A COMPARISON OF TWO LIMITED OPEN TECHNIQUES FOR CARPAL TUNNEL RELEASE

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Review of the literature shows the effectiveness of limited open carpal tunnel release to be comparable to that of endoscopic carpal tunnel release in respect of recovery of grip strength, time of return to work and complication rate. A randomised, controlled study was designed to compare the effectiveness of a single versus a double limited open technique of carpal tunnel release. Sixty-five patients (73 hands) with a mean age of 48 years were operated on, 40 hands by the single incision and 33 by the double incision method. Grip and pinch strengths, digital sensibility (Filament and 2PD tests) and Levine scores were evaluated throughout 12 months of follow-up. We found that the single incision method offers better results in respect of grip and pinch strengths: less weakness at 1 month after surgery and a faster improvement relative to pre-operative values which is statistically significant. This, however, did not translate directly into Levine functional and symptom scores which, at each assessment, did not differ significantly between the two methods.
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Controversy persists regarding the effectiveness and safety of various methods of carpal tunnel release, including conventional open (an incision going from proximal palm onto the distal forearm), limited open and endoscopic techniques. The endoscopic method is considered by some surgeons to be superior to open release because of reduced tissue trauma and post-operative morbidity, with faster return to normal activities, including return to work. However, it is still considered to have a higher complication rate (Boeckstynks and Sorensen, 1999; Nagle, 2002). Limited open carpal tunnel release with two incisions was introduced in 1993 (Biyani and Downes, 1993; Wilson, 1994) and with a single incision in 1994 (Abouzahr et al., 1995; Bromley, 1994). Review of the literature shows the effectiveness of limited open carpal tunnel decompression by either technique to be comparable to that of the endoscopic method in respect of reduced postoperative pain, quicker recovery, time of return to work, recovery of grip strength and complication rate (Cellocco et al., 2005; Higgins and Graham, 2002; Huang and Zager, 2004; Wong et al., 2003). Limited open carpal tunnel release techniques are also considered to be easier to perform and safer than the endoscopic method and do not require special equipment (Lee and Strickland, 1998; Richter and Brüser, 1996).

The operations in the ''limited open technique with single incision'' category include several variations. The length of the incision varies from 1.5 to 4 cm and additional instruments have been used to facilitate safe division of the transverse carpal ligament, including special cutting instruments with integrated light source or lighted nasal speculum (Abouzahr et al., 1995; Celocco et al., 2005; Higgins and Graham, 2002; Lee and Strickland, 1998; Wong et al., 2003). A light makes it possible to locate the tool blade precisely in the carpal tunnel by transillumination. Nakamichi and Tachibana (1997) used ultrasonographic monitoring to control the position of the cutting device in the proximal part of carpal tunnel. Although these techniques have not been commonly adopted by hand surgeons, several recent studies have shown their usefulness and supported the opinion that they provide an effective, reliable, and safe method of carpal tunnel release (Celocco et al., 2005; Higgins and Graham, 2002; Huang and Zager, 2004; Wong et al., 2003). Those who do not use any additional equipment suggest that the limited single incision technique allows identification and safe division of the transverse carpal ligament under direct vision (Biyani and Downes, 1993; Bromley, 1994; Richter and Brüser, 1996; Wilson, 1994).

Although there are many articles comparing endoscopic and open methods of carpal tunnel release, there is little in the literature comparing the various limited open methods. Since 1999, almost all cases of carpal tunnel syndrome referred to our Department have been released by one of two different limited open techniques so we designed a randomised, controlled study to evaluate the relative effectiveness of the two methods.

