesion with a posterior dislocation of the radial head can



Figure 11 B.

Figures 11 A and B. Anteroposterior and lateral roentgenograms of an antero-radical type Monteggia lesion reduced in flexion and full supination.

occur with intact orbicular and Denucé's ligaments. However, a Monteggia lesion with an anterior dislocation of the radial head will have a disruption of the orbicular ligament, and usually has a disruption of the posterior border of the quadrate ligament.

An irreducible type Monteggia lesion can occur with intact orbicular and Denucé's ligaments. The radial head dislocates inferiorly interposing the intact capsule and orbicular ligament between the radial head and capitellum.

Traumatic anterior dislocations of the radial head without fracture of the ulna are associated with disruption of the orbicular ligament, posterior border of the ligament of Denucé and the proximal interosseous membrane. Posterior dislocations of the radial head alone occur, usually, just with rupture of the orbicular ligament.

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