Clinical study of surgical treatment of carpal tunnel syndrome: Open versus endoscopic technique

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ABSTRACT

Twenty-six patients (30 hands) who underwent endoscopic carpal tunnel release were physically examined and asked to complete questionnaires on their symptoms, functional limitations and satisfaction. Their mean grip strength improved considerably from 17.5 kg before the operation to 31.3 kg at the final follow-up. Symptoms at the final follow-up were hypesthesia in 9 hands, muscle atrophy in 10, positive Tinel sign in 3, and positive Phalen sign in 1. The mean symptom severity score improved from 3.01 before the operation to 1.44 at the final follow-up and the mean functional status score improved from 3.20 to 1.54. The average times to return to activities of daily living and work were 7.3 days and 18.4 days respectively. Twenty-two of the 26 patients (85%) were satisfied. There was no injury to neurovascular structures. Arterial injuries were prevented by marking the superficial palmar arch and ulnar artery with a Doppler ultrasonic hemodrometer before surgery.

Key words: carpal tunnel syndrome, endoscopic carpal tunnel release, outcomes, operative complication

INTRODUCTION

Carpal tunnel syndrome is one of the many entrapment neuropathies that are commonly encountered by clinicians. Open carpal tunnel release (OCTR) has been widely used as a surgical alternative for patients who are resistant to conservative treatments. However, although its effectiveness has been recognized, OCTR has been associated with problems such as hypertrophic scarring, scar tenderness and delayed rehabilitation.1,14,18 Endoscopic carpal tunnel release (ECTR) has been used since Okutsu et al.16 and Chow4 reported its usefulness in 1989. We have performed ECTR since June 1996, using Okutsu’s endoscopic technique.16

OCTR requires a skin incision of several centimeters at the wrist and a post-operative rest period of 2 to 3 weeks. These post-operative requirements considerably restrict the patients’ activities of daily living. Furthermore, it is not uncommon for the patients to experience hypesthesia of the palms and discomfort of the skin incision.

The reported success rates of OCTR and ECTR have ranged from 70 to over 90%.2,10,18 However, the results have generally been evaluated in terms of neuromuscular impairments and other physical findings, while patients have been more concerned
with symptoms and function. Therefore, we report the results of a self-administered questionnaire for the assessment of the severity of symptoms and the functional status, and neuromuscular impairments and other physical findings in patients who underwent single endoscopic carpal tunnel release.

We strongly recommend marking the superficial palmar arch and ulnar artery with a Doppler ultrasonic hemodrometer before surgery to prevent injury to the artery.

**INDICATIONS FOR SURGERY**

Surgery was indicated when: (1) there was no improvement in the hand symptoms after 3 months of conservative treatment i.e., nonsteroidal anti-inflammatory medication, injection of vitamin B12 preparations and injection of steroid into the carpal tunnel, (2) the symptoms persisted for a long time and numbness was severe or accompanied by pain, (3) there was muscle atrophy of the thenar musculature and distinct muscle weakness of the abductor pollicis brevis muscle and opponens pollicis muscle.

**MATERIALS AND METHODS**

Between June 1996 and October 1999, we operated on 30 hands in 26 patients with carpal tunnel syndrome using Okutsu’s endoscopic technique. A diagnosis of carpal tunnel syndrome was made based on the presence of the characteristic symptoms of nocturnal paresthesia in the median nerve distribution and the presence of clinical signs such as a positive Tinel sign at the wrist and a positive score on Phalen’s provocation test. All patients had abnormal nerve conduction and no patients responded to 3 months of treatment with splinting and nonsteroidal anti-inflammatory medication prior to their release.

The patients, 6 men and 20 women, ranged in age from 31 years to 67 years (mean, 44 years). The surgery was performed on 21 right and 9 left hands. The average follow-up period was 13 months (range, 6 months to 42 months).

The patients were assessed for grip strength, hypesthesia, muscle atrophy, positive Tinel sign, and positive Phalen sign. Grip strength was measured with a dynamometer. Sensory disturbance was assessed by checking light touch sensibility. The Tinel sign was performed with a reflex hammer dropped from 5 inches onto the distal wrist crease. A positive response required tingling or pain in the fingers. The Phalen sign was checked with the wrist flexed 60 seconds; a positive response required pain or tingling in the fingers.

