THE CUBITAL TUNNEL AND ULNAR NEUROPATHY

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The anatomy of the cubital tunnel and its relationship to ulnar nerve compression is not well documented. In 27 cadaver elbows the proximal edge of the roof of the cubital tunnel was formed by a fibrous band that we call the cubital tunnel retinaculum (CTR). The band is about 4 mm wide, extending from the medial epicondyle to the olecranon, and perpendicular to the flexor carpi ulnaris aponeurosis.

Variations in the CTR were classified into four types. In type 0 (n = 1) the CTR was absent. In type Ia (n = 17), the retinaculum was lax in extension and taut in full flexion. In type Ib (n = 6) it was tight in positions short of full flexion (90° to 120°). In type II (n = 3) it was replaced by a muscle, the anconeus epitrochlearis.

The CTR appears to be a remnant of the anconeus epitrochlearis muscle and its function is to hold the ulnar nerve in position. Variations in the anatomy of the CTR may explain certain types of ulnar neuropathy. Its absence (type 0 CTR) permits ulnar nerve displacement. Type Ia is normal and does not cause ulnar neuropathy. Type Ib can cause dynamic nerve compression with elbow flexion. Type II may be associated with static compression due to the bulk of the anconeus epitrochlearis muscle.

Previous descriptions of the normal and pathological anatomy of the cubital tunnel are somewhat confusing. Even less clear is the relationship between the anatomy of this structure and the causes of ulnar neuropathy. For example, the ulnar nerve has been thought to be compressed by the aponeurosis between the two heads of the flexor carpi ulnaris (Feindel and Stratford 1958; Vanderpool et al 1968; Adelaar, Foster and McDowell 1984), by the arcuate ligament (Wadsworth 1977; Froimson and Zahrawi 1980; Kleinman and Bishop 1989) or by the band described by Osborne (1957) (MacNicol 1979, 1982; Dellon 1986). Others have regarded Osborne's band as the same structure as the arcuate and triangular ligaments (Wadsworth 1977; Adelaar et al 1984). It is unclear what the relationship is between these structures and the anconeus epitrochlearis muscle, which has also been reported to cause ulnar nerve

compression (Vanderpool et al 1968; Wadsworth 1977; Chalmers 1978; Hirasawa, Sawamura and Sakakida 1979; Gessini et al 1981; Mabin et al 1983; Dahners and Wood 1984; Masear, Hill and Cohen 1988).

Dynamic compression of the nerve is said to occur when the elbow is flexed due to the reduction in volume of the cubital tunnel (Feindel and Stratford 1958; Apfelberg and Larson 1973; Wadsworth 1977) but this observation does not explain why some people suffer from ulnar compression and others do not. Nerve compression during elbow flexion has also been attributed to bulging of the medial collateral ligament in the floor of the cubital tunnel (Feindel and Stratford 1958; Vanderpool et al 1968; Wadsworth 1977; Froimson and Zahrawi 1980; Balagtas-Balmaseda et al 1983) but this seems unlikely since both the anterior and posterior components of this ligament tighten during flexion (Morrey and An 1985).

There has been no precise description of the anatomical structures which are released during ulnar nerve decompression.

We have studied the anatomy of the cubital tunnel and its relationship to ulnar neuritis.

MATERIALS AND METHODS

We used 29 fresh-frozen elbows from 25 cadavers. Twenty-seven elbows (from 23 cadavers) were thawed and dissected to reveal the anatomy of the cubital tunnel and the medial collateral ligament. Two elbows from two

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Fig. 1

Fig. 2

The proximal edge of the roof of the cubital tunnel is formed by a retinaculum that originates on the medial epicondyle and inserts on the olecranon. It is distinct from the aponeurosis of the flexor carpi ulnaris muscle (FCU) with which its distal margin blends. The anatomical variations of the cubital tunnel were classified into four types according to their potential for causing ulnar neuropathy.

Fig. 3

Type 0. The cubital tunnel retinaculum is absent. There is no structure bridging the gap between the medial epicondyle (ME) and the olecranon (OI) and the ulnar nerve dislocates in flexion.

cadavers were cut into thin sections while still frozen to provide a different perspective of the anatomy.

