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Analysis of Subcutaneous Anterior Transposition versus in-situ Decompression of Ulnar Nerve with Force Transducer in Cadaver Specimen

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ABSTRACT

AIM: To evaluate the changes in the pressure values of the ulnar nerve after in-situ decompression and anterior subcutaneous transposition of the ulnar nerve.

MATERIAL and METHODS: The ulnar nerve was released in the postcondylar groove. An ultrathin (100 lm) force transducer was embedded between the posterior of the ulnar nerve and the anterior of the medial epicondyle. The elbow joint was flexed from full extension position to maximum flexion and was measured to obtain the maximum stress at 0°, 45°, 90°, and 135° of flexion. Then, the ulnar nerve was transposed anterior subcutaneously. The same measurement was applied to the two procedures. Data were compared between the two surgical techniques.

RESULTS: Our study was performed on the right upper extremities of eight (seven men and one woman) fresh frozen cadavers. The mean age of the cadavers was 67.25 ± 12.2 years. Mean values of 0°, 45°, 90°, and 135° of flexion after the ulnar nerve in-situ decompression were 0.41, 0.9, 1.7, and 4.3 N, respectively. Mean values of 0°, 45°, 90°, and 135° of flexion after anterior transposition of the ulnar nerve were 0.3, 0.73, 1.63, and 2.15 N, respectively. No significant difference was noted between the two groups in terms of 0°, 45°, and 90° of flexion values. However, there was a significant difference between the two groups in the 135° of flexion measurement values.

CONCLUSION: Anterior transposition is a more appropriate technique than in-situ decompression in the treatment of cubital tunnel syndrome that does not respond to conservative treatment regardless of the severity of the symptom.

KEYWORDS: Entrapment neuropathy, Ulnar nerve, In-situ decompression, Anterior transposition, Flexiforce

INTRODUCTION

Ulnar entrapment neuropathy is the second most common nerve entrapment in the upper extremity. The ulnar nerve may be compressed at several levels along its course in the upper extremity, but the elbow is the most common region of entrapment (7,8,24). Cubital tunnel syndrome (CuTS) refers to the compression of the ulnar nerve at the elbow.

Although the incidence is higher in men than in women, it is 25/100,000 per year (1,19). Numerous factors such as trauma, compression, bone spur and muscle disorders, ulnar nerve dislocation from the medial epicondyle, and ganglion and

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congenital anomalies may cause ulnar nerve entrapment. CuTS clinically manifests itself as pain, numbness, motor strength loss, and muscle atrophy on the ulnar side of the forearm and in the fourth and fifth digits. In untreated cases, pain and clumsiness along with loss of sensation and strength may arise on the affected side. Although conservative treatments such as night splint and activity modification may be effective in patients with mild compression findings (13,25,27,28,30), surgical treatment is administered in cases of persistent paresthesia, muscle weakness, or pain unresponsive to conservative treatment.

Several surgical procedures have been described for the treatment of CuTS. Today, it is still not possible to speak of the best treatment (9-11,13,25,31). Many techniques such as isolated decompression, anterior transposition with decompression, medial epicondylectomy, and arthroscopic decompression have been described. No consensus has been established on the surgical technique selection.

Given the literature, there are no data regarding the measurement of pressure arising on the nerve after surgical treatments for CuTS. In our cadaver study, we aimed to evaluate the changes in the values of pressure arising on the ulnar nerve after in-situ decompression and anterior subcutaneous transposition of the ulnar nerve in the cadaveric specimens.

MATERIAL and METHODS

This experimental study was conducted on the upper extremities of eight fresh frozen cadavers, at Acibadem Mehmet Ali Aydinlar University on April 2019. Approval for our study was obtained from the Institutional Review Board (Approval No: 2019-10/4; 23.05.2019). The demographic changes of the cadavers were recorded. Cadavers that had a deformity, contracture in the elbow region, or had previously undergone elbow dissection were excluded from the study. Ulnar nerve dissection was carried out by the researchers. Dissection was performed on eight cadaveric elbows using the medial approach. A 10-cm longitudinal incision was made at the posterior of the medial humeral condyle through the retrocondylar groove. The ulnar nerve was exposed in the postcondylar groove and advanced to the flexor carpi ulnaris Osborne's ligament at the distal part and from the medial epicondyle to the intermuscular septum at the proximal part.

Briefly, an ultrathin (100 lm) force transducer was embedded between the posterior of the ulnar nerve and the anterior of the medial epicondyle (Figure 1). The contact stress on the ulnar nerve was calculated by dividing the total force on the sensor by the sensing area. The elbow joint was flexed from full extension position to maximum flexion and was measured to obtain the maximum stress at 0°, 45°, 90°, and 135° of flexion. The force exerted on the ulnar nerve was measured by a flexiforce pressure sensor (Nitta Co., Ltd., Osaka, Japan). The details of the measurement system have previously been reported in the literature (2).

