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Original article

Minimally invasive endoscopic ulnar nerve assessment and surgery for cubital tunnel syndrome patients—Relation between endoscopic nerve findings and clinical symptoms

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Abstract

To minimize damage to healthy tissues, we have been performing endoscopically assisted cubital tunnel syndrome surgery based on endoscopic nerve findings since 1995. This is the first study to focus on endoscopic surgery for cubital tunnel syndrome based on endoscopic ulnar nerve findings and the subsequent postoperative clinical results. We analysed 82 upper extremities of 74 cubital tunnel syndrome patients who had undergone endoscopically assisted release surgery using the Universal Subcutaneous Endoscope system. Endoscopic observations of the ulnar nerve were made from a single 1- to 3-cm endoscopic portal incision at the cubital tunnel to 10 cm proximal and 10 cm distal. The abnormal nerve areas were identified and released based on nerve degeneration findings under endoscopic observation. The abnormal areas spread eccentrically from the entrapment point(s). In 82 diseased upper extremities, ulnar nerve entrapment occurred at the cubital tunnel. However, one extremity suffered from entrapment at the arcade of Struthers' in addition to the cubital tunnel. All patients showed improved clinical symptoms following surgery. There is no statistical relation between pre- and postoperative clinical scores of Dellon's Staging and abnormal nerve length findings. Cubital tunnel syndrome is usually caused by entrapment at the cubital tunnel; however, in some cases, there are other point entrapment(s). Our endoscopically assisted procedure avoids any damage to healthy tissues because the surgeon can observe the entrapment point(s) prior to release. Postoperative clinical recovery results clearly indicate that endoscopic nerve findings reveal entrapment points and ulnar nerve degeneration can spread maximally 10 cm distally and proximally from the entrapment point(s), even in clinically mild severity cases. All other possible entrapment points should, therefore, be observed and released using our procedure.

Keywords: cubital tunnel syndrome; endoscopic nerve findings; endoscopically assisted surgery; entrapment neuropathy; ulnar nerve entrapment

Introduction

Osborne[1] was the first to report on the treatment of cubital tunnel syndrome, and this operative procedure was the first established minimally invasive surgery for the treatment of this condition. However, considering the 7% reported postoperative persistent symptoms rate following *in situ* decompression[2] that consequently requires secondary anterior submuscular transposition, release only at the cubital tunnel is not always sufficient for all disorders clinically diagnosed as cubital tunnel syndrome.

We have been performing endoscopically assisted surgery using the Universal Subcutaneous Endoscope (USE) system[3,4] (TACT Med. Inc., Tokyo, Japan) since 1995.[5] This procedure allows the surgeon to dynamically observe and assess ulnar nerve conditions with enlarged monitor images. Endoscopic observations and assessments are made from the arcade of Struthers' (the most proximal potential entrapment point) to the deep flexor pronator aponeurosis (the most distal potential entrapment point) through a small endoscopic portal made at the cubital tunnel.

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Using this procedure, surgeons can identify and release entrapment points based on endoscopic nerve findings with minimal damage to healthy tissue and limited postoperative restriction of activity of daily living. We have achieved satisfactory results[6] equivalent to standard open procedures.

Considerations of unknown problems regarding clinical implementation of our endoscopically assisted surgical procedure include the following issues: (1) How do abnormal preoperative endoscopic nerve findings indicate preoperative entrapment points? (2) Does the correlation between these abnormal preoperative endoscopic nerve length findings and pre- and postoperative clinical severity of symptoms serve as a useful endoscopic staging?

In this study, we analysed the relation between pre- and postoperative staging that conform to Dellon's Staging,[7] as an indicator of clinical symptoms, and our endoscopically assessed abnormal nerve length findings. This analysis was carried out in order to evaluate the efficacy of our proposed endoscopic assessment procedure and to achieve a truly effective minimally invasive surgical procedure for the treatment of cubital tunnel syndrome.

Methods

We retrospectively analysed 82 upper extremities (44 male and 38 female) of 74 cubital tunnel syndrome patients who underwent endoscopically assisted surgery using the USE system from September 2003 to October 2010. All patients were followed up for more than 10 months, postoperatively. The mean age of patients at the time of operation (standard deviation, SD) was 61.6 (9.2) years (range, 36–81 years). The mean postoperative follow-up period (SD) was 31.5 (19.0) months (range, 10–90 months).

