DYNAMIC ANATOMY OF THE ULNAR NERVE AT THE ELBOW

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Neuropathy of the ulnar nerve at the elbow may result in severe impairment of hand function secondary to pain, paresthesia, and loss of motor function. Various etiologies have been demonstrated in the pathogenesis of ulnar nerve lesions at the elbow. Yet, despite widespread interest in and study of this lesion, there are still some patients in whom the etiology is uncertain. Most of the large series of ulnar nerve lesions at the elbow contain a 10–30 percent “idiopathic” group.

In this paper we will review the known specific causes for ulnar nerve lesions at the elbow and discuss the pathogenesis of this lesion. In addition, we have studied in detail the normal elbow anatomy in 15 cadavers, with special reference to the changes which occur during elbow flexion and extension. We hope a description of the “dynamic” anatomy in these normal elbows will stimulate surgeons who frequently operate on the ulnar nerve at the elbow to study more closely their patients with neuropathy. Perhaps a thorough knowledge of the normal “dynamic” anatomy will allow alert surgeons to pinpoint specific alterations in the elbow anatomy and to reduce this large group of “idiopathic” lesions.

TOPICAL AND INTRANEURAL ANATOMY

The ulnar nerve arises from the eighth cervical and first thoracic nerve roots and becomes the main continuation of the medial cord of the brachial plexus (Fig. 1). The nerve courses along the medial head of the triceps in the upper arm, behind the medial intramuscular septum. At the elbow, it passes anteriorly to lie in the postcondylar groove behind the medial epicondyde of the humerus.

Distally, the nerve passes through the cubital tunnel which is a fibro-osseous canal (the floor of the canal is made up of the olecranon and elbow joint laterally, and the medial epicondyde and medial collateral ligament medially). The roof of this tunnel is formed by a fascial band which extends from the olecranon to the medial epicondyde and overlies the two heads of the flexor carpi ulnaris. The nerve then runs along the flexor digitorum profundus in the forearm and surfaces near the pisiform at the wrist to divide into a deep and superficial division.

The ulnar nerve has no branches in the upper arm. At the elbow, it gives off muscular branches to the flexor carpi ulnaris and to the lateral aspect of the flexor digitorum profundus. In the hand, it supplies the hypothenar muscles, the interossei, the 3rd and 4th lumbricals, and the adductor pollicis. Sensory branches include the palmar and dorsal cutaneous nerves which supply sensation to the small finger and the ulnar half of the ring finger.

Sunderland1 has studied the intraneural topography of the ulnar nerve at various levels in the arm. In tracing the funicular pattern of the nerve he observed that, at the medial epicondyde, the motor branches to the intrinsic muscles of the hand and the sensory fibers to the hand are superficial, while the motor fibers to the flexor carpi ulnaris...
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nd flexor digitorum profundus are deep
ase 1). This finding may explain the
loss of motor and sensory function in the hand, sparing the forearm muscles,
which frequently occur during superficial compression of the ulnar nerve at the
eb. Sunderland has also observed
the ulnar nerve in the region of the
epicondyle has the largest percentage of funicular area and the least
compactive tissue. This factor favors better regeneration after a nerve suture.

ETIOLOGY OF ULNAR NEUROPATHIES

Table 1 summarizes the etiology of ulnar neuropathies at the elbow. The
test-known and most-studied ulnar nerve lesions are those which accompany
fractures of the lower end of the humerus; 1 of these developed latent or "tardy" ulnar nerve lesions
during a 20-year period of observation. Platt, in 1926, pointed out that fractures
of the medial epicondyle could result in a primary ulnar nerve lesion from con-
sion and scarring of the nerve or from manipulation of the elbow, and that
supracondylar or lateral epicondylar fractures result in friction neuritis of the
erve after a latent period (frequently longer than 10 years). Outward
of dislocation, with valgus deformity, produces traction in the ulnar nerve;
post-traumatic arthritis may also affect the nerve.

Wolffman, in 1930, described a series
of ulnar neuropathy patients who de-
veloped ulnar nerve lesions as a result of
pression of the ulnar nerve against the
epicondyle as they attempted to prop themselves up in bed. Compression
neuropathy of the ulnar nerve after general anesthesia (as a result of inade-
quate protection of the elbow during surgery) is well known. Vanderpool et al and Barber et al have described patients
with ulnar neuropathy at the elbow secondary to ganglia and other benign
soft tissue tumors. Occupational trauma, congenital anomalies, foreign bodies,
and lacerations about the elbow have also been described as causes. Nutritional
and metabolic neuropathies may affect the ulnar nerve.

Recurrent or habitual subluxation of the ulnar nerve may result in friction
neuritis as the nerve is displaced across the bony epicondyle during flexion.
Various authors have attributed this subluxation to a congenital posterior
position of the medial epicondyle, dislocation secondary to direct trauma,

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lax ligaments, or to a short medial epicondyle. Childress studied 2000 ulnar nerves in 1000 normal persons and found an incidence of dislocation of 16.2 percent, frequently bilateral. He concluded that a congenital "loose anchorage" of the nerve was responsible—that the subluxed position of the nerve across the epicondyle rendered it more vulnerable to traumatic injury.