Then, the ulnar nerve was freed from its retroepicondylar tunnel and transposed forward subcutaneously. Force transducer placement was completed for pressure value measurements. A subcutaneous flap is created at the elbow to accommodate the transposed ulnar nerve. The same measurement was applied to the two procedures. Data were compared between the two surgical techniques.

Statistical analysis was performed using SPSS version 12 (SPSS Inc, Chicago, IL, USA). Means and standard deviations were calculated to summarize the study data. Normal distribution was investigated using the Shapiro–Wilk test. Continuous variables were compared using the Mann–Whitney *U* test. The threshold for significance was set at $p<0.05$.

RESULTS

A total of eight cadaveric specimens, four men and four women, were included in the study. Of the cadavers, eight were right upper extremity. All cadavers had a full range of motion of the elbow joint. The mean age of the cadavers was 67.25 ± 12.2 years (51–88). Mean values of 0°, 45°, 90°, and 135° of flexion after ulnar nerve in-situ decompression were 0.41, 0.9, 1.7, and 4.3 N, respectively. Mean values of 0°, 45°, 90°, and 135° of flexion after anterior transposition of the ulnar nerve were 0.3, 0.73, 1.63, and 2.15 N, respectively (Table I). In the statistical analysis, there was no difference between the two groups in terms of the pressure values at 0°, 45°, and 90° of flexion (Figures 2–4). But when the values measured at 135° of elbow flexion were compared, we found that the values of the patients who underwent ulnar nerve in-situ decompression were higher, which was statistically significant ($p<0.001$; Table I and Figure 5).

DISCUSSION

Anterior transposition of the ulnar nerve is performed as the primary surgical procedure in CuTS. Transposition performed in this technique provides direct decompression of the nerve and prevents the traction of the nerve at elbow flexion (17,18,25).

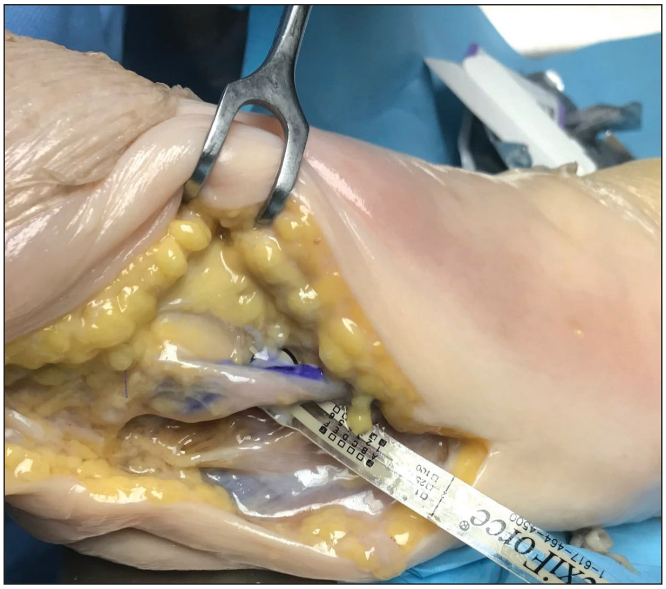

Figure 1: Transducer application after in-situ decompression.

The incidence of CuTS has increased in some occupational groups with work that requires leaning on the elbow, gripping a hand tool, and performing repetitive elbow flexion and extension. The best treatment method for CuTS is controversial. Given the literature, no superiority of anterior transposition over other surgical modalities, such as simple decompression, has been demonstrated (4,5,19–22). Erbayraktar et al. have shown that there is no significant difference in the therapeutic outcomes between in-situ decompression of the ulnar nerve and anterior transposition of the ulnar nerve in the treatment of ulnar neuropathy, regardless of the severity of neuropathy (8). However, most authors have emphasized that simple

Table I: Descriptives of Two Groups (n=8)

	In-situ decompression		Anterior transposition		
	Mean	**SD**	**Mean**	**SD**	**p***
0°	0.41	.18	0.3	0.14	0.21
45°	0.9	0.22	0.73	0.19	0.15
90°	1.7	0.2	1.63	0.15	0.16
135°	4.3	0.7	2.15	0.29	**0.001**

*****_Mann-Whitney U test._

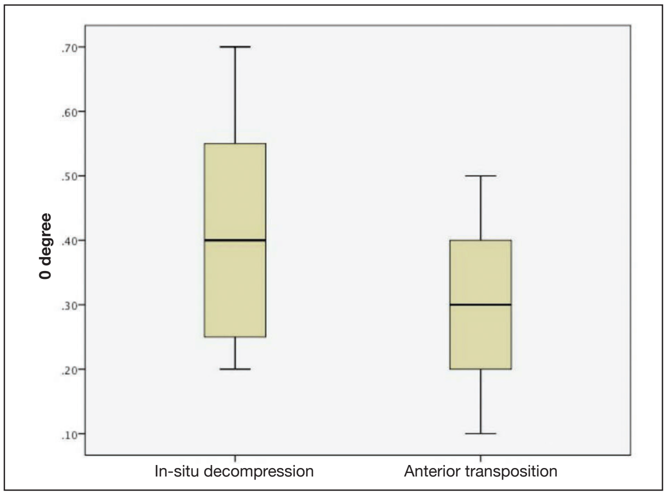

Figure 2: 0° of flexion comparison.