Diagnosis was based on clinical signs and electrophysiological test results (ulnar motor and/or sensory studies revealed a nerve conduction velocity of less than 50 m/second). Causes of the cubital tunnel syndrome were idiopathic (no apparent cause) in 21 extremities and hemodialysis-related in 61 extremities. This study excluded cases involving other factors such as a traumatic history of the same elbow joint, ulnar nerve subluxation at the same elbow joint, osteoarthritis of the same elbow joint, or systematic neuropathy.

Assessment of endoscopically assisted surgery and analysis of intraoperative endoscopic findings were discussed, and agreement was then reached by the authors of this study. The surgery was performed on an outpatient basis, under local anesthesia, and without a pneumatic tourniquet in order to dynamically observe and assess intraneural nerve blood circulation during surgery. A small 1- to 3-cm skin incision was made at the cubital tunnel to serve as a portal for the USE system. The USE system consists of a closed transparent sheath and a 4-mm standard 30° oblique viewing arthroscope. The Osborne ligament (fascial band bridging two heads of flexor carpi ulinaris muscle)[1] was exposed at the cubital tunnel and released under direct observation. The ulnar nerve was identified, and sufficient space for the insertion of the USE system was made between the nerve and the soft tissue. Under direct observation at the portal, hourglass narrowing and/or proximal pseudoneuroma formation of the ulnar nerve was judged as entrapment at the cubital tunnel. The USE system was inserted in contact with the ulnar nerve distally under endoscopic observation (Fig. 1). The USE system allowed us to make observations within a 10-cm range distally and proximally from the portal edge. The following endoscopic findings were judged as abnormal: areas where we could not observe the funiculi because of epineurial thickening (this finding was considered to indicate an entrapment point); and/or areas with winding and twisted funiculi; and/or areas with no intraneural adipose tissue (Fig. 2A–C). Conversely, areas were considered normal if there was no epineurial thickening, the funiculi were straight running, adipose tissue was present between the funiculi, and there was blood circulation between the funiculi (Fig. 2D).[6] Incidental elbow joint movement during insertion of the USE system does not affect proximal or distal observations, and our endoscopic findings also remain unaffected by any such movement. Even when the USE system is inserted between the nerve and surrounding soft tissue, intraneural blood circulation is maintained when the surrounding nerve pressure is less than 30 mmHg as Rydevik et al[8] concluded. Therefore, we use continued intraneural blood circulation as an indication of healthy noncompressed nerve areas.

The fascia and other soft tissue of the abnormal nerve area, at the opposite side of the USE sheath from the ulnar nerve, were released using a push knife under complete endoscopic observation (Fig. 3). After having identified the branch nerve, i.e., the medial cutaneous branch, we were careful not to damage it throughout the procedure. The released length of the soft tissue depended on the extent of the individual patient's abnormal nerve area. Following sufficient release of soft tissue compressing the ulnar nerve, we confirmed intraneural blood circulation throughout the observed areas, especially where intraneural blood circulation had not been observed prior to release (Fig. 4). Immediate confirmation of recovery from intraneural blood circulation disturbance could not be

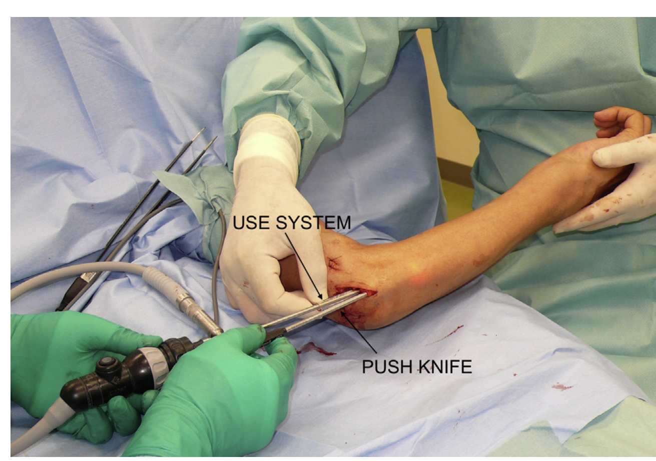

Fig. 1. Inserting the Universal Subcutaneous Endoscope (USE) system and push knife along the ulnar nerve. Releasing the contralateral side of the soft tissue of an abnormal ulnar nerve finding area using a push knife under complete endoscopic observation.

