Reducing ECTR Neurological and Vascular Complications using a Modified Chow Technique.

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Abstract
Purpose: To reduce the rate of nerve, the tendon or the vascular injuries occurring during Chow's two-portal technique, we developed a modified procedure. The surgical technique was introduced and the results were evaluated with regard to the clinical findings, nerve conduction studies, and the DASH score.
Methods: One hundred and nineteen hands of 119 patients with idiopathic carpal tunnel syndrome were subjected to our procedure wherein a cannula assembly was inserted after a partial division of both distal and proximal parts of the transverse carpal ligament through the entry and exit portals. Postoperative examinations, including grip and pinch strengths, tenderness over and around the wounds, and nerve conduction studies, were performed at 1, 3, 6, and 12 months. Numbness and the DASH score were also evaluated pre- and postoperatively. The rate of structural damage to the median nerve, the tendon, and the artery was calculated.
Results: The patients resumed their daily activities or work 13 days postoperatively. Tenderness around the wounds was detected in 66% of the patients 3 months postoperatively. Numbness disappeared or decreased in 99% of the patients 6 months postoperatively. The DASH score was available for 82 patients, and it improved from 28.2 to 18.3 postoperatively. Nerve conduction studies indicated a significant decrease in motor distal latency postoperatively. Temporal worsening of the median nerve function was observed in 2 patients, however no structural damage to the nerve, tendon, or artery was observed.
Conclusion:
Our modified technique will reduce or minimize the risk of nerve, tendon or arterial injuries.
Level of evidence: (4)
Key words: carpal tunnel syndrome, endoscopic carpal tunnel release, technique, complication

Introduction

Chow's two-portal technique has been widely used to release the transverse carpal ligament (TCL) in patients with idiopathic carpal tunnel syndrome. Although uncommon, damage to the superficial palmar arch and the branch of the median nerve has been reported. Further, migration of the median nerve and the flexor tendons into the slotted cannula has been observed during the procedure (1,2,3,4). A systematic review of the literature revealed transient neurapraxia (1.45%) to be the most common problem encountered following Chow's ECTR; structural damage to the nerve, tendon and artery accounted for 0.2% of complications (5). Some surgeons prefer to create a larger distal portal to identify the superficial palmar arch and the common digital nerve before inserting the cannula assembly (6,7). Lewicky developed the guide tube technique to reduce the risk of damage to these structures (8). The advocates of ECTR insist that the procedure is quickly learnt and only new surgeons encounter these risks (9). However, an analysis of 87 hands that underwent ECTR and 65 hands that underwent open carpal tunnel release (OCTR) demonstrated that median nerve damage, although transient or not serious, might occur even when the original Chow's method is performed correctly by an experienced hand surgeon (10). The pathomechanisms of median nerve injury during Chow's ECTR could be a compression or stretch of the median nerve during the insertion of the cannula assembly inside the carpal tunnel. Injury of the superficial palmar communication between the median and the ulnar nerves, occurs when the cannula assembly is pushed out of the exit portal (6,10,11). Increased pressure inside the carpal tunnel develops while the wrist is mounted on the hand holder and is exacerbated by the prolonged duration of the procedure. We have modified the original procedure by dividing the TCL distally and proximally before the insertion of the cannula assembly. We hypothesized that our modified procedure would minimize the risk of median nerve, tendon or arterial injuries.