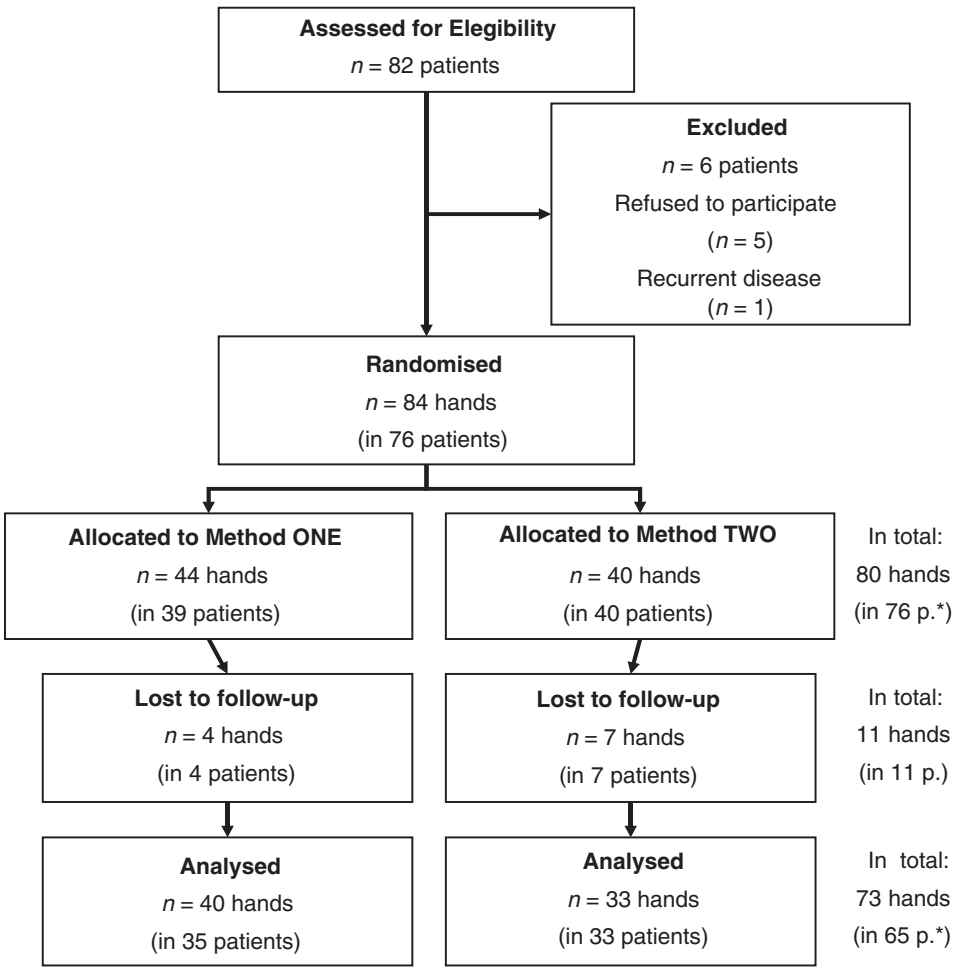
PATIENTS AND METHODS

Over the period July to December 2003, 82 patients with carpal tunnel syndrome underwent surgery. Six of 82 patients were excluded initially: five patients declined to participate in the study and one had recurrent carpal tunnel syndrome. Eleven of the 76 patients who were recruited did not attend for follow-up (four in group

ONE and seven in group TWO) and, eventually, this study included 65 patients. These included 50 women (77%) and 15 men (23%) with a mean age of 48 (range 41–60) years, in whom 73 hands underwent surgery. Fig 1 illustrates the flow of the patients in the study. Eight patients had bilateral carpal tunnel syndrome and the operation on the second hand was performed after a minimum interval of 3 months.

The diagnosis of carpal tunnel syndrome was based on clinical and electrophysiological findings. The duration of symptoms before operation averaged 5 months: in 35 patients it was shorter than 3 months, in 27 patients from 3 to 12 months and in three patients it was longer than 1 year. Some patients suffered from coexisting diseases: eight (12%) were diabetics, six (8%) had rheumatoid arthritis and 15 (23%) had a history of recent trauma to the affected hand. Thirty-seven patients (57%) had been treated conservatively by immobilisation of the wrist and analgesics or had local steroid injections before the operation.

