STRESS AND STRAIN AT THE LATERAL COLLATERAL LIGAMENT COMPLEX OF THE ELBOW JOINT

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SUMMARY

Background: The radial collateral ligament was previously believed to be the only ligament existing at the lateral aspect of the elbow joint until Morrey and An (1976) classified the ligaments to include radial collateral (RCL) and lateral ulnar collateral ligaments (LUCL). There is therefore the need to assess the impact these ligaments in elbow joint stability.

Objective: To investigate how the RCL and LUCL are affected by stress and strain in both routine and forceful movements of the limb.

Materials and Methods: Eight (8) embalmed upper extremities were used for this investigation. The elbow joint was dissected with care taken to preserve the lateral ulnar collateral ligament seen in seven of the limbs. Qualitative assessment of ligament tension was made under valgus and varus stresses. The angles at which stress was applied were 45^0, 70^0, 75^0, 90^0, 110^0, 120^0 and full extension. These angles were chosen partly because most movements during racket sporting activities take place at higher angles (Regan et al 1991). The angles were determined by hand held goniometer while the arm was firmly held in a retort stand.

Results: The RCL is more able to absorb stress and strain because of its greater flexibility enhanced by its attachment at the annular ligament. However, LUCL a thickened mass, in both valgus and varus stresses was taut throughout most of the entire arc of flexion. It is a much stronger ligament that effectively stabilizes elbow joint in both routine and forceful movement.

Conclusion: This study has been able to establish that LUCL is more prone to stress and strain. Being attached from bone to bone, it equally provides greater stability at the lateral aspect of elbow joint.

KEY WORDS: Elbow joint; Ulna and Radial Collateral Ligament; stress and strain.

INTRODUCTION

The role of ligament in providing stability at the elbow joint has been well documented (Morrey and An, 1983; An and Morrey, 1985; Hotchkiss and Weiland, 1987). Although valuable information has been gained from the reports, the improper characterization of relationships within the lateral collateral ligament mass made it difficult to appreciate the degree of involvement of the component ligaments in the movement of the elbow joint.

The description of the lateral collateral ligament complex of the elbow joint differs markedly in anatomical texts (Martin, 1958; Grant, 1972). While some hold the view that no fibres pass directly from bone to bone (Schwab et al, 1980), an ulnar insertion of the lateral collateral ligament (LCL) of the elbow has been variably illustrated in anatomy texts (Spalteholz, 1923; Grant, 1972;Langman and Woerdemen, 1978; Netter, 1987).

Summarizing, Morrey and An (1976) reported that the radial collateral ligament (RCL) is generally accepted to consist of a poorly demarcated fan-shaped structure taking its origin from the lateral epicondyle and inserting into the annular ligament. He also observed the existence of additional fibres in the collateral ligament complex inserting to the supinator crest of the ulnar bone. The ligament forms a continuous flow of fibres, situated more superficially and posteriorly extended beyond RCL before attaching at the crest. Thus, it is only partially blended with the capsule of the joint. This ligament, which he named lateral ulnar collateral (LUCL), was observed in 9 out of 10 specimens. The LUCL has also been characterized in Nigerians. It was observed in 15 out of 18 cases (Mbaka and Ejiwunmi, 1998).

The role of these ligaments in the elbow joint movement has been assessed in both valgus and varus load applications (Regan et al, 1991). The assessment, which was conducted along the axis of anatomical position (supination),

provided information on the relative contribution of the ligaments to resist varus and valgus stresses at different angles of flexion and extension.

This study is designed to investigate the interplay of these two ligaments in maintaining stability at the elbow joint in both supinated and pronated positions, and how they are affected by stress and strain in both routine and forceful movements of the limb.

MATERIALS AND METHODS

Eight (8) formalin embalmed upper extremities (five right and three left) were used for this study. All these specimens were from male cadavers. Soft tissue was carefully dissected from the elbow joint so that the anterior capsule and the medial and lateral collateral ligament complexes were clearly demonstrated. On the lateral aspect, care was taken to preserve the lateral ulnar collateral ligament that was observed in seven of the limbs. The triceps was also removed from its insertion on the olecranon. The specimens were well hydrated in order to minimize distortions and brittleness of the fibres.