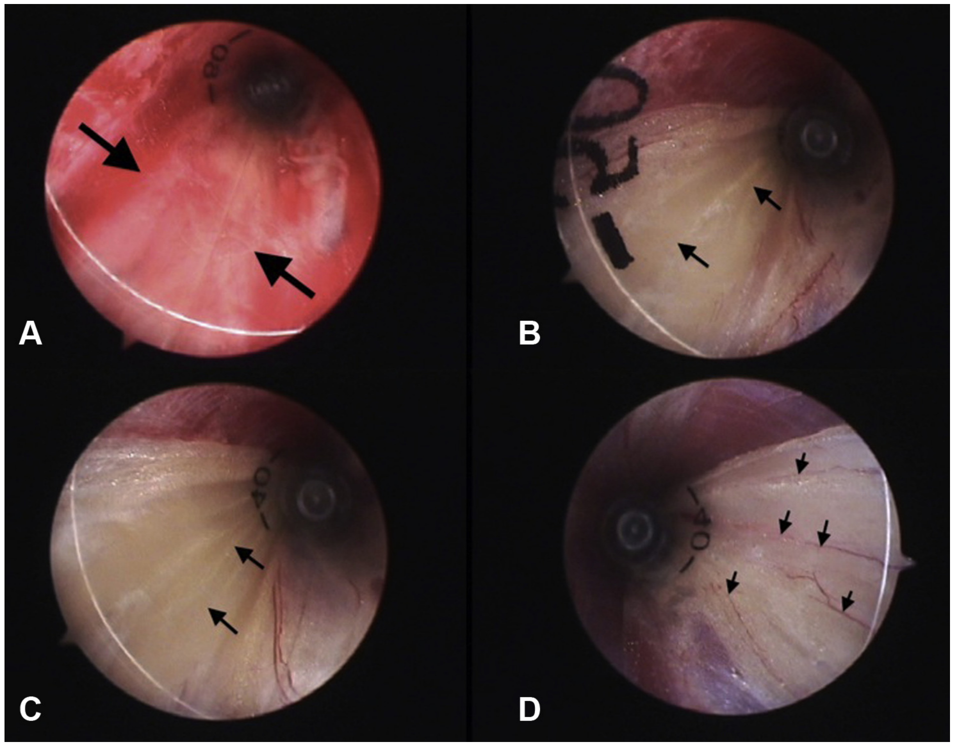

Fig. 2. Endoscopic ulnar nerve findings. (A) Areas where we could not observe the funiculi because of epineurium thickening (arrows indicate the ulnar nerve). (B) Areas with winding and twisted funiculi (arrows indicate the funiculi). (C) Areas with no intraneural adipose tissue; and/or areas with interrupted intraneural blood circulation (arrows indicate the funiculi). (D) Areas with uninterrupted blood circulation between the funiculi: normal area (arrows indicate intraneural blood circulation).

observed in areas with thickened epineurium; however, reperfusion was observed within 2–3 minutes. We were able to confirm that no newly formed entrapment points developed after the release of the initial entrapment point(s) according to the status of intraneural blood circulation.

The portal incision was closed with one to three subcutaneous stitches and a compression bandage was applied for 24 hours. We recommended that the patients gradually resume use of their upper extremity from the day after surgery.

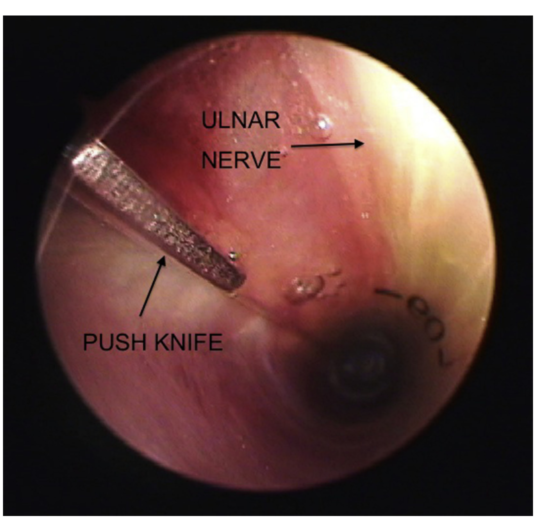

Fig. 3. Endoscopic view at release. The contralateral side of the Universal Subcutaneous Endoscope sheath while releasing the fascia and other soft tissue using a push knife.