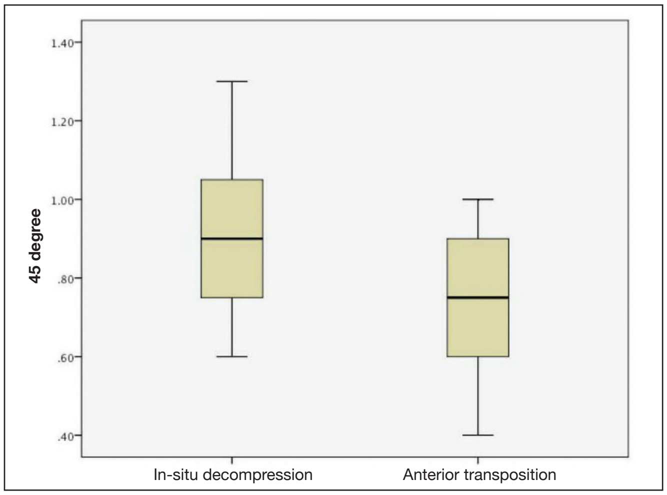

Figure 3: 45° of flexion comparison.

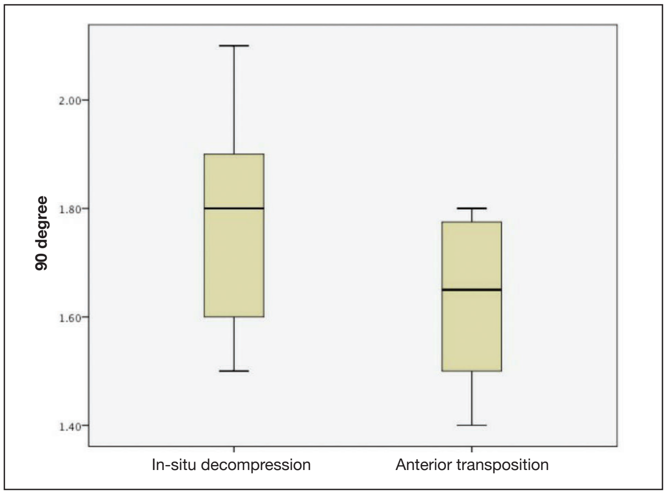

Figure 4: 90° of flexion comparison.

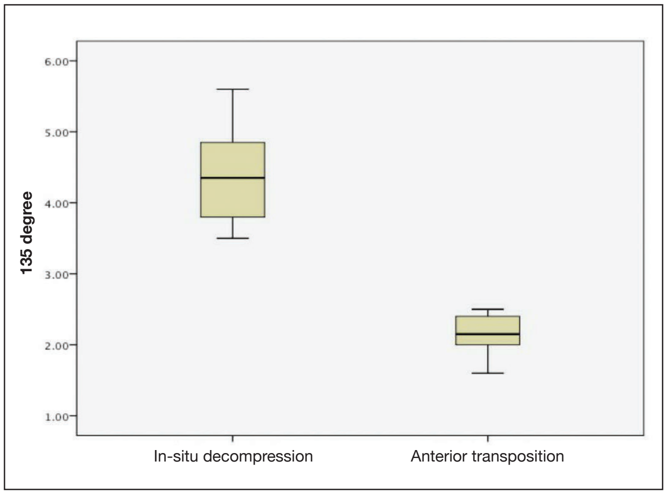

Figure 5: 135° of flexion comparison.