Valgus and varus stresses were applied on the ligaments within wide range of angles and the measure of strain (tautness) exacted was assessed by palpation. Thus, qualitative assessment was made of ligament tension or tautness through the arc of elbow flexion under neutral, valgus and varus stresses (Regan et al, 1991). The angles at which stresses were applied were determined with the aid of a hand- held goniometer while the arm was firmly held in a retort stand. With the forearm free, sequential varus, neutral and valgus stresses were applied to the elbow joint when flexed at 45^0, 70^0, 75^0, 90^0, 110^0, 120^0 and full extension. These angles were chosen partly to cover the total range of elbow flexion and partly because most movements during racket sporting activities take place at the higher angles (Regan et al, 1991).

We determined qualitatively at what level/degree of flexion slackness of fibres disappeared and the fibres became taut for the RCL and LUCL during gradual flexion and extension in anatomical position and pronation.

RESULTS

Beginning at full flexion (45°) with the limb in the anatomical position, the anterior fibres of RCL were lax with valgus stress. The same applied to the posterior fibres. At 70°under valgus stress, there was essentially no change in tonus of the anterior fibres. The posterior fibres however began to tighten. At 75°, there was a slight increase in tonus of the anterior fibres while its posterior counterpart became tauter.

However, at 90° and up to full extension both anterior and posterior fibres became increasingly taut.

It was not possible to examine the effect of valgus stress on the pronated forearm at 45^0 and 70^0 of flexion. However, at 110^0 and 120^0 respectively, there was a reversal of stress impact on the ligaments. Under valgus stress, in the aforementioned angles, the tautness was more profound on the anterior fibres. Generally, the tautness of RCL was more profound in pronation.

Resistance to varus stress differs in some respects. Following application of varus stress at 45^0 (flexion), the anterior and posterior fibres of RCL were lax. However, at 75° both fibres became partially taut. Like in valgus stress the tautness increased progressively to full extension. At 110° and beyond, the tautness was more on pronation with equal effect on both anterior and posterior fibres.

The LUCL extending from lateral epicondyle to the supinator crest was a rigid mass, the strongest ligament in this compartment with enormous strength. This ligament maintain tautness throughout the arc of flexion in both valgus and varus stresses. However, the tautness was more on the posterior fibres at full flexion (45^0). In full extension, the degree of tautness was relatively more marked in a pronated forearm than in anatomical position.

DISCUSSION

The elbow joint is highly stable being one of the most congruous joints in the body (Morrey and An, 1983). In view of the unique characteristics of the joint and the nature of its alignment, dislocation is rare except for severe trauma that usually is associated with coronoid process fracture or radial head dislocation (Linscheid and Wheeler, 1965). Another recognized complication of elbow dislocation is the avulsion of the medial epicondyle in patients below 18 years of age (Linscheid and Wheeler, 1965; Neviaser and Wickstrom, 1977).

It has been observed that the posterio-lateral part of the elbow joint is the most common site of dislocation and believed also to present as disruption of the lateral or radial ligament (Hassman et al, 1975; Norwood et al, 1981). Although RCL is primarily effective in extension to resist varus stress, it nevertheless plays minimal role in the stability of the elbow joint (Morrey and An, 1983). It is said to maintain a consistent pattern of tension or strain in all its fibre bundles no matter whether varus, valgus or no stress was applied to the elbow joint through the arc of flexion (Regan et al, 1991). The assertion conforms with our observation where the build up of strain was progressively

maintained to full extension. In both valgus and varus stresses, there was an increasing sequential strain on the ligament as the joint attains full extension. However, the impact of strain was more in varus than in valgus stress. The mode of distribution showed that anterior fibres were more tensed in pronation. This is as a result of the anterior rotatory movement of the radial head. Following the return of the radial head in supination, the exertion becomes more on the posterior fibres, progressively to full extension.

The description of LUCL by Morrey and An (1983) was pivotal in the interest generated in the reassessment of the complexity of the lateral collateral ligament (LCL). The LUCL, more recently correctly described (Morrey and An, 1983) is peculiar both in character and in function. It is a thickened band in contrast to earlier reports (Mbaka and Ejiwunmi, 1998). It has enormous load-bearing capacity and it is less elastic than the radial collateral ligament. It is as tough as the medial collateral ligament thus, accounting for great strength in providing support at the lateral aspect. It is a powerful stabilizer of the elbow joint laterally both with respect to valgus and varus stresses particularly with the latter where it maintains tension throughout the total arc of elbow flexion. Thus the LUCL is indispensable in resisting posterio-lateral displacement that is a common site of elbow joint dislocation.

