
Original article

An investigation to compare the effectiveness of carpal bone mobilisation and neurodynamic mobilisation as methods of treatment for carpal tunnel syndrome

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SUMMARY. Carpal tunnel syndrome is the most common peripheral entrapment neuropathy. There is little literature available that addresses the management of this condition, which may partly explain why physiotherapy is often overlooked as a treatment approach in its management. This study investigated the effects of two manual therapy techniques in the treatment of patients experiencing carpal tunnel syndrome. An experimental different subject design compared three groups of subjects in three different conditions (two treatment interventions and one control group). Each group consisted of seven patients. The objectives of the study were: (1) to investigate differences between treated and untreated groups; (2) to investigate differences in the effectiveness of treatment I (median nerve mobilization) compared with treatment II (carpal bone mobilization). Measurements were taken applying several measurement tools, including active range of wrist movement (ROM flexion and extension), upper limb tension test with a median nerve bias (ULTT2a), three different scales to evaluate pain perception and function, and lastly numbers of patients continuing to surgery in each group were compared. In visual terms a clear trend was demonstrated between subjects who received treatment compared to those who were not treated, in particular the descriptive analysis of results for ULTT2a and numbers of patients continuing to surgery. When analysed statistically, less could be concluded. Only scores on a Pain Relief Scale ($P < 0.01$) demonstrated highly significant differences between the three groups when analyzed using Kruskal–Wallis Test. In exploring the results of the two intervention groups, no statistically significant difference in effectiveness of treatment was demonstrated between carpal bone mobilization and median nerve mobilization. © 2000 Harcourt Publishers Ltd.

INTRODUCTION AND LITERATURE REVIEW

Carpal tunnel syndrome (CTS) is the most common peripheral entrapment neuropathy and it affects women more than men (Phalen 1966; Cailliet 1994; Katz 1994). This condition has recently become a growing reason for workers' compensation claims due to absence from work (Dean & Louis 1992; Harter et al. 1993; Katz et al. 1998).

The literature regarding some aspects of treatments and their risks is enlightening. For example, surgery to release the pressure from the median nerve may be

helpful but it can have a 15–20% failure rate (Katz 1994). Complications can and do occur with both known procedures (Palmer & Toivonen 1999) but, various conservative methods are also available and might provide relief. Harter et al. (1993) reported satisfactory results after treating 188 patients with different conservative methods such as resting splints, anti-inflammatory drugs, vitamin B6 and steroid injections. However, there are also some risks involved in some of the common conservative treatments for carpal tunnel syndrome such as vitamin B6 or steroid injections (Katz 1994; Murray et al. 1994; Tavares & Giddins 1996).

Some of the physiotherapy methods for treating CTS such as electrotherapy may offer some symptomatic relief. However, such methods do not address the pathological neurodynamics of the median nerve and its surrounding structures (Butler 1991). Anecdotal clinical evidence supports physiotherapeutic intervention with these patients as improvement has

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been seen in response to a variety of manual therapy treatment approaches. There is also some evidence of chiropractic or osteopathic manual intervention providing some relief of symptoms for patients experiencing CTS (Sucher 1993; Bonebrake 1994; Sucher 1994; Valenta & Gibson 1994; Davis et al. 1998). However, there were some methodological problems with these studies that therefore limit generalization. For example inclusion/exclusion criteria do not consider factors contributing to the neuropathy such as double crush syndrome and, thoracic or cervical origin of symptoms. Questions are also raised regarding the reliability and accuracy of the palpation methods, the method of measuring ROM employed by Sucher (1994), and the lack of statistical analysis of the results. In some studies (Bonebrake 1994; Davis et al. 1998) it is also not possible to determine which conservative method of treatment was effective as many different methods were employed. Generalization is also limited in the single case study by Valenta and Gibson (1994) due to its poor design and subsequent lack of analysis.