We examined pre- and postoperative clinical symptoms, tingling (paresthesia), pain sensation using a 3-g needle, touch sensation using a 2-g von Frey hair (modified Dellon's Staging), manual muscle testing of the abductor digiti quinti muscle and first dorsal interosseous muscle, electrophysiological testing results (nerve conduction velocity studies of the ulnar nerve across the cubital tunnel), and Dellon's Staging.

We used one-way analysis of valiance to statistically analyse the relationship between abnormal nerve lengths and pre- and postoperative Dellon's Staging ($p < 0.05$).

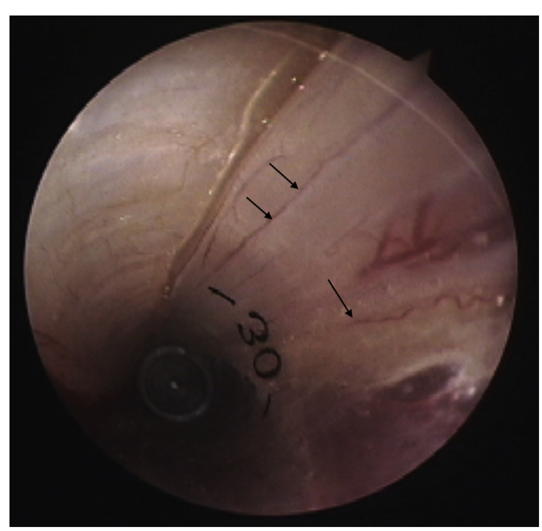

Fig. 4. Endoscopic finding of reperfusion of intraneural blood circulation following release. Arrows indicate intraneural blood circulation.

Our study design and procedure were performed in accordance with the Ethical Guidelines for Clinical Studies, July 30, 2003 (amended July 31, 2008), Japanese Ministry of Health, Labor, and Welfare.

Results

The preoperative Dellon's Staging profiles were as follows: Mild, three extremities; Moderate, 27 extremities; and Severe, 52 extremities. Abnormal nerve areas were spread eccentrically from the entrapment point(s).

According to endoscopic nerve findings, ulnar nerve entrapments at both the cubital tunnel and the arcade of Struthers' were observed in one extremity. Entrapment points in the other 81 extremities were found only at the cubital tunnel.

As for endoscopic ulnar nerve findings, the mean distal abnormal length (SD) was 4.1 (1.3) cm (range, 1–7 cm) and the mean proximal abnormal length (SD) was 5.1 (2.2) cm (range, 0–10 cm). The mean total abnormal length (SD) was 9.2 (3.0) cm (range, 2–17 cm).

The pre- and postoperative results of clinical symptoms are shown in Table 1. All patients showed one or more than one improved clinical symptom(s) following surgery, and there were no patients who required additional surgery.

The five patients postoperatively assessed as severe in Dellon's Staging were all hemodialysis patients and all suffered from cervical destructive spondyloarthropathy. However, they all showed at least some improvement in terms of tingling, pain and touch sensation, and manual muscle testing of the abductor digiti quinti and/or first dorsal interosseous.

There were no significant statistical differences between preoperative the abnormal nerve length findings and preoperative Dellon's Staging (Table 2).

Table 1
Pre- and postoperative results of clinical symptoms.

		Preoperative (hands)	Postoperative (hands)
Tingling		79	14
Pain sensation		68	2
Touch sensation		66	3
MMT of ADQ	0	11	2
	1	3	2
	2	15	1
	3	30	7
	4	14	9
	5	9	61
MMT of 1st DIO	0	11	3
	1	3	3
	2	16	1
	3	29	11
	4	14	7
	5	9	57
Dellon's Staging	Severe	52	5
	Moderate	27	19
	Mild	3	10
	Normal	0	48

1st DIO = first dorsal interosseous; ADQ = abductor digiti quinti; MMT = manual muscle testing.

Table 2
Relation between preoperative abnormal nerve length findings and preoperative Dellon's Staging.