Stress and strain in LCL complex occur in routine activities particularly in people subject to repeated pronation and supination of the upper limbs such as carpenters and secretaries (Gardner, 1970). We observed that RCL more readily absorbs stress and strain. This ligament is inherently more flexible coupled with greater degree of movement due to its insertion at the annular ligament. On the other hand, LUCL is more prone to stress and stain-an inflexible ligament that attaches from bone to bone. This is invariably due to constant pressure exerted on the ligament in all arc of movements. In sporting activities involving sudden swing of the upper extremities as in bowling, golfing, lawn tennis it seems most susceptible to damage. Thus, 'tennis elbow' which is the most common lesion of elbow joint is intimately linked to LUCL (Gardner, 1970). The diagnosis of this ailment is relatively simple. Rotational laxity of ulnar increases following damage or weakening to LUCL at its posterior part. The lesion also involves lateral subluxation of the radial head and posterior lateral rotatory displacement (O'Driscoll et al, 1990).

Even though we have used less sophisticated method, we have been able to qualitatively estimate the impact of stress and strain on the ligaments and then confirm previous biomechanical and clinical investigations. Besides, this study has equally established the behaviour of these ligaments in pronated position. Further studies of sports injuries will greatly enhance the mechanism of action of these ligaments and their role in the surgical management of elbow injuries as these ligaments have recently been used as a guide in internal fixation of displaced radial head fracture (Morgan, 2001).

However, this study is not conclusive. Further investigations will be carried out in a fresh body to compare the behaviour of these ligaments with those in embalmed cadavers.

REFERENCES

- An K N, Morrey B F. 1985 Biomechanics of the Elbow in Morrey B F, (ed): The Elbow, Philadelphia. W. B. Saunders, 43–62.

- Gardner R C (1970). Tennis Elbow: Diagnosis, Pathology and Treatment. Nine Severe Cases Treated by a New Reconstructive Operation. *Clin. Othop. And Rel. Res.* **762:** 248–253.

- Grant J C B 1972 Atlas of Anatomy. Baltimore, Williams and Wilkins Co., 49–57.

- Hassman G C, Brunn F, Neer C S (1975). Recurrent Dislocation of the Elbow. *J. Bone Joint Surg.* 57A: 1080–1084.

- Hotchkiss R N, Weiland A J (1987). Valgus Stability of the Elbow. *J. Orthop. Res.* **5:** 372–377.

- Langman J, Woerdemen M W 1978 Atlas of Medical Anatomy. Philadelphia, W. B. Saunders Co.

- Linscheid R L, Wheeler D K (1965). Elbow Dislocation. *JAMA.* **194:** 1171–1176.

- Martin B F (1958). The Annular Ligament of Superior Radio-Ulnar Joint. *J. Anat.* **92:** 473–481.

- Mbaka G O, Ejiwunmi A B (1998). The Anatomy of the Lateral Ulnar Collateral Ligament in Nigerians. *The Nigerian Postgrad. Med J.* **3:** 111–114.

- Morgan W J (2001). Fractures of the Radial Head. *J of Amer. Soc. for Surg. of the Hand* 1: 225–235.

- Morrey B F, An K N (1976). Functional Anatomy of the Ligament of Elbow. *Clin. Orthop.* **201:** 84.

- Morrey B F, An K N (1983). Articular and Ligamentous Contributions to the Stability of the Elbow Joint. *Am. J. Sports Med.* **11:** 315–319.

- Netter. F. 1987 Musculoskeletal System Part 1; Anatomy, Physiology and Metabolic Disorders. The Ciba Collection of Medical Illustrations. New Jersey, Ciba-Geigy Corporation, 43.

- Neviaser J S, Wickstrom J K (1977). Dislocation of the Elbow. A Retrospective Study of 115 Patients. *South Med.* J. **70:** 172–173.

- Norwood L A, Shook J A, Andrews J R (1981). Acute Medial Elbow Ruptures. *Am. J. Sports Med.* **9:** 16–19.

- O' Driscoll S W, Horri E, Morrey B F, CarMichael S W (1990) The Anatomy of the Lateral Ulnar Collateral Ligament (LUCL) of the Elbow. *Athroscopy,* **6:** 100–103.

- Regan W D, Kofinek S L, Morrey B F, An K N (1991). Biomechanical Study of Ligaments around the Elbow Joint. *Clin. Orth. and Related Res.* **271:** 170–179.

- Schwab G H, Bennett J B, Woods G W, et al (1980). Biomechanics of Elbow Instability. The role of the Medial Collateral Ligament. *Clin. Orthop.* **146:** 42–52.

- Spalteholz W. 1923 Hand Atlas of Human Anatomy (Translated by L. F. Baker) Philadelphia J. B. Lippincott.