Other research has explored the biomechanical changes of the transverse carpal ligament and the degenerative changes to the connective tissue and tenosynovium (Schuind et al. 1990; Allampallam et al. 1996), these degenerative changes could explain the common limitation of reduced active ROM of the wrist (Sucher 1994). Several authors have suggested treating CTS with manipulation of the carpal bones (Patterson 1998; Sucher & Hinrichs 1998) and Maitland (1991) suggested mobilizing the pisiform and stretching the flexor retinaculum. Literature concerning the effects of joint mobilisation as applied by manual therapists is however lacking and at present there is no specific literature exploring the treatment of CTS.

Some studies have investigated the effects of nervous system mobilization on nerve entrapment problems (Butler 1991; Elvey 1995; Shacklock 1995a). The rationale in treating patients with nervous system mobilization is an attempt to improve axonal transport and by this mechanism to improve nerve conduction (Butler & Gifford 1989; Shacklock 1995a,b). Mobilization of a nerve may reduce the pressure existing within the nerve and could therefore result in an improvement of blood flow to the nerve. Consequently, regeneration and healing of an injured nerve may also occur (Butler 1991). Rozmaryn et al. (1998) treated patients experiencing CTS with nerve gliding exercises and report in 70.2% of patients good or excellent results. A combined approach was illustrated by Exelby (1995) who investigated lateral glide of the proximal row of carpal bones (as described by Mulligan 1992) while maintaining tension on the median nerve.

From the existing literature it is therefore considered that different manual therapy techniques may help

those patients who are interested in treatment other than surgery. However, due to the lack of literature within this area it seems that there is an urgent need for structured research to inform patient management.

METHODOLOGY

The aims of this study were firstly to investigate the effectiveness of manual therapy intervention in patients experiencing CTS when compared to a control group, and secondly to investigate the difference in effectiveness between two approaches to manual therapy treatment for CTS, carpal bone mobilization and mobilization of the nervous system. The subsequent research null hypothesis was that there will be no significant differences in the recovery of patients experiencing CTS according to whether they have been treated with neurodynamic mobilization, carpal bone mobilization or received no treatment at all.

An experimental different subject design enabled comparison between the two interventions and a control group as follows:

Group I 7 CTS patients	<u>received</u>	Condition 1 Neurodynamic mobilization
Group II 7 CTS patients	<u>received</u>	Condition 2 Carpal bone mobilizations
Group III 7 CTS patients	<u>received</u>	Condition 3 Control group (no treatment)

Incidental sampling from a waiting list for surgery provided a sample population of 21 patients experiencing CTS. The ratio of male to female was 1:2. Their ages ranged from 29 to 85 years with the mean age of 47.1 (S.D. 14.8). In looking at the presentation of symptoms, 12 right hands and 9 left hands were presented with 9 patients presenting with bilateral symptoms. The mean duration of symptoms for the subjects was 2.3 years (S.D. = 2.5) with a range of 1 to 3 years. After selection, the subjects were randomly allocated to one of the three groups by pulling names out of a hat.

Inclusion criteria included a positive electrodiagnostic test, positive clinical tests (Phalen/Tinel's), positive upper limb tension test 2a with a median nerve bias (ULTT2a), with positive diagnosis of CTS by a surgeon indicating that the patient was a candidate for decompression surgery. Exclusion criteria included known psycho-social problems, diabetes mellitus, herpes zoster, rheumatoid arthritis, pregnancy, hyperthyroidism, known congenital abnormality of the nervous system, and cervical or thoracic spine origin of symptoms on assessment.

Several measurement tools were selected for use in this study in order to reflect the multidimensional presentation of CTS that encompasses its characteristic presentation of pain, daily pattern, and

limitation of range of movement and function. Initially it was planned that electrodiagnostic tests would be utilized but the reliability and validity of their results of these tests have been questioned (Redmond & Rivner 1988; Glowacki et al. 1996). A pilot study explored issues of reliability for the measurement tools that had not been previously investigated.

Symptom diary

The subjects were requested to complete a 24 h daily symptom diary as used by Elton et al. (1979) (see Fig. 1). The Visual Analogue Scale (VAS) component provided information regarding severity of symptoms and the diary provided information on duration and frequency of the symptoms. The reliability and sensitivity of VAS has already been established (Huskisson 1974; Huskisson et al. 1976). Furthermore, it was concluded by Levine et al. (1993) that measurement of severity of symptoms and functional scales in patients experiencing CTS are reproducible, internally consistent and responsive to clinical change.

