Movement of the Ulnar Nerve at the Elbow: A Sonographic Study

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Objectives—The aim of this study was to measure the degree of movement of the ulnar nerve in the cubital tunnel using sonography in patients with ulnar neuropathy at the elbow compared to a healthy control group.

Methods—We examined the ulnar nerve in the cubital tunnel using sonography with the elbow extended and then flexed in 26 patients with ulnar neuropathy and 13 control participants. The distance from the ulnar nerve to the skin, medial epicondyle, and tip of olecranon at the inlet of the cubital tunnel and the distance from the ulnar nerve to the skin and olecranon recess at the outlet of the cubital tunnel were measured when the elbow was extended and flexed, respectively. Displacement of the ulnar nerve during elbow extension and flexion between patients with ulnar neuropathy and controls was compared.

Results—There was significantly greater displacement of the ulnar nerve to the medial epicondyle at the inlet of the cubital tunnel in the patients with ulnar neuropathy (mean ± SD, 4.22 ± 3.79 mm) compared to the controls (1.76 ± 1.51 mm) during elbow extension and flexion ($P = .008$).

Conclusions—A significantly greater degree of movement of the ulnar nerve occurs in patients with ulnar neuropathy at the elbow compared to healthy people, as determined by sonography.

Key Words—cubital tunnel syndrome; elbow; movement; sonography; ulnar nerve; ulnar neuropathies

Ulnar neuropathy at the elbow is the second most common entrapment neuropathy after carpal tunnel syndrome.1–4 Cubital tunnel syndrome is considered the likely cause of a large number of cases of ulnar neuropathy at the elbow. During elbow flexion, the cubital tunnel ligament is tightened and has the potential to compress the ulnar nerve beneath the tunnel. Moreover, the ulnar nerve tends to shift to the anteromedial side and sometimes moves onto the tip of or crosses over the epicondyle as the elbow is flexed.5 Movement of the ulnar nerve after elbow extension and flexion may contribute to friction injury and be a predisposing factor for ulnar neuropathy at the elbow.6,7

High-resolution sonography has been used to assess the degree of nerve enlargement in the evaluation of entrapment neuropathy.8–10 Sonography helps characterize not only the course and size of the nerve but also the degree of movement of the nerve during motion via dynamic observation.11
There are few reports regarding movement of the ulnar nerve in patients with ulnar neuropathy at the elbow, and ulnar nerve movement in the cubital tunnel during elbow flexion and extension in particular has not been well studied. Of the previous studies that have examined ulnar nerve movement, most focused on whether the ulnar nerve was subluxated or dislocated. The objective of this study was to measure the dynamic movement of the ulnar nerve using sonography in patients with ulnar neuropathy at the elbow compared to a healthy control group to further understand the pathophysiologic mechanisms of ulnar nerve injury at the elbow.

Materials and Methods

From April 1, 2008, to December 31, 2011, 26 consecutive patients with ulnar neuropathy at the elbow and 13 healthy control participants were enrolled in our study at the Department of Physical Medicine and Rehabilitation of the Korea University Guro Hospital. Ulnar neuropathy was diagnosed by clinical symptoms (pain at the elbow, numbness, tingling, or hand weakness), physical examination findings (weakness or sensory changes in the ulnar distribution), and electrodiagnostic findings based on criteria developed by the American Association of Electrodiagnostic Medicine.12 The control group did not undergo nerve conduction studies. However, all of the patients with ulnar neuropathy underwent nerve conduction studies, and the diagnosis of ulnar neuropathy was made by those studies. All patients included in the ulnar neuropathy group met these criteria and had a diagnosis of ulnar neuropathy. We excluded patients who had undergone previous ulnar nerve surgery, had direct elbow trauma, or had other peripheral neuropathy. The control group had no history of peripheral neuropathy or symptoms of numbness, pain, or weakness in any extremity. This study was approved by the Institutional Review Board of the Korea University Guro Hospital, and written informed consent was obtained from all participants.

The examinations were performed by a board-certified physiatrist with 10 years of experience with sonography. Sonographic analyses were performed without information about the participants. An HDI 5000 ultrasound device (Philips Healthcare, Bothell, WA) with a 12–15-MHz linear array transducer was used for this study. Each participant was placed in the supine position and imaged with the elbow fully extended and then passively flexed to 90°. Cross-sectional images of the ulnar nerve and the cubital tunnel were taken at both the inlet and outlet of the tunnel with elbow extension. The transducer was then removed and replaced at the same position of the inlet and outlet of the tunnel with elbow flexion to 90° (Figure 1). The position of the transducer was placed at the same area of the arm with elbow extension and flexion guided by the bony landmark and Osborne band. An effort was made to minimize transducer pressure on the nerve to minimize its effect on nerve movement.