OBSERVATIONS

The cubital tunnel retinaculum and the roof of the cubital tunnel. There was a retinaculum at the proximal end of the roof of the cubital tunnel in all but four of our specimens. A retinaculum is a fibrous band attached to bone at each end. Its purpose is to retain the structures beneath it. It was about 4 mm wide, and extended from the medial epicondyle to the tip of the olecranon. Its fibres were oriented transversely, perpendicular to those of the flexor carpi ulnaris aponeurosis which blended with its distal margin (Fig. 1). With the elbow flexed, its proximal edge can be palpated distinct from the deep fascia with which it is continuous. With the elbow in extension the retinaculum is lax.

Distally, the deep forearm fascia invests the flexor carpi ulnaris in two layers, the deeper layer continuing distally for about 3 cm at which point the cubital tunnel ends. The flexor carpi ulnaris takes origin from these

fasciae and a few fibres also arise from the cubital tunnel retinaculum.

Classification of variations. The various forms of the CTR have been classified into four categories (Fig. 2). In type 0 ($n = 1$) the cubital tunnel retinaculum was absent and the ulnar nerve was dislocated (Fig. 3). In type Ia ($n = 17$) the 'normal' retinaculum was thin and became taut in full flexion but did not compress the nerve. In type Ib ($n = 6$) it was pathologically thick, and became taut between 90° and 120° of flexion. This type was associated with obvious evidence of chronic nerve compression (indentation with proximal swelling of the nerve) (Figs 4 and 5). In type 2 ($n = 3$) the retinaculum was replaced by a muscle, the anconeus epitrochlearis (Fig. 6).

Of the four pairs of elbows from the same cadavers, one pair included a type Ib and a type II retinaculum, one showed a type II and a type Ia, and the other two pairs were both type Ia. There was therefore no constant relationship between the right and left sides.

The floor of the cubital tunnel. The floor of the cubital tunnel is formed by the capsule of the elbow and the posterior and transverse parts of the medial collateral

Fig. 4a

Fig. 4b

Type Ib. The cubital tunnel retinaculum is lax in extension (a) but tight in flexion, (b) causing ulnar nerve compression (arrow).

Fig. 5a

Fig. 5b

Type Ib. Tunnel views of the specimen in Figure 4. In extension, the CTR is lax (a) and the volume of the cubital tunnel is adequate. With elbow flexion, the CTR is tightened (b), compressing the nerve.

ligament. The nerve lies posterior and almost parallel with the anterior medial collateral ligament (Fig. 7). None of the ulnar nerves crossed this ligament and in no case was nerve compression caused by bunching of the ligament.

Clinical correlation. Each of the variants has been correlated with cases of clinical disease. We observed absence of the cubital tunnel retinaculum (type 0) in one patient operated on for a dislocating ulnar nerve and friction neuritis. We regard type Ia as normal. This has been confirmed during anterior transposition of the ulnar nerve, which is performed routinely during total elbow replacement in patients who have not had symptoms of ulnar neuropathy. Type Ib, a tight CTR in a position short of full flexion has been seen frequently in patients with ulnar neuropathy treated successfully by decompression and nerve transposition. Finally, compression due to the presence of an anconeus epitrochlearis muscle has been reported in the literature (Vanderpool et al 1968; Wadsworth 1977; Chalmers 1978; Hirasawa et al 1979; Gessini et al 1981; Mabin et al 1983; Dahners and Wood 1984; Masear et al 1988). The aetiology of the nerve compression is confirmed by the fact that excision of the muscle resulted in relief of symptoms.

DISCUSSION

The cubital tunnel retinaculum. Von Clemens (1957) observed a fibrous structure analogous to what we call the CTR in 70 of 100 specimens examined. Several authors have attributed to Testut the conclusion that it is a fibrous analogue of the anconeus epitrochlearis muscle (Von Clemens 1957; Wachsmuth and Wilhelm 1968; Gessini et al 1981; Mabin et al 1983; Masear et al 1988). Osborne (1957) described this anatomical structure as the lesion responsible for ulnar nerve compression, and it is often referred to as the Osborne band. Dellon (1986) noted that the band was present in almost all cases of ulnar nerve compression treated surgically and in 77% of cadaver elbows. We propose the term cubital tunnel retinaculum since this structure is indeed a retinaculum, originating and inserting on bone and retaining the underlying ulnar nerve. The cubital tunnel is thus roofed by the retinaculum and the deep layer of the aponeurosis of the flexor carpi ulnaris. The CTR is anatomically and functionally discrete from that aponeurosis (Wachsmuth and Wilhelm 1968).