Functional box scale

Huskisson et al. (1976) developed a functional scale and tested it on patients with rheumatoid arthritis. For the purpose of this study the most limited

function was discussed with the patients and a slightly modified scale, the functional box scale (FBS) (Waterfield & Sim 1996) combined with a simple descriptive scale was used (Fig. 2).

Pain Relief Scale

When assessing the effects of treatment, the Pain Relief Scale (PRS) was found to be more effective and more sensitive, compared to other scales (Huskisson, 1974). Fig. 3 shows the modified PRS used in this study.

Measurement of Active range of movement – wrist flexion and extension

Measurements of Range of movement (ROM) were taken by an independent examiner as described by Daniels & Worthingham (1986) using a standard goniometer. The same goniometer was used for all measurements.

Upper limb tension test 2a, the median nerve biased test

Being a specific tension test that has been developed to bias the median nerve (Butler 1991), it was performed in this study to reproduce symptoms or identify changes in existing symptoms. For the purpose of this study the test measured positive/negative responses only. Butler’s definition (1991, p 162–163)

Please mark below level of severity of your symptoms. Record ONLY waking hours.
 Use one chart for each day and please record at least four different times a day.
 Please record also times at night that your symptoms woke you up.
 Please chose one of the following scores:

- 0 No symptoms (you are able to do every kind of your daily activity)
- 1 Low level of symptoms (you are aware of it only when you direct attention to it).
- 2 Symptoms which could be ignored at times.
- 3 Constant symptoms but you are able to continue working.
- 4 Very severe level of your symptoms which makes concentration difficult, but undemanding tasks can be coped with.
- 5 Intense incapacitating symptoms.

Date Day

	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
5																								
4																								
3																								
2																								
1																								
0																								

Fig. 1—Weekly symptoms chart (incorporating Visual Analogue Scale).

Please mark on the scale below your present ability/disability to button/unbutton a shirt or to grip. Please choose one of the following scores:

- 0 Able to do alone without any problem
- 1 Able to do alone with slight ability problem
- 2 Able to do alone with some difficulties
- 3 Able to do alone but with a lot of difficulties
- 4 Not able to do alone

0	1	2	3	4
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Fig. 2—The Functional Box scale (modified box scale of pain and simple descriptive scale).

definition was applied concerning positivity of the test:

- It reproduces the patient's symptoms.
- The test responses can be altered by movement of distant body parts
- There are differences in the test from the left side to the right side and from what is known to be normal.

The order of the ULTT2a was standardized in a pilot study as is described in Butler (1991, p 153) as slight glenohumeral abduction, shoulder girdle depression, elbow extension, lateral rotation of the whole arm, wrist, thumb & finger extension and finally glenohumeral abduction. All movements were taken to the end of available range (R2) or to the point where first symptoms were produced (P1).

Subjects continuing to surgery

Each subject was followed up after intervention to see if they proceeded to surgery.

Procedures

All measurements except the PRS measurement were undertaken by an independent examiner pre treatment intervention to obtain baseline readings. All the measurement tools were then utilized post intervention by the same independent examiners.

Please mark on the scale below your experience of symptom relief following the treatment you have received. Please choose one of the following scores:

- 0 I have **not** experienced any relief of my symptoms
- 1 The symptoms relief can be described as poor
- 2 Moderate symptom relief
- 3 I have a good amount of symptom relief
- 4 I have excellent symptom relief but still not complete
- 5 I have complete symptom relief

0	1	2	3	4	5
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Fig. 3—The modified pain relief scale.

The procedure for treatment was as follows: subjects in group I were treated with ULTT2a mobilization (Butler 1991, p 154); group II were treated by carpal bone mobilization (posterior-anterior and/or anterior-posterior mobilization techniques) and flexor retinaculum stretch (Maitland 1991, p 205). Grade of treatment, amplitude of mobilization, and the progression of treatment was decided on an individual patient basis depending upon the irritability and severity of the individual patient's symptoms (Butler 1991; Maitland 1991). Group III received no intervention.