Each patient was assessed 1 day before the operation. Digital sensibility was measured using Semmes–Weinstein monofilament testing. We also used two-point discrimination testing and have compared the sensitivity of this test to the more sensitive Semmes–Weinstein test. Measurements were performed on the thumb, index and middle fingers. The results were expressed in ranks: (1) touch detectable with a green filament, 2PD 6 mm, (2) touch detectable with a blue filament, 2PD 10 mm, (3) touch detectable with a purple filament, 2 PD q15 mm and (4) touch detectable with a red filament, 2PD > 15 mm, (Table 1). The measurements from each patient were summated and divided by three to provide the "Sensory Index" (Table 1). Thus, a Sensory Index of 1 indicates normal sensation in all three radial digits (thumb, index and middle fingers). A Sensory Index of



* The total number of patients is larger than the sum of the patient numbers from the two trial arms, because there were 3 patients with bilateral disease who received different types of surgery for their hands.

Fig 1 Flowchart of the patients in the study.

1.3 indicates normal sensation in two (1 + 1 ranking) and satisfactory sensation (2 ranking) in one finger (calculations: 1 + 1 + 2 = 4; 4/3 = 1.3). All the results of sensory testing are reported as Sensory Indices in this article.

Table 1—The "Sensory Index" which was used to quantify measurements with the Semmes-Weistein monofilaments and the two-point discrimination test

2PD test (mm)	*Thumb*	*Index*	*Middle*	*Sensory Index*
6	1	1	1	1
10	2	2	2	2
15	3	3	3	3
>15	4	4	4	4
S-W test	*Thumb*	*Index*	*Middle*	*Sensory Index*
Green filament	1	1	1	1
Blue filament	2	2	2	2
Purple filament	3	3	3	3
Red filament	4	4	4	4

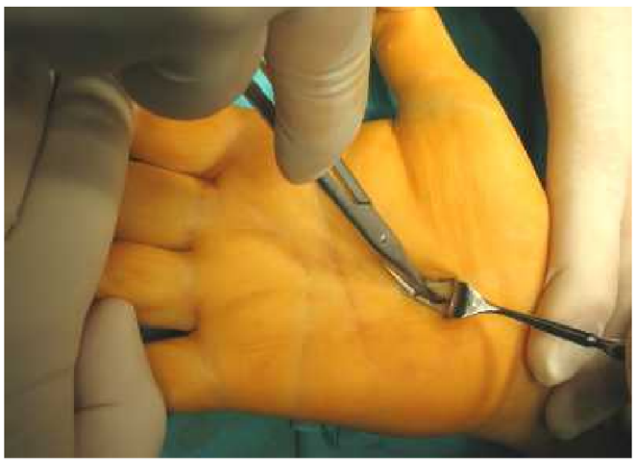


Fig 2 Incision and technique of the operation in Method ONE.

This method of quantification of digital sensibility measurements is new and invented in this Unit. Motor tests included measurement of total grip, two-point, three-point and key-pinch strength with a Jamar dynamometer and a pinch-meter from the set of DataLink (Biometrics and Co Ltd, Gwent, UK). All patients also completed the Levine questionnaire, which consists of a symptomatic and a functional part (Levine et al., 1993).

The operations were randomised blindly into two groups: one group (40 hands) was assigned to have one small incision (Method ONE) and the other group (33 hands) to have two small incisions (Method TWO). At the end of each month, the patients who were on the operation list on the next month were randomly assigned to the Method ONE or Method TWO. This was done by the senior author by drawing slips of paper from an envelope. Bilateral patients were randomised in the same way. Five of the eight bilateral patients received the same type of surgery (Method ONE) whereas three bilateral patients received different types of surgery on the two hands.

Method ONE was performed as described by Bromley (1994) with the length of the palmar longitudinal incision averaging 2 cm. Mini-retractors were used to facilitate identification of the transverse carpal ligament, which was divided with scissors under direct vision as far proximally as possible and, always, proximal to the distal wrist crease (Fig 2). The median nerve was not exposed, in most cases.