Patients were asked to rate on scales their symptoms, hand finger function and satisfaction. The symptom severity scale had 11 items including daytime pain, nocturnal pain, paresthesia, numbness, and weakness. The functional status scale had 8 items: difficulty in writing, buttoning clothes, holding a book, gripping the telephone, opening jars, performing household chores, carrying grocery bags, and bathing and dressing. For each item on the symptom and functional scales, there were five possible responses: ‘no difficulty’, ‘mild’, ‘moderate’, and ‘severe difficulty’; and ‘so difficult, cannot do it’. Each scale score was calculated as the mean of the responses to the individual items. Satisfaction scale had one item with five response categories, ‘completely satisfied’, ‘very satisfied’, ‘somewhat satisfied’, ‘unsatisfied’, and ‘very unsatisfied’. These responses were put into 2 categories: ‘completely or very satisfied’ versus ‘somewhat satisfied, unsatisfied, or very unsatisfied’.

We set the statistical significance at p< 0.05 using paired t-test and the chi-square test.

**SURGICAL TECHNIQUE**

The superficial palmar arch and the ulnar artery were marked using a Doppler ultrasonic hemodrometer (Fig. 1). After injection of a local anesthetic, a transverse incision of 1 cm was made in the anesthetized area and in the fascia of the same region. An obturator was then inserted into the carpal tunnel from the ulnar side of the palmaris longus tendon. After removing the obturator a clear plastic outer tube was introduced. The arthroscope was inserted through the clear plastic tube. The median nerve, flexor tendon, and transverse carpal ligament could be observed (Fig. 2A). A retrograde hook knife was introduced along the ulnar side of the clear plastic tube. The transverse carpal ligament was incised under endoscopic guidance. It was released at the ulnar side (Fig. 2B). Finally, the distal portion of the flexor retinaculum (DFR) was incised (Fig. 2C). The skin incision was closed with a single stitch. The following day, patients were encouraged to perform a range of gentle and active motion exercises. Sutures were removed 1 week following surgery, and the patient was instructed to use the hand within comfort zones for the first 2 weeks. Return to work depended on the amount of manual use required for each patient’s occupation — no absolute recuperation period was recommended.
Figure 1  Marking of the superficial palmar arch and the ulnar artery. A variation in the location and development of the superficial palmar arch and the ulnar artery can be seen.

Figure 2  Endoscopic observations. (a) The transverse carpal ligament is observed. (b) Release of the transverse carpal ligament. The released ends of the transverse carpal ligament are only separated by 2 mm. (c) The released ends of the transverse carpal ligament are separated by 6 mm or more after release of the distal portion of the flexor retinaculum.
RESULTS

Clinical results

Physical findings are shown in Table 1. Grip strength improved considerably from a preoperative mean value of 17.5 kg to 31.3 kg at the final follow-up (p < 0.001). Preoperatively, the specific symptoms were hypesthesia in 28 hands, muscle atrophy in 22, positive Tinel sign in 26, and positive Phalen sign in 29. At the final follow-up, some specific symptoms persisted: hypesthesia in 9 hands, muscle atrophy in 10, positive Tinel sign in 3, and positive Phalen sign in 1. The decreases were significant (p < 0.001).

Table 2 shows the mean values with standard deviations of symptom severity and functional status scores preoperatively and at the final follow-up. The symptom severity and functional status mean scores improved from 3.01 and 3.20 preoperatively to 1.44 and 1.54 at the final follow-up (p < 0.001). The profiles of the specific symptoms are also shown in Table 2. All specific symptom scores improved significantly following surgery (p < 0.001).

Patient satisfaction (Table 3)

Twenty-two of the 26 patients (85%) indicated that they were completely or very satisfied with the surgical results at the final follow-up.

Return to activities of daily living and work

The average time to return to activities of daily living and work were 7.3 days (range, 6 days to 11 days) and 18.4 days respectively (range, 14 to 22 days).

Complications

There was no injury to the neurovasculature structures, painful scarring, pillar pain, or infection.