All data were analyzed using the SPSS computer package for Windows release 6.0, employed with a critical value of *P* set by convention at 0.05 (Hicks, 1995). The reliability studies were analyzed using Kendall's coefficient of concordance as recommended by Hicks (1995) for repeated measurements. The related *t* test was applied for within group pre and post test analysis (VAS and ROM), and the ANOVA between conditions was utilized for the analysis of ROM. The Kruskal-Wallis test (Hicks, 1995) was employed to analyze the PRS, FBS and VAS, while data obtained from the ULTT2a and numbers continuing to surgery were analyzed descriptively. All tests utilized were two tailed.

No change in the original surgical treatment plan for the patients was expected. The subjects were selected from the surgical waiting list and the surgical option remained available during and at the end of the study. Every subject participating in the study was asked to give informed consent and had the opportunity to withdraw at any time during the study without affecting their right for surgery. The study was granted the approval of the involved hospital's Research Ethics Committee and their Research & Development Committee.

RESULTS

Results from the VAS

Table 1 illustrates the results of the VAS. Using a Kruskal-Wallis test on the data ($H = 6.406$, $n = 21$) the results were found to be significant at $P < 0.05$. This suggests that there is a significant difference in the VAS scores post treatment intervention of three different interventions.

The results for each group pre and post treatment intervention were analyzed using the related *t*-test looking for differences within the groups. For group III the results were not significant ($P > 0.05$) but for groups I and II the results were highly significant ($P < 0.02$, $P < 0.001$ respectively), suggesting that there was a difference pre and post treatment intervention in both treated groups.

Table 1. Results of Visual Analogue Scale Measurement pre and post treatment (RX) intervention

<i>n</i>	Group I pre RX intervention	Group I post RX intervention	Group II pre RX intervention	Group II post RX intervention	Group III pre RX intervention	Group III post RX intervention
1	0	0	2	1	2	3
2	1	0	2	1	1	2
3	3	1	4	1	4	2
4	4	2	1	0	2	2
5	3	2	2	0	0	1
6	4	4	2	0	3	3
7	2	2	3	2	2	2
Total	17	11	16	5	14	15
Mean	2.42	1.57	2.2857	0.71	2	2.14
related <i>t</i> -test analysis	<i>t</i> = 2.52 Significant <i>P</i> < 0.02		<i>t</i> = 5.28 Significant <i>P</i> < 0.001		<i>t</i> = -0.35 Not significant	

Results of the functional box scale measurements

A correlation study was conducted in order to find the correlation of this tool with the VAS and to inform regarding its reliability. Using a Spearman test on the data ($r_s = +0.804$, $n = 18$) the results were found to be significant ($P < 0.05$ for a one tailed test).

Table 2 illustrates the results of the FBS. Using a Kruskal–Wallis test on the data post treatment intervention ($H = 5.27$, $n = 21$) the results were found to be not significant at $P < 0.05$. This suggests that there is no significant difference in the FBS scores post treatment intervention for the three different interventions.

Results of the pain relief scale (PRS)

Table 3 illustrates the results of the PRS post treatment intervention. Using a Kruskal–Wallis test on the data ($H = 13.58$, $n = 21$) the results were found to be significant at $P < 0.05$. This suggests that there was a significant difference in the PRS scores post treatment intervention for the three different interventions.

Results of ROM measurements of wrist flexion/extension

A pilot study was conducted initially to establish the intra-tester reliability for the measurement of ROM

flexion/extension (F/E), using Kendall's coefficient of concordance (Hicks 1995) the results were found to be significant ($P < 0.05$) for a one tailed test, establishing satisfactory reliability. Table 4 illustrates the results of wrist ROM flexion between subjects. Using a related *t* test the results of pre and post intervention measurements were found to be significant for group I.

Table 5 illustrates the results of ROM measurement for wrist extension between subjects. Using a related *t* test the results were found to be significant for groups I and II.

