Effect of Anterior Versus Posterior in situ Decompression on Ulnar Nerve Subluxation

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Abstract

We sought to determine the effect anterior versus posterior in situ decompression with 360° external neurolysis on ulnar nerve subluxation.

Ten cadaveric specimens were used, with anterior release performed on 5 specimens and posterior release the other 5 specimens. Each specimen was released for 4 cm centered over the cubital tunnel followed by 12 cm, 20 cm, and 20 cm with 360° external neurolysis. After release, the elbow was brought through a range of motion from 0° to 140° of flexion.

Compared with posterior release, anterior release demonstrated significantly more total subluxation of the ulnar nerve for all release types from 80° to 120° of flexion ($P<.05$). At 140° of flexion, the 4-cm release, the 12-cm release, and the 20-cm release with 360° external neurolysis also demonstrated significantly more total subluxation with anterior release ($P<.05$).

Ulnar nerve subluxation was significantly lower with posterior release, compared with anterior release for limited and complete in situ decompression.

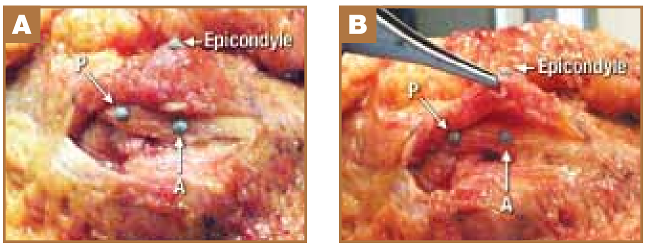
Compression of the ulnar nerve at the medial elbow is the second most common compressive neuropathy. The most commonly used surgical treatments for this condition include in situ decompression and complete release with anterior transposition of the nerve. In situ decompression of the ulnar nerve at the elbow has been shown to provide adequate resolution of symptoms related to ulnar nerve compression[1-6] and has demonstrated equivalent outcomes to both subcutaneous and submuscular transposition in several recent prospective randomized controlled studies.[7-10] However, there is much variability in the surgical technique that is used for in situ decompression.

In situ decompression of the ulnar nerve was first described by Osborne[11] in 1957. The original procedure involved dividing the fibrous band of tissue bridging the 2 heads of the flexor carpi ulnaris (FCU) through its attachments to the medial epicondyle and the olecranon.[11] Currently, in situ decompression is being performed with several variations in both total length of the decompressed nerve and amount of nerve that is freed circumferentially.[8-10,12-14] The precise effects of these variations on the incidence and degree of ulnar nerve subluxation after in situ decompression are not known. The effect of anterior versus posterior release of the soft tissues on ulnar nerve subluxation has also not yet been explored.

Previous studies, both in vivo and in cadaveric models, have examined intraneural and extraneural pressures and strain of the ulnar nerve at the elbow.[15-19] However, no studies have specifically examined the movement of the ulnar nerve in relation to the medial epicondyle. As subluxation of the ulnar nerve has been implicated as a cause of ulnar nerve symptoms and as a reason for unsuccessful surgical intervention, we wanted to better understand this phenomenon and any surgical techniques that could reduce the incidence and degree of ulnar nerve subluxation.

We conducted a study to determine the effects of 3 factors on ulnar nerve subluxation during in situ decompression: (1) anterior versus posterior release, (2) limited release (4 cm centered over cubital tunnel) versus complete release (20 cm total, from arcade of Struthers through FCU fascia), and (3) complete release by simple unroofing versus complete release

Figure 1. Anterior release (A) and posterior release (B) marker placement (A, marker at midpoint of ulnar nerve within cubital tunnel; P, proximal ulnar nerve marker).



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with 360° external neurolysis. Another major goal was to objectively characterize the movement of the ulnar nerve when it subluxates.