	Dellon's Staging			*p*	
	Mild	Moderate	Severe		
Mean total abnormal length (SD) (cm)	11.3 (2.3)	9.9 (2.5)	10.0 (3.4)	0.75	NS
Mean proximal abnormal length (SD) (cm)	6.0 (1.7)	5.6 (1.7)	5.6 (2.5)	0.95	NS
Mean distal abnormal length (SD) (cm)	5.3 (0.6)	4.4 (1.5)	4.5 (1.5)	0.56	NS

NS = not significant; SD = standard deviation.

There seems to be some relation between the severity of postoperative Dellon's Staging and preoperative abnormal nerve length findings; however, there were no significant statistical differences between preoperative abnormal length and postoperative Dellon's Staging (Table 3).

There were no significant statistical differences between the improvement grade (preoperative minus postoperative Dellon's Staging) and abnormal length (Table 4).

There were no complications or recurrence of clinical symptoms in this series during the follow-up periods.

Discussion

In entrapment neuropathy (nerve compression syndrome), the purpose of surgery is to achieve decompression of the diseased nerve areas. To treat cubital tunnel syndrome, the second most common entrapment neuropathy of upper extremities, Curtis performed anterior subcutaneous translocation of the ulnar nerve. Since this initial operative procedure, many other types of operative procedures— *in situ* (simple) decompression, epicondylectomy, anterior transposition (anterior subcutaneous transposition, anterior intramuscular transposition, anterior submuscular transposition), and ulnar groove plasty—have been performed.

During cubital tunnel syndrome surgery, care must be taken because there are several possible entrapment points of the ulnar nerve, i.e., the arcade of Struthers', intramuscular septum, medial head of the triceps muscle, cubital tunnel, and the deep flexor pronator aponeurosis. In cubital tunnel syndrome, the Osborne ligament area (cubital tunnel) is the most common entrapment point; however, in some cases, the patient

Table 3
Relation between preoperative abnormal nerve length findings and postoperative Dellon's Staging.

	Dellon's Staging				*p*	
	Normal	Mild	Moderate	Severe		
Mean total abnormal length (SD) (cm)	9.8 (2.8)	9.9 (4.5)	10.2 (2.8)	11.8 (2.9)	0.55	NS
Mean proximal abnormal length (SD) (cm)	5.4 (2.1)	5.8 (2.9)	5.8 (2.2)	6.2 (1.6)	0.82	NS
Mean distal abnormal length (SD) (cm)	4.4 (1.5)	4.2 (2.0)	4.4 (1.1)	5.6 (1.3)	0.32	NS

NS = not significant; SD = standard deviation.

Table 4
Relation between abnormal nerve length findings and improvement grade.

Improvement grade	0	1	2	3	p	
Mean total abnormal length (SD) (cm)	11.6 (2.6)	10.3 (2.7)	9.7 (3.4)	9.6 (3.1)	0.42	NS
Mean proximal abnormal length (SD) (cm)	6.1 (1.8)	5.8 (2.0)	5.5 (2.3)	5.3 (2.5)	0.75	NS
Mean distal abnormal length (SD) (cm)	5.4 (1.1)	4.5 (1.1)	4.2 (1.8)	4.3 (1.4)	0.26	NS

Improvement grade = preoperative minus postoperative Dellon's Staging; NS = not significant; SD = standard deviation.

may have a combination of entrapment points, and it is difficult to correctly identify these other entrapment points preoperatively. Residual symptoms and/or postoperative recurrence may occur because of the existence of remaining and/or newly formed entrapment points that may develop as a result of the primary operation.[2,9,10]

The use of the electophysiological inching technique can accurately diagnose and identify entrapment point(s) of the peripheral nerve.[11] However, it is not always technically possible to perform this technique preoperatively at every institution, and it may not be considered as an acceptable procedure by every patient because it is painful.

In standard procedures, the surgeon assesses the entrapment points based on neural findings such as morphological or colour changes and palpation that can only be obtained after making a wide skin incision that completely exposes the ulnar nerve from 10 cm proximal to 10 cm distal of the cubital tunnel, resulting in extensive and unnecessary damage to healthy tissue. By contrast, by using the USE system, we observe and assess all possible entrapment points prior to invasion of any soft tissue and without making a wide skin incision. Following our endoscopic observations and assessments, we then release all entrapment points up to optimal lengths from 10 cm distal to 10 cm proximal through a small cubital portal incision with minimal damage to healthy tissue. Not only does our procedure release all preexisting entrapment points based on endoscopic nerve findings, it also allows us to intraoperatively confirm that there are no newly formed entrapment points following the release of the soft tissue.