In further exploring the results of wrist ROM F/E between conditions, a one way ANOVA for unrelated designs demonstrated $F = 0.99$, $df_{bet} = 2$, $df_{error} = 18$ for flexion ROM, and $F = 1.243$, $df_{bet} = 2$, $df_{error} = 18$ for extension ROM, the results therefore were not significant. This suggests that there is no relationship between the type of treatment given to the subjects and the subsequent measurement of ROM of the wrist.

Results of the ULTT2a

Intra tester reliability was established within the pilot study, with Kendall's coefficient of concordance (Hicks, 1995) being significant ($P < 0.05$) for a one tailed test. Figure 4 illustrates the results of the ULTT2a post treatment intervention between

Table 2. Results of the Functional Box Scale Measurements Treatment scores pre and post treatment (RX) intervention

<i>n</i>	FBS Group I pre RX intervention	FBS Group I post RX intervention	FBS Group II pre RX intervention	FBS Group II post RX intervention	FBS Group III pre RX intervention	FBS Group III post RX intervention
1	0	0	1	1	0	0
2	1	0	2	0	3	3
3	4	1	4	1	4	4
4	1	0	1	0	2	2
5	2	1	0	0	3	3
6	3	3	3	1	3	3
7	3	3	3	2	2	2
Total	14	8	14	5	17	17
Mean	2	1.14	2	0.71	2.42	2.42

Table 3. Results of the Pain Relief Scale Measurement post Treatment intervention

<i>n</i>	PRS Group I	PRS Group II	PRS group III
1	5	3	0
2	4	3	0
3	3	4	0
4	4	5	0
5	3	3	0
6	1	5	0
7	2	3	0
Mean	3.14	3.71	0
Total	22	26	0

groups. Visual analysis suggests that the manual therapy interventions are associated with the improvements seen in the ULTT2a.

Number of subjects continuing to surgery

An important indication for effectiveness of the treatment in this study was the number of subjects who returned to their originally planned surgery. Only two patients from group I and one patient from group II chose to continue to surgery, while six patients from group III (control) continued with their planned surgery (Fig. 5).

SUMMARY OF RESULTS

Table 6 summarizes the results of the statistically significant findings to aid clarity for consideration in the discussion. As the Table 6 illustrates, two of the between condition analyses were statistically significant, the Kruskal–Wallis (PRS and VAS) suggesting differences between the three groups. Beyond this the three between subject analyses of related *t* tests (VAS and ROM F/E) suggest differences within groups I (VAS, ROM F/E) and II (VAS, ROM ext).

DISCUSSION

This study set out to investigate the effectiveness of two methods of mobilization in the management of

(CTS) compared to a control group. It was found that the differences in scores for the VAS were statistically significant between the three conditions ($P < 0.05$). Furthermore, a visual improvement is suggested by the VAS for groups I and II, supported by a statistically significant related *t* test pre and post intervention for groups I and II, suggesting some improvement.

Although the results on the FBS were not statistically significant, most subjects from both treated groups scored their inability to perform certain activities lower after 3 weeks of treatment. This suggests that improvement in function was achieved in the treated groups. The results post treatment intervention for the FBS although visually different were not statistically significant ($P > 0.05$). Development of the methodology and in particular utilizing a larger sample size would be useful in exploring this effect further.

The results of the PRS were highly significant ($P < 0.01$) and demonstrated that there were differences between the three groups. The differences in the results can be seen from the visual analysis and it is apparent that group II did slightly better than the other groups. However, a small sample size and a placebo effect may have contributed to the positive results.

In analyzing the results between subjects of ROM flexion, group I was significantly better and group II was visually better although the results were not statistically significant. Comparison of the results for ROM extension indicate that both groups I & II showed significant improvement whereas group III did not. This highlights a clear difference in favour of the treated groups. Had the sample size been larger, the results from ROM flexion group II may also have reached significance.