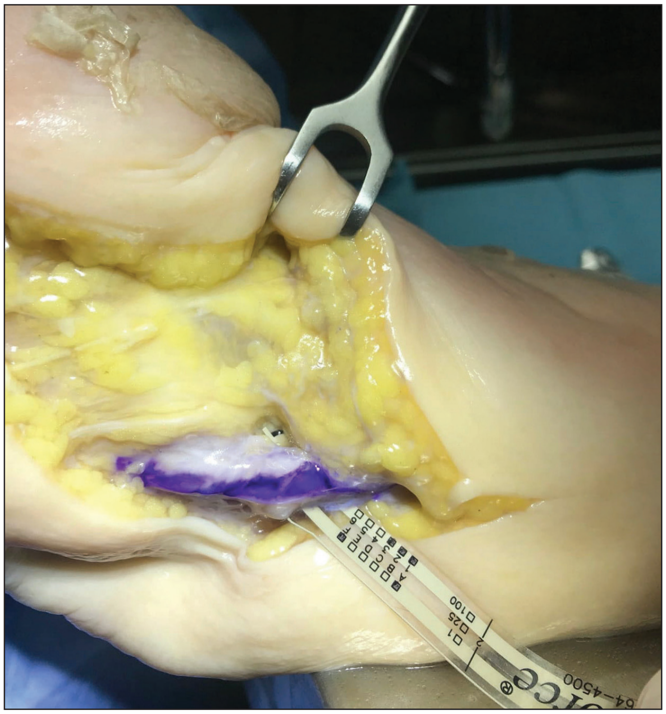

Figure 6: Transducer application after transposition.

decompression is not a good option in the treatment of CuTS (11,15,21). In our study, we found that the cadaveric ulnar nerve that underwent simple decompression was exposed to a higher pressure than the anteriorly transposed ulnar nerve at 135° of elbow flexion. We think that the traction-related pressure effect induced by elbow flexion on the ulnar nerve that underwent anterior transposition is lower. Although no superiority was asserted between the two techniques in the literature, the results of our study demonstrated that anterior transposition was a more effective method because of reduced pressure on the ulnar nerve.

Medial epicondylectomy is another method described in CuTS. However, complications such as tenderness, postoperative pain, flexor-pronator weakness, and valgus instability have been reported to develop after medial epicondylectomy (11,21). Although it has advantages over anterior transposition, the fact that it is a technique that most surgeons are unfamiliar with and has some weaknesses are its disadvantages. However, it is not an appropriate technique in an elbow with excessive valgus and ulnar nerve subluxation.

Ulnar nerve instability is the most important factor in failed cubital tunnel decompression with a rate of 2.4%–20%. Ulnar nerve instability that may arise following simple decompression should be paid attention. In a cadaver study, the rate of instability is 50%, especially in decompression carried out more than 4 cm proximally to the medial epicondyle (6).

Dellon et al. indicated that anterior transposition is the best method to reduce the pressure arising on the nerve (6). Some authors have reported that anterior transposition leads to devascularization of the nerve (17). However, King and Morgan demonstrated the presence of perineural anastomoses after anterior transposition (17). Moreover, Prevel et al., and Sugawara refused devascularization by stating that transposition transports not only the ulnar nerve but also its collateral vessels (23,29). To prevent this complication, its location in the epicondylar groove should be preserved during decompression, and it should not be dissected circularly to preserve the feeding vessels and surrounding soft tissues.

To maintain the stabilization of the ulnar nerve, compressive superficial bands should be released without applying neurolysis. Elbow movements should be checked for subluxation after the release, and anterior transposition should be performed in cases where subluxation is observed (14,16). Anterior transposition of the ulnar nerve is especially preferred in patients who previously had elbow trauma, had elbow arthropathy with concomitant contracture, and underwent ulnar neuropathy surgery. Many surgeons recommend transposition in patients with high-grade McGowan lesion, preoperative ulnar nerve subluxation, and developed ulnar nerve instability during in-situ decompression. In the study by Hsu et al., it was found that the rate of subluxation was much higher in the release of the anterior connection of Osborne's ligament on the medial epicondyle than that of in the release of the posterior connection in the olecranon (16). Uscetin et al. reported that the epitrochleoanconeus muscle should be kept in mind as a rare cause of CuTS (31). They reported that subfascial anterior transposition might be accepted as a good surgical alternative to prevent subluxation after complete dissection of the ulnar nerve.

The quantitative measurement values used are the strengths of our study. We demonstrated that anterior transposition reduces the pressure that the ulnar nerve is exposed in elbow flexion more than in-situ decompression in the treatment of CuTS. We would like to emphasize that anterior transposition is the best treatment in CuTS since we detected ulnar nerve instability that may develop after decompression, recurrence due to inadequate decompression, and inadequate decompression at full elbow flexion.

In recent years, endoscopic ulnar nerve decompression has been gaining popularity with the advantages of a small incision, low rate of ulnar nerve injury, and rapid recovery time (12). However, it has not been widely adopted because of the requirement for more expensive instruments, the duration of the learning curve, and the complication rates compared with open decompression techniques (3,18).

CONCLUSION

The treatment of CuTS has not yet been standardized. With our study, we believe that the choice of anterior transposition in the treatment of CuTS syndrome will relax the nerve more than in-situ decompression treatment, reduce the traction-related compression arising in elbow flexion, relieve the patient's complaints more, and decrease the recurrence rates. Anterior transposition is an appropriate technique to be used in the treatment of CuTS unresponsive to conservative treatment regardless of the symptom severity.

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