Endoscopic management of cubical tunnel syndrome according to our endoscopic ulnar nerve findings revealed equivalent clinical recovery rates when compared to other procedures.[12] Based on our procedure's satisfactory postoperative clinical recovery rates, our endoscopic ulnar nerve findings provide a reliable assessment of the diseased nerve areas and entrapment points. Our only case with two entrapment points (one per 82 upper extremities) indicates the limitations of simple decompression procedures for cubital tunnel syndrome when the patient suffers from multiple entrapment points. Our procedure allows us to intraoperatively assess possible entrapment points without the need for complex, painful preoperative electrophysiological examinations.

Recently, some surgeons have shown interest in minimally invasive endoscopically assisted approaches for the treatment of cubital tunnel syndrome. However, they have not properly taken diseased nerve area assessment procedures into consideration. Our procedure is different from other endoscopically assisted procedures that release all possible entrapment points without making any prior assessment of nerve conditions.

Peripheral nerve compression causes intraneural blood circulation disturbances and intraneural pressure changes, and these conditions can lead to blood–nerve barrier breakdown, endoneural edema, connective tissue thickening, nerve demyelination, and axonal degeneration.[13] Endoscopic nerve findings have not previously been described in the medical literature, except for our papers.[6,14] Endoscopic nerve degeneration findings that include lack of adipose tissue, winding and/or twisted funiculi, and thickened epineurium can be correlated on an order from mild to severe neuropathic severity, and our endoscopic nerve observations showed that these abnormal nerve findings extend both proximally and distally from the entrapment point(s). These endoscopically assessed conditions are indicators of nerve degeneration; however, intraneural blood flow changes are the only "active" indicators for nerve decompression assessment during surgery. We presume that nerve degeneration develops owing to an interrupted intraneural blood circulation around the entrapped area because abnormal blood circulation-based endoscopic nerve findings gradually decrease concentrically away from the entrapment point.

Iba et al[15,16] reported extraneural pressure measurement results at the cubital tunnel. Dellon et al[17] and Gelberman et al[18] reported intraneural ulnar nerve pressure measurement results at proximal, within, and distal to the cubital tunnel in cadavers. However, intraneural ulnar nerve pressure measurement procedures have not been applied in clinical studies. Moreover, there have not been any studies that measure pressure along the entire length of all possible entrapment points. As a result, other assessment procedures for decompression of the ulnar nerve are needed. This is why we decided to use endoscopically observed nerve degeneration findings and intraneural blood circulation findings as indicators of the absence of entrapment and compression.

In this study, abnormal nerve length findings and pre- and postoperative Dellon's Staging show no significant statistical correlation. From this result, it was impossible to establish endosocopic staging using endoscopic nerve length findings. However, it also indicates that even in patients with clinically mild symptoms, nerve degeneration may spread widely; therefore, the ulnar nerve should be endoscopically observed and assessed both distally and proximally from the cubital tunnel. Nerve degeneration areas due to entrapment may correlate to segmental blood supply as well as points of compression; however, this has not been confirmed in this study.

Another advantage of endoscopically assisted ulnar nerve observation is that the surgeon can dynamically observe intraneural blood circulation during and following ulnar nerve release with the elbow in different positions, i.e., full elbow extension or different degrees of flexion. This means that our procedure can be used to examine the ulnar nerve using magnified endoscopically assisted observation to help determine the existence or development of any newly formed entrapment points.

Lankester and Giddins[19] stated that recurrence following simple decompression surgery at the cubital tunnel was felt to be the result of subluxation of the nerve over the epicondyle. However, we had no postoperative patient complaints of ulnar nerve subluxation and/or clinical symptoms in this study because the ulnar nerve is not separated from the ulnar groove floor in our procedure.

As a limitation of this study, compared with other endoscopic cubital tunnel release surgeries, our procedure requires insertion of a transparent closed sheath next to the ulnar nerve. This may cause some nerve compression that could result in intraneural blood circulation changes prior to the release of the surrounding soft tissue. During intraoperative observation, intraneural blood circulation could be transiently disturbed by this compression. However, postoperative observation of intraneural blood circulation provides proof of complete decompression of the ulnar nerve.