Similarly to a previous study by Yoon et al,13 the inlet of the cubital tunnel was defined as the triangular space at which the hyperechoic Osborne band was initially observed as the transducer was traced inferiorly. This triangular space is bordered by the Osborne band, the medial epicondyle, and the olecranon. The outlet of the cubital tunnel was defined as the level at which the two heads of the flexor carpi ulnaris were joined, forming a border along the ulnar bone. Subluxation of the ulnar nerve at the elbow was defined as the movement of the ulnar nerve to the tip of the medial epicondyle, and dislocation was defined as complete dislocation of the ulnar nerve from the medial epicondyle during elbow flexion, as in previous studies.5,14

Three distances were measured at the inlet of the cubital tunnel: the distance from the center of the ulnar nerve to the skin, the distance from the nerve to the medial epicondyle, and the distance from the nerve to the tip of olecranon (highest portion). Two distances were measured at the outlet of the cubital tunnel: the distance from the center of the ulnar nerve to the skin and the distance from the nerve to the olecranon recess. The center of the ulnar nerve was measured using the cross point of the major and minor axes of the elliptical or circular nerve (Figure 2). At the inlet of the cubital tunnel, displacement of the ulnar nerve during elbow extension and flexion was calculated as the difference in the distance of the ulnar nerve to the skin, medial epicondyle, and tip of the olecranon between elbow extension and flexion, respectively. At the outlet of the cubital tunnel, displacement of the ulnar nerve during elbow extension and flexion was calculated as the difference in the distance of the ulnar nerve to the skin and olecranon recess between elbow extension and flexion.

SPSS version 12.0 software (SPSS Inc, Chicago, IL) was used for all statistical analyses. Age, sex, and the frequency of subluxation or dislocation were compared between the patients with ulnar neuropathy and the control group by a t test and χ² test. Displacement of the ulnar nerve from the skin and bony landmark during elbow flexion and extension was tested for normality by the Shapiro-Wilk test. Logarithmic transformation was applied at displacement of the ulnar nerve as needed to ensure a normal distribution. To analyze the results, analysis of covariance was used after adjustment for age and sex.
Results

A total of 26 patients (16 male and 10 female) with ulnar neuropathy at the elbow and 13 controls (4 male and 9 female) were enrolled in this study. The mean duration of symptoms ± SD in the patients with ulnar neuropathy was 2.78 ± 3.04 months. The longest duration of symptoms in the patients with ulnar neuropathy was 14 months. The duration of symptoms did not significantly correlate with the degree of ulnar nerve displacement. The mean ages of the patients with ulnar neuropathy and the controls were 47.65 ± 13.47 and 51.62 ± 13.35 years, respectively. Subluxation and dislocation were observed in 12 of 26 patients with ulnar neuropathy (46.15%) and 3 of 13 controls (23.08%). The degrees of subluxation and dislocation (the distance from the nerve to the medial epicondyle) were 6.12 ± 3.16 and 3.00 ± 1.20 mm in the patients with ulnar neuropathy and controls. The degrees of displacement in 3 controls who had subluxation of the ulnar nerve were 1.8, 3.0, and 4.2 mm to the medial epicondyle, respectively. There were no statistically significant differences in terms of age, sex, frequency, and the degree of subluxation or dislocation of the ulnar nerve between the two groups ($P > .05$).

In moving from elbow extension to flexion, the ulnar nerve was displaced to the anteromedial side near the skin surface. At the inlet of the cubital tunnel, the degrees of displacement of the ulnar nerve from the medial epicondyle

![Image]

Figure 1. Sonographic measurement with the elbow extended and flexed and transverse sonograms of the ulnar nerve. 
A, Sonographic measurement with the elbow extended. 
B, Ulnar nerve at the inlet of the cubital tunnel with the elbow extended. 
C, Sonographic measurement with the elbow flexed. 
D, Ulnar nerve at the inlet of the cubital tunnel with the elbow flexed. 
ME indicates medial epicondyle; OLE, olecranon of the humerus; and U, ulnar nerve.
during elbow extension and flexion were 4.22 ± 3.79 mm in the patients with ulnar neuropathy and 1.76 ± 1.51 mm in the controls, respectively, which was statistically significant (P < .05). There were no statistically significant differences in movement of the ulnar nerve during elbow extension and flexion at the outlet of the cubital tunnel between the patients with ulnar neuropathy and the controls (P > .05; Table 1). Finally, there was no difference in dynamic movement of the ulnar nerve according to the severity of electrodiagnostic findings in the patients with ulnar neuropathy.