Patients and Methods

From March 2003 to April 2006, a total of 163 carpal tunnel release surgeries were performed in 142 patients with carpal tunnel syndrome at our institution using the modified Chow's two-portal technique; these cases were prospectively included in this study. The inclusion criteria were idiopathic carpal tunnel syndrome, no previous carpal tunnel surgery, no double lesions such as cervical myelopathy, and no systemic disease. The ethical committee in this hospital approved the study protocol. Carpal tunnel syndrome was diagnosed based on clinical history, findings of a

physical examination, nerve conduction studies, and magnetic resonance imaging (MRI). Two patients underwent simultaneous ulnar nerve anterior transposition and these were excluded. Twenty-one patients were excluded because they were lost to follow-up within 3 months postoperatively. In the case of the 18 patients, for whom surgery was performed on both hands simultaneously, only the worse-affected side was included in the analysis. Three patients underwent bilateral surgeries separately and the hand receiving the second surgery was not analyzed. Thus, a total of 119 hands of 119 patients were analyzed. Of these, 18 were males and 101 were females. Their ages ranged from 27 to 88 years (average, 61). The duration of symptoms, as reported by the patients, ranged from 1 to 360 months (average, 52). Two patients who had experienced numbness for 1 month before their first visits to our hospital had muscle atrophy in the thenar area, indicating that the disease had developed before they were aware. MRIs of their wrists were consistent with idiopathic carpal tunnel syndrome. Seventy-seven patients complained of symptoms in both the hands. In 82 patients, the dominant hand was involved. There were no patients who used workmen's compensation insurance.

As physical examinations, we recorded the area of sensory disturbance, grip strength, key pinch strength and the presence of trigger finger. Scar tenderness or tenderness around the wounds was recorded as positive when the patient complained of any degree of pain under the pressure exerted by the examiner's thumb. Nerve conduction studies (NCS) were performed using a Neuropack MEB-5504 (Nihon Kohden, Tokyo) as described previously (13). Motor distal latency (MDL), the amplitude of compound muscle action potential (CMAP), sensory conduction velocities (SCV) and the sensory nerve action potential (SNAP) were recorded. In our institution, an MDL of less than 4.4 ms and an SCV of more than 44m/s were defined as normal. The reproducibility and accuracy of measurement were described previously (12). Based on NCS, the preoperative severity of the disease was classified into 4 stages (12). Among the 119 patients, the disease was adjudged mild in 3 patients, moderate in 13, severe in 91, and extremely severe in 12. Postoperative physical examinations were carried out by each of the authors based on their daily shifts for outpatient consultations. NCS were carried out by technicians. These examinations were performed preoperatively and at 1, 3, 6, and 12 months postoperatively. The disability of the arm, shoulder and hand (DASH) scores were available for 82 patients both pre- and postoperatively. The postoperative DASH score was reported by 59 patients at 3 months, by 12 at 6 months, and by 11 at 12 months. We

carefully evaluated the postoperative worsening of the median nerve function, which was defined as the aggravation of the MDL or SCV, or the aggravation of numbness.

Repeated measures were used to evaluate the effect of postoperative duration on the MDL and SCV values, the amplitude of the CMAP and SNAP, and the grip and pinch strengths. A post hoc test was performed using the paired t- test. The pre- and postoperative DASH scores were compared, using a paired t- test. The factors that may have affected the worsening of the DASH score were evaluated, using a chi-squared test. The correlation coefficient between the improvement of the stage of the disease and the age was calculated, as was that between the improvement of stage of the disease and preoperative severity. A P value of less than 0.05 was considered to be statistically significant.

Surgical Technique

The surgery was performed under local anesthesia using a pneumotourniquet. Using unaided vision, the forearm fascia that lies proximally, and the proximal part of the TCL that lies distally over the median nerve were divided longitudinally for approximately 5 to 10 mm through an entry portal. An exit portal of 1cm was made over the triangular zone located immediately distal to the distal edge of the TCL. Under unaided vision, it was identified and divided to approximately 5 to 8 mm. Then the cannula assembly was inserted into the carpal tunnel. Carpal tunnel release was completed by simply connecting the two divisions proximally and distally, using a hook knife. After the cannula was withdrawn, an endoscope was inserted into the proximal portal to examine the median nerve and the cut edges of the TCL along the entire course of the carpal tunnel.