Materials and Methods

Five matched pairs of fresh-frozen cadaveric upper extremities (10 arms total) were used. The extremities were disarticulated at the level of the glenohumeral joint to maintain resting tension of the ulnar nerve proximally. No subluxation occurred in the cadaver during range of motion before ulnar nerve release. The skin incision used for all specimens was made midway between the medial epicondyle and the olecranon and was extended 10 cm proximally and distally. In 5 specimens, anterior release was performed on the ulnar nerve; the soft tissues were taken directly off the medial epicondyle in the region of the cubital tunnel. In the other 5 specimens, posterior release was performed; the soft tissues were taken directly off the olecranon. For the anterior release, the Osborne ligament was incised at its anterior attachment; for the posterior release, this ligament was taken down at the posterior attachment.

Retroreflective markers were placed on the apex of the medial epicondyle, at the midpoint of the ulnar nerve within the cubital tunnel, and at 1 point proximally along the nerve in order to record the motion of the nerve relative to the medial epicondyle (**Figures 1A, 1B**). Three-dimensional motion was captured using a kinematic analysis system (SMART Motion Capture System; eMotion, Padua, Italy). The specimens were stabilized with Steinmann pins through the humerus with the humerus positioned parallel to the ground and the anterior surface of the arm facing upward. The distal radioulnar joint was pinned in a neutral position to prevent pronation/supination of the forearm during testing.

The midpoint of the cubital tunnel was determined by placing the arm into extension and drawing a line from the apex of the medial epicondyle to the olecranon. Each specimen was initially released a length of 4 cm centered over the cubital tunnel, and then 12 cm and 20 cm. After the 20-cm release, 360° external neurolysis was performed. After each release and after the 360° external neurolysis, the elbow was taken through full range of motion, 0° to 140°. Anterior and medial ulnar nerve subluxation was recorded in millimeters at 20° intervals of flexion.

Figure 2A depicts the overall motion of the ulnar nerve during subluxation. The amount of subluxation occurring was described and quantified by dividing the nerve motion into medial subluxation and anterior subluxation. Medial subluxation of the nerve was measured as the amount of lateral-to-medial movement of the nerve along the motion vector X, or the x-axis (**Figure 2B**), and anterior subluxation was measured as the amount of the movement of the nerve toward the apex of the medial epicondyle along the motion vector Y, or the y-axis (**Figure 2C**). The x-axis and y-axis are perpendicular to each other in the anteroposterior plane. Total subluxation was determined by taking the square root of $[(\text{medial subluxation})^2 + (\text{anterior subluxation})^2]$ (**Figure 2D**). Statistical analysis was performed using a one-tailed Student t test.