The anconeus epitrochlearis muscle. The anconeus epitrochlearis muscle is present in 3% to 28% of cadaver elbows (Von Clemens 1957; Wachsmuth and Wilhelm 1968; Dellon 1986). It has been described as the cause of unilateral or bilateral ulnar neuritis in several case reports (Vanderpool et al 1968; Wadsworth 1977; Chalmers 1978; Hirasawa et al 1979; Gessini et al 1981; Mabin et al 1983; Dahners and Wood 1984; Masear et al 1988), and has been found in up to 9% of cases of ulnar neuritis treated by surgical decompression (MacNicol 1979).

Fig. 6

Type II. Rather than a fibrous band, a muscle – the anconeus epitrochlearis – is present.

Fig. 7

The ulnar nerve lies posterior to the anterior medial collateral ligament (AMCL) throughout the cubital tunnel. The floor of the tunnel is formed only by the posterior and transverse components of the medial collateral ligament and joint capsule (not shown).

Static compression due to muscle bulk is the suggested cause of the neuritis (Hirasawa et al 1979).

The function of the anconeus epitrochlearis is uncertain. It is probably atavistic in humans, but may be an elbow adductor in other primates (Von Clemens 1957; Wachsmuth and Wilhelm 1968). The suggestion has been made that it is part of the triceps (Sucher and Herness 1986) and may contribute to elbow extension (Wachsmuth and Wilhelm 1968). Others have disputed this suggestion on the basis that it is innervated by a branch of the ulnar nerve (Von Clemens 1957; Hirasawa et al 1979; Dellon 1986; Masear et al 1988). Our observations that the muscle shortens during elbow extension suggests that it may be an accessory to the medial head of the triceps; the medial head receives its innervation from a branch of the radial nerve that courses with the ulnar nerve. This would explain why the nerve to the anconeus epitrochlearis also comes from the ulnar nerve.

Ulnar nerve dislocation. Ulnar nerve dislocation or

subluxation has been reported in as many as 16% of the general population and in 28% of cadavers (Childress 1975; Dellon 1986; Masear et al 1988). It has been attributed to laxity of the supporting structures, but without specifying which structures are lax (Childress 1975; Wadsworth 1977; Chalmers 1978; Dellon 1986).

The CTR constrains the ulnar nerve from dislocating and its absence is associated with ulnar nerve dislocation. This is consistent with the fact that excision of the anconeus epitrochlearis muscle was complicated by ulnar nerve dislocation in seven of eight patients reported by Chalmers (1978).

Capacity of the cubital tunnel. The distance between the origin and the insertion of the CTR decreases with flexion, resulting in tightening of the band (Osborne 1957; Von Clemens 1957; Vanderpool et al 1968; Froimson and Zahrawi 1980) and a decrease in the capacity of the cubital tunnel (Apfelberg and Larson 1973; Adelaar et al 1984).

Bulging of the medial collateral ligament in the floor of the tunnel has been proposed as a cause of nerve compression (Feindel and Stratford 1958; Vanderpool et al 1968; Wadsworth 1977; Froimson and Zahrawi 1980), but this was not seen in the present study. Morrey and An (1985) found that the MCL tightened with elbow flexion, so it is unlikely that it would bulge into the floor of the cubital tunnel. However, we did observe that the groove on the inferior surface of the medial epicondyle is not as deep as the groove on its posterior surface and that

the floor of the tunnel therefore appears to 'rise' with elbow flexion.

Other causes of decreased capacity of the cubital tunnel, such as space occupying lesions, are known to occur but are not relevant to this discussion.

CTR classification and clinical significance. The classification of the CTR into four types has clinical relevance. Absence of the structure (type 0) permits ulnar nerve dislocation, and may lead to friction neuritis. Type I, the most common, is subdivided into two groups. In type Ia a normal or underdeveloped CTR is present and does not cause symptoms. In type Ib the CTR is tight in flexion and can cause dynamic nerve compression. Type II may cause static compression due to the bulk of the anconeus epitrochlearis muscle.

Conclusions

- 1) The roof of the cubital tunnel is formed by the cubital tunnel retinaculum and the flexor carpi ulnaris aponeurosis.
- 2) The retinaculum is a remnant of the anconeus epitrochlearis muscle.
- 3) It constrains the ulnar nerve, preventing its dislocation.
- 4) Its anatomical variations can be classified into four types which explain some cases of ulnar neuritis.

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