Results

The postoperative follow-up period was 3 months for 17 patients, 6 months for 63, and 12 months for 39; the average period follow-up period was 7.5 months. For some patients, data acquisition was incomplete, thus resulting in missing data. Since due to symptom improvement. many of the patients were satisfied with the results at 6 month, 63 of them did not return to the office for the 12 month follow-up. ECTR was not converted to OCTR in any of the patients; instead, the distal skin incision was slightly extended up to 7 mm to identify and cut the distal part of the TCL.

The operation time ranged from 8 to 23 min (average time, 15 min).

The total length of the operative wound ranged from 2 to 3 cm (average length, 2.2cm).

Migration of the flexor tendons or the median nerve into the slot was observed in none of the patients.

The results of subjective symptoms, physical findings, NCS, and the return to daily activities or work are listed in Tables 1, 2, and 3. The findings are briefly described as follows.

All the patients complained of numbness preoperatively but only one patient claimed that numbness persisted at the 6 month follow-up. The numbness that had worsened in 1 patient had disappeared completely by 12 months postoperatively (Table 1).

Overall, the DASH score improved significantly from 28.2 to 18.3 postoperatively ($P < 0.001$). However, in 19 of the 53 patients 3 months postoperative DASH score had worsened when compared with their preoperative score. These patients experienced a longer duration of preoperative symptoms ($P = 0.0014$), persistent numbness ($P = 0.038$), and the presence of trigger finger or deQuervain disease 3 months postoperatively ($P = 0.034$).

Postoperatively, 35 patients developed trigger finger and 1 patient developed deQuervain disease in the involved hand.

The MDL improved over a period of time ($P < 0.0001$).

Compared to the preoperative values, only 1 patient exhibited worsening of the MDL at 1 month postoperatively and this had improved within 6 months. The average amplitude of CMAP improved as time elapsed ($P < 0.0001$). It became greater than the preoperative value at 3 months postoperatively ($P = 0.0083$)(Table 3).

Among the 103 patients monitored at 6 month postoperatively, the severity was normal in 24 patients, mild in 9, moderate in 27, severe in 36, and extremely severe in 7. There was an average improvement of 1 stage during the 6month's follow-up. A significant correlation was observed between the improvement of stage and age ($r = -0.24$, $P = 0.013$), but not between the improvement of stage and preoperative severity ($r = -0.049$, $P = 0.63$).

The postoperative worsening of the median nerve function was observed in only 2 patients. This worsened function was manifested as increased numbness or a difficulty in pinching using the thumb and the little finger accompanied by a worsened MDL; these conditions had resolved by postoperative months 12 and 6, respectively. Thus, the rate of temporal worsening of the median nerve function after our procedure was 1.7%. Structural damage to the nerve, tendon or artery was observed in none of the patient.

Discussion

The principal finding of this study was that the rate of transient median nerve injury was 1.7% and no structural damage to the nerve, tendon or artery was observed. The return to daily activity or work was on average 13 days postoperatively. We believe that the division of both proximal and distal edges of the TCL is important to reduce the resistance encountered while inserting the cannula assembly into the tunnel; resistance may be encountered because the carpal tunnel is the narrowest at the level of the hook of the hamate.

Our procedure also reduced concern regarding the damage to the group 2 communicating branch between the ulnar and median nerves; this branch is parallel and very close to the TCL (14).

However, temporal median nerve damage was still observed in 2 patients. In 1 patient who complained of recent numbness postoperatively, significant resistance was experienced when the cannula assembly was pushed out of the canal. This could have been avoided if the incision of the exit portal had been extended, and if the distal part of the TCL had been cut long before the insertion of the cannula assembly. Another patient who complained of

weakness of thumb opposition exhibited worsening of the MDL with decreased amplitude of CMAP at 1 month postoperatively. In this case, mild resistance was encountered while inserting the cannula assembly and the surgery was uneventful. The numbness decreased immediately after the surgery; a particular recurrent motor nerve might have been responsible for the weakness. This observation was not unique to ECTR; it has also been observed after OCTR (10).