When analyzing the results of ROM between conditions visually it can be seen that for ROM flexion and extension groups I & II both demonstrated improvement whereas group III did not. Despite these trends, statistical analysis employing an ANOVA demonstrated that the visual differences were not statistically significant. However, it might be

Table 4. The results of measurement of active ROM wrist flexion (ROMF) pre and post treatment intervention

<i>n</i>	ROMF group I pre RX (degrees)	ROMF group I post RX (degrees)	ROMF group II pre RX (degrees)	ROMF group II post RX (degrees)	ROMF group III pre RX (degrees)	ROMF Group III post RX (degrees)
1	60	70	52	46	53	52
2	55	61	63	76	41	50
3	57	74	56	60	62	61
4	35	52	48	45	55	56
5	55	65	60	69	62	62
6	46	42	51	65	32	35
7	55	62	24	59	58	59
Total	363	426	354	420	363	375
Mean	51.85	60.85	50.57	60	51.85	53.57
Related <i>t</i> -test analysis	$t = 3.302$ Significant < 0.05		$t = 1.834$ Not significant		$t = 1.29$ Not significant	

Table 5. The results of active wrist ROM extension (ROME) pre and post treatment intervention

n	ROME group I pre RX (degrees)	ROME group I post RX (degrees)	ROME group II pre RX (degrees)	ROME group II post RX (degrees)	ROME group III pre RX (degrees)	ROME group III post RX (degrees)
1	45	74	39	58	47	48
2	67	69	59	69	65	66
3	70	71	66	72	61	63
4	38	60	66	74	59	60
5	55	82	70	71	60	75
6	45	52	54	71	50	48
7	59	64	46	63	74	70
Total	379	472	400	478	416	430
Mean	54.14	67.42	57.14	68.28	59.42	61.42
Related t-test analysis	$t=2.87$ Significant <0.05		$t=4.38$ Significant < 0.05		$t=0.86$ Not significant	

that in a study with a larger sample the differences between the conditions would have reached significance.

Although good intra-tester reliability for measuring wrist ROM was found, difficulties were encountered while performing the active movement measurements on some subjects. It was found that in some cases symptoms of pain or paraesthesia were the limiting factor and not the actual physiological range of the wrist as found on healthy subjects in the pilot study. However, it can be argued that the same factor that caused the limitation of active ROM in the main study was responsible for the dysfunction of the patients, making this a useful test and in practice an indication of the subjects' willingness to perform the movement. Improvement of symptoms subsequently resulted in improvement of ROM (see results). These findings justify the measurement of active rather than passive physiological ROM.

Visual analysis of the results of the ULTT2a illustrated differences in the improvement between the three groups post treatment. All subjects in the non intervention group III still had positive tests post treatment but the results of groups I & II demonstrated improvement. It can also be seen that group I who received nerve mobilization did slightly better

than group II who received carpal bone mobilization. This can perhaps be explained by the nature of the technique chosen for group I which treated directly the pathomechanics of the median nerve i.e. vascular and mechanical factors of the nerve (Sunderland 1978; Lundborg 1988; Mackinnon & Dellon 1988). Group II, who received treatment for the nerve interfacing, also achieved improvement of the pathomechanics of the median nerve. However, it might be that problems along the course of the median nerve proximal to the wrist contributed to the incomplete recovery of the neurodynamics of some patients from group II, i.e. the double crush syndrome (Upton & McComas 1973). It was initially intended to use the extended Chi square on the ULTT2a data, but due to the limited number of subjects it was not possible to fulfil the requirements of minimum numbers in the contingency table for this test. It was therefore not possible to explore the above visually observed differences through statistical analysis.

Perhaps the most important indication for effectiveness of the treatment in this study was the number of treated subjects who returned to their originally planned surgery, where both treatment intervention groups illustrated a considerable change in results compared to the control group. This decision was left completely to the patients considering their experience of symptom relief, improvement of function

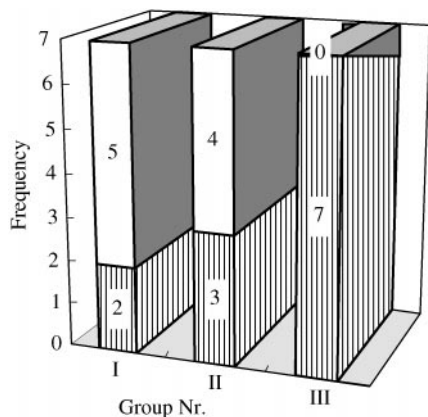


Fig. 4—Bar graph demonstrating the results of the ULTT2a post RX intervention in terms of a positive or negative test (all subjects tested positive prior to intervention) ▨ positive; □ negative.