<table>
<thead>
<tr>
<th>Finding</th>
<th>Preoperative evaluation</th>
<th>Postoperative evaluation</th>
<th>p value of difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grip strength (kg) (mean ± SD)</td>
<td>17.5 ± 8.2</td>
<td>31.3 ± 11.6</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Hypesthesia</td>
<td>28 (93)</td>
<td>9 (30)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Muscle atrophy</td>
<td>22 (73)</td>
<td>10 (33)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Positive Tinel sign</td>
<td>26 (87)</td>
<td>3 (10)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Positive Phalen sign</td>
<td>29 (97)</td>
<td>1 (3)</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

The values represent the number of hands treated (%)

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Preoperative evaluation</th>
<th>Postoperative evaluation</th>
<th>p value of difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symptom severity scale</td>
<td>3.01 (0.77)</td>
<td>1.44 (0.34)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Daytime pain</td>
<td>2.97 (0.67)</td>
<td>1.50 (0.71)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Nocturnal pain</td>
<td>3.00 (0.64)</td>
<td>1.49 (0.61)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Paresthesia</td>
<td>3.00 (0.87)</td>
<td>1.57 (0.62)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Numbness</td>
<td>3.30 (0.95)</td>
<td>1.44 (0.62)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Weakness</td>
<td>3.07 (0.91)</td>
<td>1.33 (0.59)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Functional status scale</td>
<td>3.20 (0.86)</td>
<td>1.54 (0.48)</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

Values are mean (SD); scales range from 1, no symptoms, to 5, most severe.
DISCUSSION

The usefulness of the OCTR technique for carpal tunnel syndrome has been recognized by various investigators. OCTR has been reported to bring about an improvement in symptoms in more than 80% of all cases. However, OCTR involves a surgical skin incision from the centre of the palm extending up the wrist. This incision is necessary to avoid injuries to the palmar cutaneous branch of the median nerve, and certain other neurovascular structures. Although numbness is significantly improved by OCTR, reported problems include scar tenderness, injury to the motor branch of the median nerve, infection, and stiffness arising from post-operative bed rest. With progress in arthroscopic techniques and related equipment, ECTR has become feasible. This procedure gives a good surgical outcome with less scar tenderness and an earlier rehabilitation compared with OCTR.

If complete transverse carpal ligament release is done, there cannot be any difference in the recovery of paralysis of carpal tunnel syndrome regardless of size of skin incision. Many studies found no difference in surgical outcomes between OCTR and ECTR. ECTR likewise is reported to produce good results in a high percentage of cases. If the skin incision is minimal, complaints at the site of skin incision are not frequent.

Since June 1996, to achieve less surgical invasiveness and early rehabilitation, we selectively performed ECTR using the universal subcutaneous endoscope (USE) system by a single portal technique instead of conventional OCTR. Our data show significant improvements in the severity, functional status and neuromuscular impairments following ECTR. The average time to return to activities of daily living and work were 7.3 days and 18.4 days respectively, and 85% of the patients were completely or very satisfied with the surgical results. However, ECTR involves the risk of injury to neurovascular structures. To prevent arterial injury, we mark the superficial palmar arch and ulnar artery with a Doppler ultrasonic hemodrometer before surgery and to prevent nerve injury, we release the transverse carpal ligament using the USE system. There were not any arterial or nerve injuries in our 30 operations.

The majority of arterial injuries associated with ECTR involve the ulnar artery and the superficial palmar arch. Injuries to the ulnar artery and superficial palmar arch occur in 2.3 to 4.2%, and 0.6 to 2.3% of all cases respectively. Injuries to the ulnar artery are due to inaccurate insertion of the cannula, and injuries to the superficial palmar arch occur when the transverse carpal ligament is released. Lee et al., in a cadaveric study, reported that the distance from the distal end of the transverse carpal ligament to the superficial palmar arch was on average 1.2 cm and varied greatly (0.0 to 2.7 cm) from one individual to another. We also noticed an individual difference in the laterality of the superficial palmar arch and ulnar artery as illustrated in Figure 2. The variation poses a risk of injury to the superficial palmar arch when a cannula is inserted and when the transverse carpal ligament is released. We believe that these potential vascular injuries from ECTR can be prevented by confirming and marking the superficial palmar arch and ulnar artery with a Doppler ultrasonic hemodrometer before surgery. We are able to prevent arterial injuries by releasing the transverse carpal ligament with a hook knife while ensuring that the light at the tip of an arthroscope, in a clear plastic tube, does not go beyond the marked artery. With this procedure, we have encountered no arterial injuries, so we recommend it as a useful technique to prevent arterial injuries.