Although the rate of the transient median nerve damage was lower using the modified procedure than when using the original Chow's ECTR reported previously by us (15%) (10) and Kiymaz et al.(13%) (15), Chow et al. and Qualietta, et al. reported an even lower rate of transient damage of the nerve (4,9). This difference may partly arise from the definition of transient nerve damage. There is a possibility that the other series did not include cases with no apparent worsening of the symptoms but accompanied by a definite worsening of motor distal latency. This type of damage is peculiar to ECTR and can often be overlooked (10). Furthermore, the size of the hand may also be responsible. Most of our data were derived from Japanese women who have relatively small hands. It may be difficult to insert the cannula assembly into small hands with small carpal tunnels (16). However, most importantly, permanent injuries to the structures that might occur, for example, when sectioning the perineurium of the median nerve (3,5), or when sectioning the superficial palmar artery (5), are unlikely to occur while performing the modified procedure.

We strongly recommend that the inside of the carpal tunnel should be observed endoscopically after removing the slotted cannula. One of the drawbacks of ECTR is the incomplete release of the TCL (17). This can be easily and effectively resolved if the endoscope is inserted into the carpal tunnel from the entry portal and the stumps of the TCL are confirmed from proximal end toward the distal end.

Using our technique, it can be somewhat difficult to divide the distal part of the TCL under unaided vision through a small skin incision. However, we believe that the surgeons should not limit themselves to making a small incision; rather the incision should be extended until the distal part of the TCL is confirmed. This is of prime importance to enable the safe release of the TCL. Further, we found that this technique could be accomplished with ease and within 10 minutes once sufficient experience is acquired. If the surgeon is familiar with the original technique, this modified technique can

be easily mastered after a few trials.

There are concerns as to whether our procedure is really effective in enabling patients to regain the functional use of the involved hand soon after the operation. The grip strength had decreased at 1 month postoperatively due to pain over the wound; this phenomenon has been observed after all carpal tunnel release procedure. Although a direct comparison between our procedure and others is difficult because of ambiguity in the definition of resuming daily activities, and differences in the insurance used by the patients, the average period of 13 days may not be longer than that after the original Chow's ECTR.

Oertel et al reported that 92.7% of the patients who received ECTR returned to their normal daily activities between 3 weeks and 3 months postoperatively (3). Quaglietta et al. reported that the average times to return to daily life activity and work were 10 and 20 days, respectively (4). Chow et al. demonstrated that 65% of non-worker's compensation patients were able to return to work on or before 2 weeks, while only 60% of worker's compensation patients returned to work on or before 4 weeks postoperatively (9). Kahraman et al. reported that the average time to return to work or complete recovery was 12 days (18).

According to Oertel et al., pillar pain, which is defined as a diffuse pain syndrome in the area of the wrist, was noted in 7.3% of the patients after ECTR (3). Kahraman et al. reported that 3 out of 30 hands had pillar pain after ECTR (18). Our procedure divides the TCL, whereas the subcutaneous fat and the palmar fascia are left intact. Although the sensory nerve over the palm was preserved, some scar tenderness or tenderness around the TCL edges persisted in 66% of the patients at 3 months postoperatively. We defined tenderness at the scar or around the scar as positive when the patient experienced any degree of pain under pressure exerted by the examiner's thumb. Ideally, a quantitative method to evaluate scar tenderness should have been employed to enable a comparison of the results of the different procedures.

There were limitations to the present study. Firstly, as there was no control, we could not compare our results with the original technique in a prospective manner. Secondly, the follow-up periods were not sufficiently long enough to confirm any recurrence of the symptoms. Thirdly, the DASH score was limited to 82 patients; in retrospect, the Boston carpal tunnel syndrome questionnaire should have been employed because it can be more responsive to symptom changes.

Conversely, the strength of this study is that NCS were repeatedly performed so that postoperative nerve damage was very closely monitored.

Conclusion

By virtue of its safety and efficacy, we recommend our modified technique for the release of the TCL.