Method TWO was performed as described by Wilson (1994). A 1 cm transverse incision was performed at the level of the distal wrist crease, the median nerve was identified and, then, the proximal part of the transverse carpal ligament cut with scissors under direct vision as far distally as possible (Fig 3). A Kocher probe, as used for inguinal hernia surgery, was then passed through the carpal tunnel and a second, longitudinal incision of length 2 cm was made at the site of subcutaneous protrusion of the end of the Kocher probe, where it

Table 2—The results of sensory, motor, and Levine testing (median values of all measurements are given)

	Pre-operatively		*At 1 Month*		*At 3 Months*		*At 6 Months*		*At 12 Months*	
	Method		*Method*		*Method*		*Method*		*Method*	
	ONE	*TWO*	*ONE*	*TWO*	*ONE*	*TWO*	*ONE*	*TWO*	*ONE*	*TWO*
Total grip strength (kg)	16.6	18.1	16.1	14.9	20.3	18.9	23.4	23.0	24.2	24.1
Two-point pinch (kg)	2.2	2.6	2.0	2.1	2.6	2.4	2.9	2.9	3.0	3.0
Three-point pinch (kg)	3.0	3.5	2.8	2.8	3.4	3.2	3.7	3.9	3.8	4.2
Key pinch (kg)	4.0	4.7	4.0	4.1	4.8	5.0	5.3	5.7	5.4	5.9
Sensory Index (Static 2 PD test)	1.9	1.8	1.5	1.5	1.3	1.4	1.2	1.2	1.2	1.3
Sensory Index (S-W filament test)	2.0	2.1	1.7	1.8	1.5	1.6	1.4	1.4	1.3	1.4
Levine symptom score	3.3	3.4	2.6	2.9	1.6	1.8	1.4	1.4	1.1	1.2
Levine functional score	2.9	2.9	2.5	2.8	1.8	1.8	1.5	1.5	1.2	1.2

exited from the carpal tunnel. After identification of the probe subcutaneously, then deep to the palmar fascia, the distal part of the transverse carpal ligament was divided with scissors under direct vision.

All the procedures were performed under brachial block anaesthesia with the use of a tourniquet. Six surgeons, three consultants and three registrars with at least 2 years training in hand surgery, were involved in the operations. The registrars always operated with the assistance of the senior surgeon. The day after the operation, patients were discharged and, thereafter, were followed as outpatients.

All of the patients were assessed at 1, 3, 6 and, finally, at 12 months postoperatively. At each assessment, the sensory, motor and Levine tests described previously were repeated.

The results are presented as direct, median values (Table 2) and as a proportion of pre-operative values, which were assumed to be 100% for each variable (Table 3). Since the distribution of variables was not normal (Shapiro–Wilk test), the results were statistically verified using the Mann-Withney *U*-test. Statistical significance was calculated for per cent differences (postoperative relative to pre-operative values) at each follow-up assessment between Methods ONE and TWO. We considered this method of calculation to reflect changes of analysed variables more objectively. Power analysis was performed so that, for continuous variables, there was an 80% chance of detecting a significant difference ($P<0.05$) if the true difference was as great as 0.4 times the standard deviation.

Complications of surgery and of recovery, including neurovascular injuries, wound infection and Complex Regional Pain Syndrome Type 1 (Reflex Sympathetic Dystrophy, Algodystrophy) were recorded immediately after surgery and at each follow-up visit.