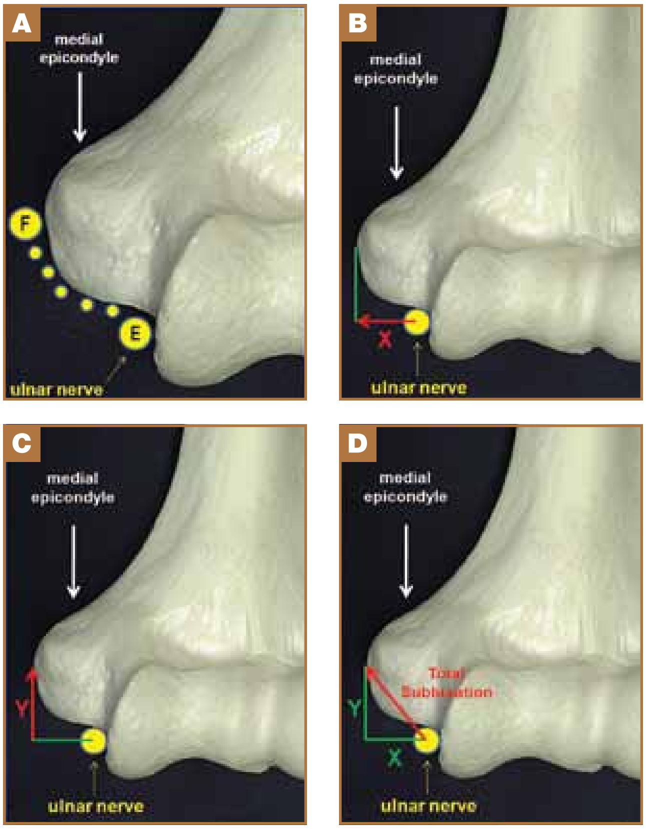

Figure 2. (A) Motion of ulnar nerve as elbow is ranged from full extension to full flexion (E, position of nerve during full extension; F, position of nerve during full flexion). (B) Motion vector X, or x-axis, for measurement of medial subluxation of ulnar nerve (red arrow, path of motion). (C) Motion vector Y, or y-axis, for measurement of anterior subluxation of ulnar nerve. Path of motion is represented by red arrow. (D) Motion vector for total subluxation experienced by ulnar nerve (red arrow, path of motion).

Results

Compared with posterior release, anterior release demonstrated significantly more anterior subluxation of the ulnar nerve for the 20-cm release from 60° to 120° of flexion ($P<.05$), with a mean difference of 40% (4 mm of motion) between the anterior and posterior releases at each 20° increment of flexion. There was also more anterior subluxation for the 20-cm release with 360° external neurolysis from 60° to 140° of flexion ($P<.05$), with a mean difference of 50% (5 mm of motion) between the anterior and posterior releases at each 20° increment of flexion. There was no statistically significant difference in medial subluxation between the anterior and posterior groups for any of the releases performed (**Figures 3A, 3B**).

Compared with posterior release, anterior release demonstrated significantly more total subluxation (combined anterior and medial subluxation) of the ulnar nerve for all the release types between 80° and 120° of flexion ($P<.05$) (**Figure 4**). At