References

1. Chow JCY. Carpal tunnel release. In: McGivney JB. ed. *Operative Arthroscopy* Philadelphia: New York: Lippincott-Raven, 1996:1041-1066.

2.Nagle DJ, Fischer TJ, Harris GD, et al. A multicenter prospective review of 640 endoscopic carpal tunnel releases using the transbursal and extrabursal chow techniques.
Arthroscopy 1996;12:139-143.

3. Oertel J, Schroeder HWS, Gaab MR. Dual-portal endoscopic release of the transverse ligament in carpal tunnel syndrome: results of 411 procedures with special reference to technique, efficacy, and complications. Neurosurgery 2006;59:333-339.

4. Quaglietta P, Corriero G. Endoscopic carpal tunnel release surgery: retrospective study of 390 consecutive cases. *Acta Neurochir Suppl* 2005;92:41-45.

5. Benson LS, Bare AA, Nagle DJ, Harder VS, Williams CS, Visotsky JL. Complications of endoscopic and open carpal tunnel release. Arthroscopy 2006;22:919-924.

6. Arner M, Hagberg L, Rosen B.
Sensory disturbances after two-portal endoscopic carpal tunnel release: a preliminary report. *J Hand Surg [Am]* 1994;19:548-551.

7.Seiler JG 3rd, Barnes K, Gelberman RH, Chalidapong P.
Endoscopic carpal tunnel release: an anatomic study of the two-incision method in human cadavers. *J Hand Surg [Am]* 1992;17:996-1002.

8. Lewicky RT. Endoscopic carpal tunnel release: the guide tube technique. *Arthroscopy* 1994;10(1):39-49.

9. Chow JC, Hantes ME. Endoscopic carpal tunnel release: thirteen years' experience with the Chow technique. *J Hand Surg [Am]* 2002;27(6):1011-1018.

10. Uchiyama S, Yasutomi T, Fukuzawa T, Nakagawa H, Kamimura M, Miyasaka T. Median nerve damage during two-portal endoscopic carpal

tunnel release. *Clin Neurophysiol* 2004;115(1):59-63.

11. Stancic MF, Micovic V, Potocnjak M.
The anatomy of the Berrettini branch: implications for carpal tunnel release. *J Neurosurg* 1999;91(6):1027-1030.

12. Uchiyama S, Itsubo T, Yasutomi T, Nakagawa H, Kamimura M, Kato H. Quantitative MRI of the wrist and nerve conduction studies in patients with idiopathic carpal tunnel syndrome. *J Neurol Neurosurg Psychiatry* 2005; 76:1103-1108.

13.Uchiyama S, Toriumi H, Nakagawa H, Kamimura M, Ishigaki N, Miyasaka T. Postoperative nerve conduction changes after open and endoscopic carpal tunnel release. *Clin Neurophysiol* 2002;113:64-70.

14. Ferrari GP, Gilbert A. The superficial anastomosis on the palm of the hand between the ulnar and median nerves. *J Hand Surg* 1991:16B:511-514.

15. Kiymaz N, Cirak B, Tuncay I, Demir O.
Comparing open surgery with endoscopic releasing in the treatment of carpal tunnel syndrome. *Minim Invasive Neurosurg* 2002;45(4):228-230.

16. Schonauer F, Belcher HJCR. Anthropometry and endoscopic carpal tunnel release. J.Hand Surg. 1999; 24B:6-8.

17. Stutz N, Gohritz A, van Schoonhoven J, Lanz U. Revision surgery after carpal tunnel release-analysis of the pathology in 200 cases during a 2 year period.
J Hand Surg 2006 31B:1:68-71.

18. Kahraman CS, Kafadar A, Akboru MM, Atabey CC. Endoscopic carpal tunnel release using the biportal technique. *Military Medicine* 2006;171:150-152.