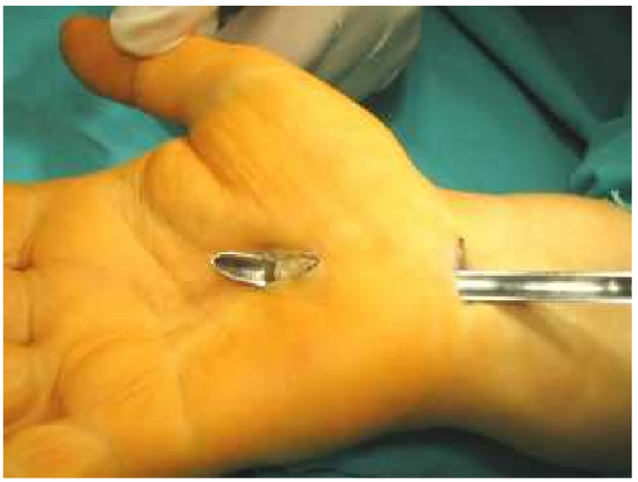


Fig 3 Incisions and technique of the operation in Method TWO.

RESULTS

This study included 65 patients, 50 women (77%) and 15 men (23%) with a mean age of 48 (range 41–60) years, in whom 73 hands underwent surgery. Eight patients had bilateral carpal tunnel syndrome.

Tables 2 and 3 summarise the results of the assessments performed in the study.

There were no statistically significant differences (minimum $P>0.2$) between Methods ONE and TWO in respect of improvement of sensation (decrease of Sensory Indices) throughout follow-up.

At 1 month after surgery, the total grip and all pinch strengths decreased relative to the pre-operative values. Statistically significant differences between Method ONE and Method TWO groups were noted only in total grip ($P<0.05$) and key-pinch ($P<0.005$) strengths, favouring Method ONE (Table 3). Except at 1 month, the total grip strength improved in both groups

Table 3—Results of the sensory, motor and Levine tests expressed as a per cent of pre-operative values (assigned as 100% for each variable)

	Pre-operatively		*At 1 Month*		*At 3 Months*		*At 6 Months*		*At 12 Months*	
	Method		*Method*		*Method*		*Method*		*Method*	
	ONE	*TWO*	*ONE*	*TWO*	*ONE*	*TWO*	*ONE*	*TWO*	*ONE*	*TWO*
Total grip strength	100	100	97*	82	122*	104	141*	127	146*	133
Two-point pinch	100	100	92	81	118*	92	129*	114	134*	118
Three-point pinch	100	100	93	81	113*	93	125*	112	127	120
Key pinch	100	100	99*	86	120*	106	131	121	133	125
Sensory Index (Static 2 PD test)	100	100	82	85	71	75	65	69	64	69
Sensory Index (S-W filament test)	100	100	85	87	73	75	67	69	65	66
Levine symptom score	100	100	79	89	52	55	42	44	36	38
Levine functional score	100	100	85	97	63	65	50	52	41	43

Statistically significant differences between ONE and TWO methods are asterisked.

throughout follow-up. However, the improvement was statistically significantly greater ($P<0.05$, relative to pre-operative values) after Method ONE method at each assessment. The findings for two-point pinch strength paralleled those for grip strength at all assessments, except that at 1 month, when the difference between the methods was not statistically significant ($P>0.2$). The three-point pinch strength was statistically significantly greater ($p<0.05$, relative to pre-operative measurements) after Method ONE at 3 and 6 months assessments. At 1 and 12 months the differences for three-point pinch strength between the two methods were statistically insignificant. Except at 1 month after surgery, key-pinch strength improved faster relative to pre-operative values throughout the follow-up after Method ONE, but this was only statistically significant at the 1 and 3 months assessments.

Relative to pre-operative values, a statistically significant mean improvement of total grip strength occurred at 3 months after Method ONE (median 122%) and at 6 months after Method TWO (median 127%), two-point pinch strength at 3 months after Method ONE (median 118%) and at 12 months after Method TWO (median 118%), three-point pinch strength at 6 months after Method ONE (median 125%) and at 12 months after Method TWO (median 120%), and key-pinch strength at 3 months after Method ONE (median 120%) and at 6 months after Method TWO method (median 121%) (Table 3).

The decrease of Levine functional and symptom scores was greater after Method ONE at each assessment, but the differences were not significant (minimum $P>0.1$).