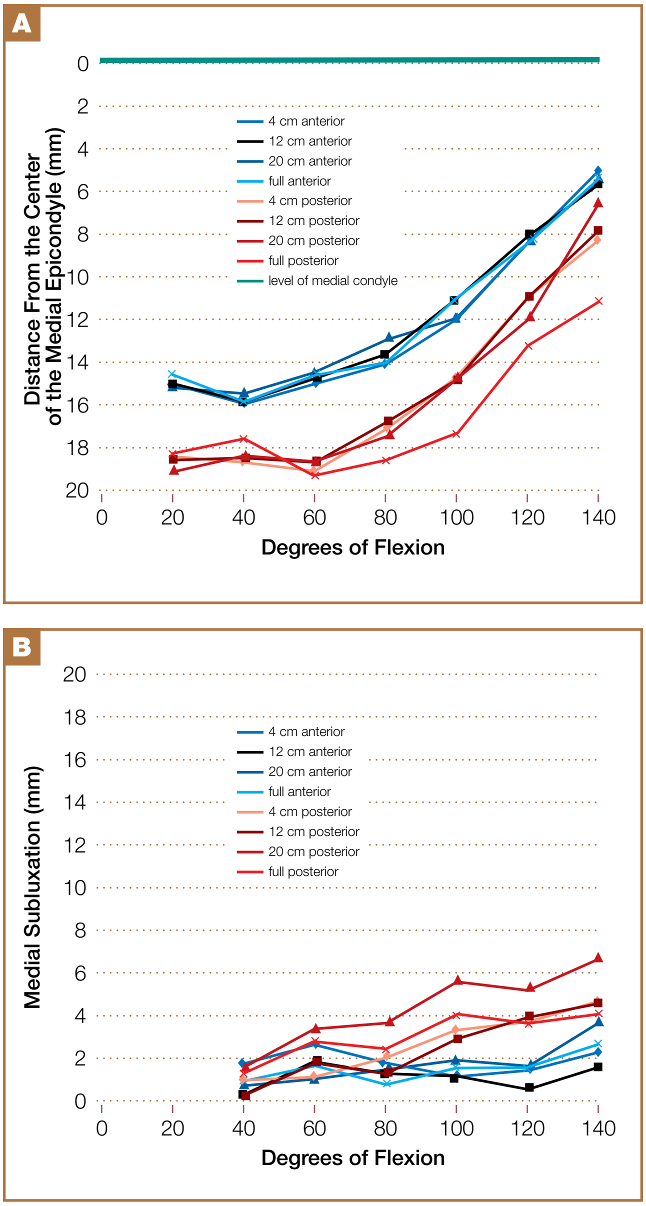

Figure 3. (A) Anterior subluxation of ulnar nerve for anterior release and posterior release at 0° to 140° of flexion for 4-cm, 12-cm, 20-cm (P<.05), and 20-cm with 360° external neurolysis releases (P<0.5). (B) Medial subluxation for anterior release and posterior release at 0° to 140° of flexion for 4-cm release, 12-cm release, 20-cm release, and 20-cm release with 360° external neurolysis (P<0.5).

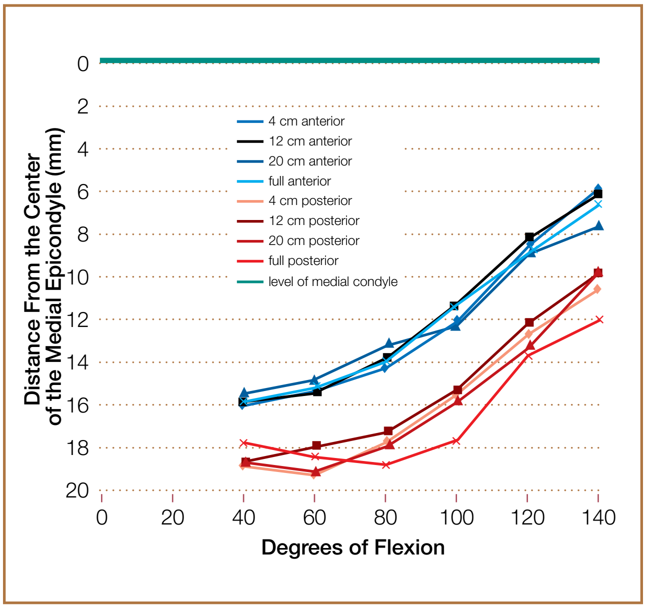

Figure 4. Total subluxation, combined anterior and medial subluxation, of ulnar nerve for anterior release and posterior release at 0° to 140° of flexion for 4-cm (P<.05), 12-cm (P<.05), 20-cm (P<.05), and 20-cm release with 360° external neurolysis.

140° of flexion, the 4-cm, 12-cm, and 20-cm release with 360° external neurolysis also demonstrated significantly more total subluxation with anterior release (P<.05). At maximal flexion of 140°, anterior release, compared with posterior release, yielded 44% more total subluxation with the 4-cm release (5.9 vs 10.6 mm from apex of medial epicondyle to ulnar nerve), 38% more subluxation with the 12-cm release (6.1 vs 9.8 mm), and 45% more subluxation with the 20-cm release with 360° external neurolysis (6.6 vs 12.0 mm). Although anterior release with the 20-cm release without 360° external neurolysis demonstrated more total subluxation at 140° of flexion, the difference was not statistically significant (**Table**). None of the releases for the anterior or the posterior groups resulted in subluxation of the ulnar nerve anterior to the apex of the medial epicondyle.

Discussion

Surgical treatment for ulnar nerve compression at the medial elbow is most commonly unsuccessful as a result of either inadequate decompression or formation of a new compressive site. Failure has been reported in association with a variety of release types, including in situ decompression with neurolysis, isolated release of the cubital tunnel, and medial epicondylectomy, and in association with submuscular, subcutaneous, and intramuscular transpositions.[20-22] In cases in which no residual or new compression sites are identified, it is possible that the nerve has sustained too much preoperative damage for recovery to occur.