19. Greenslade JR, Mehta RL, Belward P, Warwick DJ.
Dash and Boston questionnaire assessment of carpal tunnel syndrome outcome: what is the responsiveness of an outcome questionnaire? *J Hand Surg* 2004 ;29B:159-164.

Table 1. Pre- and postoperative subjective findings, physical findings, and DASH scores

	Preoperative	Postop. 1 month	Postop. 3 months	Postop. 6 months	Postop. 12 months
Numbness	119	N = 119	N = 119	N = 102	N = 39
None	complained	27	53	68	27
Decrease compared with the previous exam.		75	58	33	11
No change		16	8	1	1
Worse		1	0	0	0
Nocturnal pain	N = 119	N = 119	N = 119		
None	52	117	119		
Positive	67	2	0		
Tenderness over or around the scar	N = 119	N = 119	N = 119	N = 102	N = 39
None	119	11	41	85	39
Positive	0	108	78	17	0
Grip strength (kg)	N = 119	N = 115	N = 116	N = 100	N = 39
Mean ± SD	17.9 ± 8.6	12.1 ± 6.6	16.1 ± 7.6	18.5 ± 8.2	19.4 ± 7.1
		P < 0.001	*P* = 0.0025	*P* = 0.18	
Key pinch strength (kg)	N = 118	N = 114	N = 114	N = 99	N = 38
Mean ± SD	5.5 ± 1.9	5.2 ± 1.8	5.6 ± 1.9	6.0 ± 2.0	6.1 ± 2.0
		P = 0.008	*P* = 0.58	*P* < 0.001	
DASH score	N = 82		N = 53	N = 18	N = 11
	28.2 ± 18.4		22.0 ± 16.4	13.4 ± 10.9	10.1 ± 6.7
			P = 0.502	*P* < 0.001	*P* < 0.001

***P*-value is expressed as compared with the preoperative value.**

Table 2.

Periods of return to daily activities or work in the various occupations

Occupation (n)	Average age	Average days to return
Housewife (39)	66	12 (1–62)
Education, Training, and Library (3)	44	20 (14–28)
Health Support (3)	52	24 (4–60)
Food Preparation and Serving Related (4)	59	4 (1–9)
Building and Ground Cleaning and Maintenance (3)	56	13 (7–21)
Personal Care and Service (4)	52	20 (1–60)
Sales and Related (5)	51	10 (5–21)
Office and Administrative Support (4)	57	11 (1–28)
Farming, Fishing, and Forestry (4)	64	12 (1–21)
Construction and Extraction (5)	53	12 (2–31)
Production (10)	52	11 (1–30)
Transportation (1)	51	10

Housewives: return to daily activities. Others: return to work.

No patients used workmen's compensation insurance.

Table 3: Average value of parameters of nerve conduction studies before and after surgery.

	Preoperative N = 119	Postop. 1 month N = 118	Postop. 3 months N = 116	Postop. 6 months N = 101	Postop. 12 months N = 37
MDL (ms)	7.7 ± 2.3 (106)	6.0 ± 1.6 (104)	5.3 ± 1.3 (107)	4.9 ± 1.3 (96)	4.9 ± 1.1 (37)
Amplitude CMAP (mV)	7.1 ± 5.2	7.1 ± 5.0	7.4 ± 5.3	9.2 ± 5.5	8.6 ± 4.9
SCV (m/s)	35.7 ± 5.2 (16)	38.3 ± 5.4 (48)	42.1 ± 5.0 (58)	43.7 ± 5.0 (61)	43.5 ± 5.6 (24)
Amplitude SNAP (μV)	4.0 ± 2.7	4.3 ± 3.1	5.9 ± 4.4	6.9 ± 4.8	6.6 ± 4.4

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MDL: motor distal latency, CMAP: compound muscle action potential, SCV: sensory nerve conduction velocity,
SNAP: sensory nerve action potential. The patients who had undetectable MDL or SCV were excluded.
The number of hands examined is indicated in parentheses.
Normal value of MDL < 4.4 ms, SCV > 44 m/s.