There were no neurovascular injuries or incompletely divided carpal ligaments in either group. One superficial wound infection occurred in each group, but neither required antibiotic therapy. Three patients in each group complained of tender scars but these resolved spontaneously within 3 months. There were no cases of pillar pain in either group. There was one case of CRPS Type 1 in the Method TWO group, which developed 1 month after surgery. This patient was successfully treated with 1-week of in-patient, systemic dexamethasone and mannitol administration, followed by physiotherapy. At 3 months, this patient was available for further follow-up.

DISCUSSION

In contrast to the number of articles comparing endoscopic and open methods, there are only a small number of articles in the literature comparing the various techniques of limited open carpal tunnel release. Abouzahr et al. (1995) described a single incision limited open carpal tunnel release using a lighted speculum, which was introduced between the palmar fascia and the transverse carpal ligament to allow complete division of the ligament under direct vision. The procedure was performed in 28 cadaver hands and the transverse carpal ligament was completely divided in all hands without nerve or tendon injury, but the superficial palmar arch was injured in one hand. Richter and Brüser (1996) compared the results of carpal tunnel release employing a single 2.5 cm incision with a more conventional open technique with a 4.5 cm incision. A total of 80 patients underwent surgery, 40 by each method. A statistically significant difference was showed in favour of the short incision method, but only for total and pinch grip strengths at 3 weeks after surgery. Six weeks from surgery, there was no significant differences between the two methods in respect of resolution of night symptoms, improvement of sensation, degree of scar tenderness and time to return to work. Lee and Strickland (1998) proposed the technique of carpal tunnel decompression using a 1.0 to 1.5 cm palmar incision, using a specially designed carpal tunnel ''tome.'' The results of the treatment of 694 hands in 525 patients in a 29-month follow-up were presented. The postoperative resolution of symptoms and recovery of grip, key and three-point pinch strengths were comparable to the results of endoscopic carpal tunnel release presented in the literature. Two median nerve lacerations (0.3%) occurred in this study. Wong et al. (2003) compared the results of limited open carpal tunnel release using the Lee and Strickland instrumentation with two-portal endoscopic release in a prospective, randomised trial. Thirty patients with bilateral carpal tunnel syndrome had simultaneous bilateral release, one hand with the limited open and the other hand with the endoscopic technique. The outcomes were similar at 12 month follow-up. However, at the second and fourth postoperative week, patients experienced significantly less tenderness of the scar and pillar pain after the limited open method. Klein et al. (2003) reported use of a 1 cm incision, localised to the proximal palm over the transverse carpal ligament, without any additional instruments. This approach allowed these authors to divide the ligament completely under direct observation, without any neurovascular complications. Operation was performed on 149 hands in 104 patients, but only 28 patients were followed for 6 months. They experienced considerable relief of carpal tunnel syndrome symptoms, total grip strength approached the pre-operative values and hand function assessed by questionnaires improved significantly. The major benefit of this technique was the fact that patients were able to use their hands for activities of daily living on the day of surgery. Nakamichi and Tachibana (1997) reported use of a 1-1.5 cm palmar incision for carpal tunnel release under ultrasonographic monitoring. The authors compared the effectiveness of this method in 50 hands with conventional open carpal tunnel release in 53 hands at 24 months follow-up. The ultrasonographically assisted release group had better results at 3 and 6 weeks after surgery in respect of pain and tenderness in the wrist, as

well as grip and pinch strengths. Patients appreciated the more aesthetic scar followed this ultrasonographic technique. However, nearly all scars from any surgery for carpal tunnel syndrome are not a cosmetic problem. Saw et al. (2003) compared the outcome of carpal tunnel release by single portal endoscopic in 74 hands with open methods in 76 hands at 3 months. As these authors used a 2 cm palmar incision for "open" carpal tunnel decompression, one limb of this trial can be considered to have been a limited open technique. These authors found a statistically significant difference between the two treatment groups only in respect of the time of return to work, which was, on average, 8 days sooner after endoscopic operations.