Another potential cause for the persistence of symptoms after adequate decompression is compromise of the blood supply to the ulnar nerve. When anterior transposition of the ulnar nerve is performed, approximately 10 to 15 cm of the nerve must be circumferentially freed and lifted from its native bed.[22] The ulnar collateral arterial branches distal to the medial epicondyle must be ligated in the process. Primate models have demonstrated decreased regional blood flow and relative ischemia of the nerve for 72 hours after subcutaneous transposition.[23] This effect is transient, but there is still cause for concern in patients with either severe ulnar nerve disease or reason for vascular compromise (eg, peripheral vascular disease, diabetes, hyperlipidemia). We found only 1 case report of a patient with immediate postoperative ulnar nerve dysfunction secondary to ischemia caused by anterior transposition.[24] The patient had only mild to moderate ulnar nerve compression before surgery and no significant comorbidities. Although the risk for ulnar nerve devascularization after elimination of its extrinsic blood supply during anterior transposition may be low, it still exists.

In situ decompression involving the full length of the nerve from the arcade of Struthers through the FCU fascia has the dual benefit of eliminating all native sites of compression without disrupting the extrinsic blood supply to the nerve. In addition, using a posterior release to prevent anterior subluxation of the nerve also lessens the chance that iatrogenically created compression sites (eg, medial intermuscular septum, reentry point into forearm fascia) will become a problem.

As cadavers were used in this study, we do not know whether the amount of ulnar nerve subluxation that occurred with each release correlates with actual clinical symptoms in vivo. Establishing a true relationship between subluxation and symptoms involves conducting a prospective randomized trial in vivo; comparison of anterior release and posterior release would be required, along with intraoperative measurement of ulnar nerve subluxation and postoperative examination for symptom relief and any improvements in sensibility and strength. A cadaveric study by Gelberman and colleagues[15] implicated traction or strain on the ulnar nerve as a cause of increased intraneural pressures during flexion, given that direct focal compression within the cubital tunnel was not observed. In a later cadaveric study, Hicks and Toby[16] reported no decrease in the strain of the ulnar nerve after in situ release, which constituted a full release from the arcade of Struthers through the FCU fascia without 360° external neurolysis. A limitation of the present study is that we do not know what effect anterior versus posterior release may have on ulnar nerve strain, as it was not directly measured.

Other studies have demonstrated adequate relief of symptoms following in situ decompression in the treatment of cubital tunnel syndrome.[1-6] The true rate of ulnar nerve subluxation occurring with in situ decompression is unknown. Although reports conflict regarding whether subluxation decreases the efficacy of in situ decompression,[7,21,25] the idea that subluxation might exacerbate ulnar nerve symptoms still prompts some surgeons to convert from in situ decompression to anterior transposition when subluxation is observed during surgery.[14] We hope that the present study, which showed significantly less subluxation with posterior release, will lead to increased use of in situ decompression in the clinical setting. In addition, creating a sling—suturing the soft-tissue flap formed by the posterior release to the underlying subcutaneous tissues in vivo—may further act to prevent anteromedial subluxation of the ulnar nerve during flexion.

The word *subluxation* traditionally has been used in reference to joints. Its definition in terms of the motion of the ulnar nerve relative to the medial epicondyle is not clear. In the present study, we characterized the components of ulnar nerve motion relative to the medial epicondyle and reported this motion as a quantifiable measure. However, because retroreflective markers were placed on the nerve to measure its motion, we were unable to characterize ulnar nerve motion before soft-tissue release. Investigators can better characterize baseline ulnar nerve motion by conducting a follow-up study focusing on the evaluation of ulnar nerve motion at the medial elbow before decompression.

Overall, we found decreased ulnar nerve subluxation with posterior release, compared with anterior release for limited and complete in situ decompression. Therefore, posterior releases may increase the utility of in situ decompression in treating ulnar never compression at the elbow.

Table. Total Distance From Ulnar Nerve to Medial Epicondyle at 140° of Elbow Flexion

	Total Distance, mm			
Release Type	Posterior Release	Anterior Release	% Difference, Anteromedial Subluxation	P
4 cm	10.6	5.9	Anterior 44% > Posterior	<.05
12 cm	9.8	6.1	Anterior 38% > Posterior	<.05
20 cm	9.8	7.6	Anterior 22% > Posterior	.08
20 cm with 360° external neurolysis	12.0	6.6	Anterior 45% > Posterior	<.05

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