A number of studies on nerve injuries associated with ECTR have been reported. Transient numbness of the ulnar nerve has the highest incidence at 0.2 to 8%, followed by injuries to the median nerve at 0.2 to 1.3%, injuries to the digital nerve at 0.3 to 2% and injuries to the communicating branch of the median nerve and ulnar nerve at 0.1 to 1%. Inaccurate insertion of a cannula into the Guyon’s canal is accountable for transient numbness of the ulnar nerve. Injuries to the median nerve and injuries to the communicating branch of the median nerve and ulnar nerve occur when the transverse carpal ligament is released. According to Chow et al., these combined injuries are often found in early stage cases, or are correlated with a learning curve, with the incidence of these injuries being inversely proportional to the number of years of experience on the part of the surgeon. Thus, they recommend learning the surgical technique on cadaveric specimens. We received training from surgeons experienced in the technique.

<table>
<thead>
<tr>
<th>Patient satisfaction</th>
<th>No. of patients (%)</th>
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<tbody>
<tr>
<td>Complete satisfied</td>
<td>10 (39)</td>
</tr>
<tr>
<td>Very satisfied</td>
<td>12 (45)</td>
</tr>
<tr>
<td>Somewhat satisfied</td>
<td>3 (12)</td>
</tr>
<tr>
<td>Unsatisfied</td>
<td>1 (4)</td>
</tr>
<tr>
<td>Very unsatisfied</td>
<td>0 (0)</td>
</tr>
</tbody>
</table>

Table 3

Clinical study of surgical treatment of carpal tunnel syndrome
and practiced on cadavera. This was helpful in preventing neurovascular injuries and helped us obtain good surgical results.

The USE system has an external cannula located on the ulnar side of the median nerve, so the distance between a hook knife inserted along the ulnar side of the external cannula and the median nerve is 6 mm, or the width of the external cannula. Therefore, the danger of injuring the median nerve appears to be very low when releasing the transverse carpal ligament. Release of the transverse carpal ligament under complete endoscopic vision is important to prevent injury to the median nerve and digital nerves, as recommended by Okustu et al.16 Incomplete release of the transverse carpal ligament poses a greater problem with ECTR than with OCTR. The incidence of incomplete release with ECTR was reportedly high, 10% to 50% in a cadaver study11,22 and low, 0.1 to 6% in clinical studies.1,5 Confirming accurately whether the release is complete or incomplete is difficult in clinical cases. In actual clinical practice, the incidence of incomplete release may be higher. Therefore, the possibility of release being incomplete cannot be ruled out even when numbness improves. Incomplete release may be tolerated if numbness is improved significantly. However, some studies reported cases where numbness recurred and symptoms increased after incomplete release.1,4,18

Measures to prevent incomplete release will now be considered. Okutsu et al.17 reported a distance between the cut ends of approximately 2 mm with complete release of the transverse ligament alone, but that the distance between the cut ends increases to more than 6 mm when the distal portion of the flexor retinaculum (DFR), located distal to the transverse carpal ligament, is released, demonstrating the importance of releasing both the DFR and the transverse carpal ligament. We have confirmed this in Figures 2B and 2C, and we have observed by postoperative magnetic resonance imaging that the transverse carpal ligament is completely released (Figs. 3a and 3b). Therefore, it is important to release up to the DFR to prevent incomplete release.

CONCLUSION

Marking the superficial palmar arch and ulnar artery with a Doppler ultrasonic hemodrometer before surgery is a useful technique for preventing injury to the artery. It is important to release not just up to the transverse carpal ligament but up to the DFR to ensure complete release. If performed carefully, ECTR can produce satisfactory results without complications. Thus, we will continue to selectively perform ECTR to surgically treat carpal tunnel syndrome.

Figure 3 Preoperative and postoperative magnetic resonance imaging. (a) Preoperative magnetic resonance imaging. The arrows show the transverse carpal ligament. The axial image Delineated the carpal bones and transverse carpal ligament walls of the carpal canal. H, hook of the hamate; T, beak of the trapezium. (b) Postoperative magnetic resonance imaging. The arrows show the sites of the sectioned transverse carpal ligament. There is a significant increase of the carpal canal cross-sectional area compared with preoperative magnetic resonance image findings.
REFERENCES