Osborne, in 1957, called attention to a band of fibrous tissue bridging the two heads of the flexor carpi ulnaris and compressing the ulnar nerve in the "cubital tunnel." He reported that division of this band relieved the ulnar nerve symptoms in 13 cases of tardy ulnar palsy. Feindel and Stratford observed a narrowing of the cubital tunnel in flexion, secondary to an elevation of the floor and a tightness of the roof. Vanderpool et al. dissected 18 cadavers and observed that the aponeurotic fascial roof of the cubital tunnel stretched 5 mm for each 45° of elbow flexion. They reported 40 cases of ulnar nerve compression at the elbow, 15 of which were found to have cubital tunnel compression secondary to post-traumatic arthritis. Ho and Mar- mor have similarly described a tight fascial band from the olecranon to the medial epicondyle which compressed the ulnar nerve.

DYNAMIC ELBOW ANATOMY

We dissected 15 ulnar nerves in 3 adult male and 6 adult female cadaver elbows, ranging in age from 26 to 83 years. None of these cadavers had had a clinical history or anatomical evidence of ulnar nerve neuropathy. There was no instance of a subluxing ulnar nerve. All elbows were within the anatomical limits of normal cubital angles (5° to 30° valgus position). Passive elbow flexion of 25° to 50° and extension of 155° to 180° could be obtained, indicating a full range of motion in each.

Olecranon-epicondyle relationships were then measured. The medial epicondyle to olecranon distance was almost invariably increased by one cm during flexion, as these two bony landmarks became more widely separated. This finding agreed with those in Vanderpool's elbow dissections, where he observed a 5 mm increase in length for each 45° of elbow flexion.

The medial intramuscular septum was remarkably constant in each specimen, averaging 1.14 cm in depth. Similarly, the medial epicondyle width varied little among specimens and averaged 1.1 cm. The nerve mesentery above the elbow allowed a 1 cm excursion, and below the elbow a 0.6 cm excursion (Fig.

![Fig. 2. (left) The nerve mesentery allows 1 cm excursion above the elbow, and (right) 6 mm excursion below the elbow.](image)
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..ed 15 ulnar nerves in 6 adult female cadavers in age from 26 to 80. of these cadavers had had from or anatomical evidence of nerve neuropathy. There was of a subluxing ulnar nerve within the anatomical cubital angles (5° to 30°). Passive elbow flexion to and extension of 155° to 180° was observed, indicating a full range of motion.

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The space in the cubital tunnel and condylar groove was evaluated by two methods.

1. Soft, moist medical grade acrylic was inserted into the canal during flexion and extension and allowed to harden into a mold of the nerve groove. The results were quite dramatic.

2. Molds of the condylar groove during extension showed a smooth, rounded, spacious canal. Molds of the condylar groove demonstrated a flattened triangle or ellipse shape (with an average height of 7.2 mm). The nerve became a flattened triangle or ellipse shape (with an average height of 5.8 mm). The nerve became a flattened triangle or ellipse shape (with an average height of 3.2 mm).

Bake's dilators were gently placed in the canal during flexion and extension before the nerve was exposed (Fig. 5). It was found that a 3 mm dilator would easily enter the canal during extension while only a 3 mm dilator could be placed during flexion. Thus, the differences in the nerve molds and the disparity in Bake's dilators indicated that the condylar canal is approximately 2.5 mm smaller during flexion.

Nerve diameters averaged 4.7 mm above, 5.4 mm in the condylar canal, and 4.7 mm below the elbow, illustrating the flattening of the nerve within the postcondylar groove.

The results of these studies allow a descriptive representation of the changes in elbow anatomy which affect the nerve during elbow flexion (Fig. 6).

1. The postcondylar groove is narrowed and flattened during flexion by the stretch of the fibrous band running from the olecranon to the medial epicondyle and bridging the roof of the cubital tunnel and the postcondylar groove.

2. At the same time, the nerve is gently stretched above and below the postcondylar groove.

3. The medial head of the triceps pushes the nerve upward and medially and appears to impact it in the angle formed by the medial intramuscular septum and the fibrous band inserting on the medial epicondyle.

4. The cubital tunnel and the postcondylar groove are thus narrowed during flexion, compressing the nerve against unyielding fibro-osseous structures.

5. A similar mechanism may force the nerve to subluxate out of the postcondylar groove across the epicondyle, if it is not firmly held in place.

SUMMARY

The topical and intraneural anatomy of the ulnar nerve at the elbow is re-
viewed. Known theories of the pathogenesis of ulnar neuropathy include bony fractures and separations such as tardy.

**Fig. 4.** (above) Moist acrylic is injected into the postcondylar groove. (center) The aponeurotic roof of the postcondylar groove has been incised, showing the mold in place. (below) Molds of the canal made in extension are smooth and round, in flexion they are curved and flattened.

**Fig. 5.** (left) A 5 mm Bake’s dilator may be inserted into the postcondylar groove during extension, but (right) a 3 mm dilator is the largest that may be inserted during flexion.

**Fig. 6.** Composite schematic representation of the dynamic elbow anatomy. This figure shows stretch and compression of the nerve, and the change in the postcondylar groove during flexion and extension.

ulnar palsy, congenital anomalies, trauma, tumors, habitual subluxation of the ulnar nerve, and cubital tunnel compression.

Dissection of 15 cadaver elbows indicated that the nerve is compressed, stretched, and impacted against unyielding structures during elbow flexion. Measurements of the changing anatomy of the elbow during flexion has allowed...
Descriptive model of the dynamic forces on the ulnar nerve.

We hope a thorough knowledge of the emerging normal anatomy of the elbow and its influence on the ulnar nerve will educate surgeons working in this area to be more observant of deviations in anatomy. In this manner, the large group of idiopathic ulnar nerve lesions of the elbow may ultimately be investigated and successfully treated.

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REFERENCES


diagram depicting the ulnar groove during flexion.