Conclusion

Our postoperative clinical results indicate that abnormal endoscopically observed nerve findings can be used to identify entrapment point(s). The extent of the abnormal nerve findings does not correlate with preoperative clinical severity and postoperative clinical results. Consequently, surgeons must pay attention to the sites, range, and severity of ulnar nerve degeneration even in patients with mild clinical symptoms.

Conflicts of interest

All authors declare no conflicts of interest.

Acknowledgements

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References

1. Osborne G. Compression neuritis of the ulnar nerve at the elbow. *Hand*. 1970;2:10–13.
2. Goldfarb CA, Sutter MM, Martens EJ, et al. Incidence of re-operation and subjective outcome following in situ decompression of the ulnar nerve at the cubital tunnel. *J Hand Surg Eur*. 2009;34:379–383.
3. Okutsu I, Ninomiya S, Natsuyama M, et al. Subcutaneous operation and examination under Universal Endoscope. *J Jpn Orthop Assoc*. 1987;61:491–498 [in Japanese, English abstract].
4. Okutsu I, Ninomiya S, Takatori Y, et al. Endoscopic management of carpal tunnel syndrome. *Arthroscopy*. 1989;5:11–18.
5. Okutsu I, Hamanaka I, Chiyokura Y, et al. Endoscopic treatment of cubital tunnel syndrome using the USE system in long-term haemodialysis patients. *Kansetsukyo*. 2000;25:137–141 [in Japanese, English abstract].
6. Yoshida A, Okutsu I, Hamanaka I. Endoscopic anatomical nerve observation and minimally invasive management of cubital tunnel syndrome. *J Hand Surg Eur*. 2009;34:115–120.
7. Dellon AL. Review of treatment results for ulnar nerve entrapment at the elbow. *J Hand Surg Am*. 1989;14:688–700.
8. Rydevik B, Lundborg G, Bagge U. Effects of graded compression on intraneural blood blow. An in vivo study on rabbit tibial nerve. *J Hand Surg Am*. 1981;6:3–12.
9. Gabel GT, Amadio PC. Reoperation for failed decompression of the ulnar nerve in the region of the elbow. *J Bone Joint Surg Am*. 1990;72:213–219.
10. Kleinman WB. Revision ulnar neuroplasty. *Hand Clin*. 1994;10:461–477.
11. Kimura J. Principles and pitfalls of nerve conduction studies. *Ann Neurol*. 1984;16:415–429.
12. Mowlavi A, Andrews K, Lille S, et al. The management of cubital tunnel syndrome: a meta-analysis of clinical studies. *Plast Reconstr Surg*. 2000;106:327–334.
13. Mackinnon SE, Novak CB. Compression neuropathies. In: Green DP, Hotchkiss RN, Pederson WC, Wolfe SW, eds. *Operative Hand Surgery*. 5th ed. Philadelphia: Churchill Livingstone; 2005:999–1045.
14. Okutsu I, Hamanaka I, Yoshida A. Endoscopic findings of entrapment neuropathy – cubital tunnel syndrome. *Kansetsukyo*. 2008;33:33–37 [in Japanese, English abstract].
15. Iba K, Wada T, Aoki M, et al. Intraoperative measurement of pressure adjacent to the ulnar nerve in patients with cubital tunnel syndrome. *J Hand Surg Am*. 2006;31:553–558.
16. Iba K, Wada T, Aoki M, et al. The relationship between the pressure adjacent to the ulnar nerve and the disease causing cubital tunnel syndrome. *J Shoulder Elbow Surg*. 2008;17:585–588.
17. Dellon AL, Chang E, Coert JH, et al. Intraneural ulnar nerve pressure changes related to operative techniques for cubital tunnel decompression. *J Hand Surg Am*. 1994;19:923–930.
18. Gelberman RH, Yamaguchi K, Hollstien SB, et al. Changes in interstitial pressure and cross-sectional area of the cubital tunnel and of the ulnar nerve with flexion of the elbow. An experimental study in human cadavers. *J Bone Joint Surg Am*. 1998;80:492–501.
19. Lankester BJ, Giddins GE. Ulnar nerve decompression in the cubital canal using local anaesthesia. *J Hand Surg Br*. 2001;26:65–66.