Discussion

This study showed that movement of the ulnar nerve within the inlet of the cubital tunnel was greater in the patients with ulnar neuropathy at the elbow compared to the control group. The cause of idiopathic ulnar neuropathy is unclear in many cases, and whether the greater movement of the ulnar nerve at the elbow is the cause or the consequence of ulnar neuropathy remains unknown. However, the large movement of the nerve in the cubital tunnel may induce friction of the nerve against soft tissue around the nerve or stretch injury, which might make the nerve vulnerable to neuropathy. Previous studies have focused on ulnar nerve subluxation/dislocation rather than on subtle movement of the ulnar neuropathy within the cubital tunnel, which, as shown in this study, is greater in the proximal cubital tunnel in patients with ulnar neuropathy at the elbow.14–16

Table 1. Displacement of the Ulnar Nerve Between Elbow Extension and Flexion in Patients With Ulnar Neuropathy at the Elbow and Healthy Control Participants

<table>
<thead>
<tr>
<th>Segment</th>
<th>Group</th>
<th>Ulnar Nerve Displacement, mm</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outlet of cubital tunnel</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ulnar nerve to skin</td>
<td>Neuropathy</td>
<td>1.37 ± 0.22</td>
<td>.483</td>
</tr>
<tr>
<td>Control</td>
<td>1.09 ± 0.80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ulnar nerve to olecranon recess</td>
<td>Neuropathy</td>
<td>1.55 ± 1.22</td>
<td>.429</td>
</tr>
<tr>
<td>Control</td>
<td>1.09 ± 1.07</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1. Displacement of the Ulnar Nerve Between Elbow Extension and Flexion in Patients With Ulnar Neuropathy at the Elbow and Healthy Control Participants.

Values are mean ± SD. Displacement of the ulnar nerve during elbow extension and flexion indicates the difference in the distance of the nerve to the skin and bony landmark between elbow extension and flexion. P values represent overall differences between the neuropathy and control groups by analysis of covariance.
phy in 78 healthy volunteers, it was reported that the incidence rates of subluxation and dislocation of the ulnar nerve at the elbow were 20.5% and 3.8%, respectively. Another study that used sonography as a measuring tool found that of 91 patients with ulnar neuropathy at the elbow, 18.7% showed subluxation and 9.9% showed dislocation of the ulnar nerve. The difference in the prevalence rates of subluxation or dislocation in patients with ulnar neuropathy at the elbow compared to the healthy people has not been previously established.

Although the exact cause of ulnar neuropathy at the elbow cannot be definitively identified at this time, the impact of hypermobility of the ulnar nerve has been supported by surgical reports. In cases of ulnar neuropathy at the elbow accompanied by subluxation or dislocation, anterior transposition of the ulnar nerve has shown potential benefits. In addition, Palmer and Hughes suggested that simple decompression of the cubital tunnel may not effectively treat the underlying source of nerve irritation in cases of ulnar nerve hypermobility.

Okamoto et al previously reported that the cross-sectional area of the ulnar nerve in cases of hypermobility was greater in cases without subluxation or dislocation. Although all of the participants included in that study were healthy, it is worth noting that, similarly to cases of entrapment and compression neuropathy, the cross-sectional area of the nerve was increased in cases of hypermobility.

This study had several limitations that warrant consideration. First, errors in nerve measurement may have occurred because in some cases, the shape of the nerve changed from oval to circular when the elbow was flexed and extended, respectively. The distance between the center of the nerve and the skin or bony landmarks was measured, and repeated measurements were made to reduce measurement error. The center of the nerve rather than the nearest surface of the nerve was used to reduce error caused by changes in shape. Another limitation of this study was that we did not perform a 3-dimensional evaluation of ulnar nerve movement. This study was designed to compare two positions of elbow motion, including full extension and 90° flexion. The ulnar nerve does not move in a straight course, and differences in the cubital tunnel distance were measured from the starting point of extension to the ending point of flexion.

As shown in this study, a significantly greater degree of movement of the ulnar nerve occurs in patients with ulnar neuropathy at the elbow compared to the healthy people, as determined by sonography. Larger prospective studies could be designed to determine whether there is a causative effect.

References