Cellocco et al. (2005) compared two different techniques of limited open carpal tunnel release. A mini-open blind technique utilised a 2 cm transverse incision at the wrist and a cutting instrument equipped with an integrated light source. This allowed precise location of the tool blade by transillumination and blind division of the transverse carpal ligament. Limited open carpal tunnel decompression was performed through a 3 to 4 cm palmar incision. Ninety-nine hands in 82 patients were operated on using the mini-open blind technique and 123 hands in 103 patients by the single incision method. Assessment at 19 months revealed statistically significantly lower Levine scores in the patients in whom the mini-open blind method had been used, but this difference disappeared at 30 months. Seven cases of recurrence were noted after limited open operations, whereas only one recurrence occurred after mini-open blind operations. This unexpectedly high recurrence rate of 7% after limited open surgery was not explained in the article. There were no major neurovascular complications in either group. One might question the 4 cm long palmar incision used in this study as a "limited open" technique, since what is nowadays called the "conventional open method" commonly uses a 4 cm incision distal to the distal wrist crease (Richter and Brüser, 1996; Saw et al., 2003).

Our study showed that Method ONE of limited open carpal tunnel release offers a quicker recovery in respect of grip and pinch strengths. This difference was statistically significant. There was no significant difference in recovery between the two methods in terms of sensory recovery and no difference in terms of complications such as scar tenderness and pillar pain. However, the objective advantages in terms of grip and pinch did not translate directly into Levine functional and symptom scores. These, at each assessment, were lower (indicating greater relief of symptoms and better functional status) in the Method ONE group, but the difference was not significant. This finding suggests that greater improvement of grip strength is not necessarily a definitive argument for superiority of one technique over the other. Resolution of the symptoms of carpal tunnel syndrome and improvement of dexterity of the hand in performance of activities of daily living, assessed by the Levine scores, generally increased throughout follow-up and were not influenced significantly by the method of operation.

In respect of the technical demands of each method, the authors' subjective comments may be of interest. Method TWO was introduced into the Department in 1999, and, until the commencement of this study, approximately 300 carpal tunnel releases had been carried out by this method. Four neurovascular complications occurred throughout this period: two injuries of the superficial palmar arch and two lacerations of common digital nerves. These were all repaired at the time of the initial operation. Method ONE was introduced in 2001 and, until commencement of this study, approximately 140 operations had been carried out by this method. The complications which occurred throughout this period using Method ONE included one complete median nerve laceration, one flexor pollicis longus tendon division and five cases of incomplete transverse carpal ligament release. All of these complications were diagnosed during the post-operative period and required secondary surgery. All but one complication occurred when younger trainees were performing the operation, in spite of assistance by the senior consultant. None of these complications occurred during the period of the study. However, these previous findings made us very careful with Method ONE and only some of us are enthusiasts for this method. Method ONE is more technically demanding and requires a longer learning time with experienced assistance. It is the senior author's individual observation that, in Method ONE, the division of the proximal 1 cm of the transverse carpal ligament (localised at the level of the distal wrist crease) is, in many cases, performed blindly. This is because the distance from the proximal end of the incision to the proximal edge of the ligament is approximately 4 cm and visualisation of the proximal part of the ligament may be difficult when an incision of only 2 cm is used. Moving the incision more proximally, we can complete the proximal release under direct vision, but the scar is closer to the distal wrist, which negates the intended benefit of the limited incision technique in avoiding an incision in the critical "pillar" region. By way of contrast, Method TWO offers better visualisation of the transverse carpal ligament and the vital structures in the carpal tunnel and allows division of the ligament under direct vision from each end.

In spite of quicker recovery of strength after carpal tunnel decompression by Method ONE, we feel that this advantage does not outweigh the fact that patients' subjective satisfaction with either method was similar throughout follow-up. Therefore, we do not consider that either of the two methods examined in this study as superior, but consider them equally effective. Based on our overall clinical experience of the two methods we recommend Method TWO as easier to perform, less technically demanding and relatively safer when done by less experienced surgeons.

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