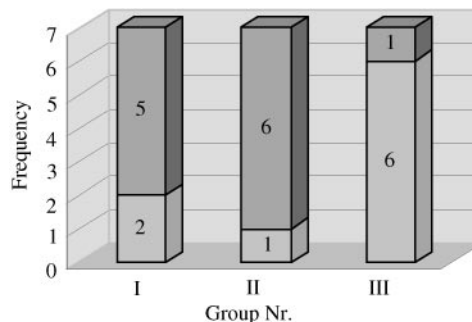


Fig. 5—Bar graph demonstrating the number of subjects continuing to surgery post intervention (all subjects were intending to undergo surgery prior to intervention) ▨ no operation; □ operation.

Table 6. Summary of the statistically significant results

Statistical analysis	Measurement tool	Statistically significant group
Kruskal–Wallis	PRS and VAS	between I II and III
Related <i>t</i> test	ROM flex	I
Related <i>t</i> test	ROM ext	I and II
Related <i>t</i> test	VAS	I and II

and the change in the nocturnal behaviour of the symptoms. The same limitation to this analysis applies as to the ULTT2a where statistical analysis was not possible due to the spread of subjects across the contingency table for an extended Chi square test.

As discussed in the literature review, several measures were chosen to reflect the multidimensional nature of CTS. It was not a surprise to therefore see the differences in results gained from the different measurement tools. One of the reasons for these differences could be the different nature of the scales. For example, the PRS measured the relief of symptoms post intervention and compared one group of no scores against two groups of scores on this scale. The use of electro-diagnostic testing would strengthen the results of this study, but the reliability and validity of these tests would need to be improved.

The results of this study suggest that differences existed between the recovery of patients experiencing CTS who received specific manual treatment intervention and those who were not treated. These results also support Butler (1991) who describes the peripheral nervous system as having considerable regenerative powers. These results are also in agreement with Harter et al. (1993) and Rozmaryn et al. (1998) who used other conservative methods of treatment and with the chiropractic and osteopathic researchers who used different manipulation techniques on CTS and claim good results (Sucher 1993; Bonebrake 1994; Sucher 1994; Valenta & Gibson 1994).

Butler (1991) suggests a few hypotheses that may explain the improvement seen after treating the patients with different methods of manual therapy. Mobilization of the carpus may result in alteration of the pressure in the nervous system and subsequently to a dispersion of any existing intra-neural oedema. The carpal tunnel with the flexor retinaculum is part of the interface of the median nerve, and mobilization of the interface could therefore have an effect on any extraneural component which is the cause of the problem (Butler 1991). Treatment of the interface may assist in normalizing the pressure gradients in the carpal tunnel and consequently normalize the blood supply and the axonal transport system (Butler 1991). Against this, any other existing factors such as congenital abnormalities in the nervous system could predispose the subject to the development of carpal tunnel syndrome. Such abnormalities may have lessened the patient's potential for recovery.

Although some statistically significant results were obtained from this experimental study, no conclusion can be drawn regarding the longer term effects. Some studies have addressed longer time scales (Sucher 1994; Kluge et al. 1996; Rozmaryn et al. 1998). Unfortunately the time restrictions of this study did not permit further follow up. Had the study continued for a longer period of time, the different treatments could be monitored for the longevity of their effects.

Generalization of the results of this study is limited due to several factors, some of which have been discussed above. Because of the interesting results obtained, this study would be worthwhile repeating with a larger sample size and randomly selected subjects recruited from more than one site.

CONCLUSION

This study has investigated the effects of two manual therapy techniques as treatment for patients experiencing CTS. Several measurement tools were utilised to evaluate effectiveness of treatment. The results were not always statistically significant, but in visual terms a clear trend was demonstrated between subjects who received treatment compared to those who were not treated.

The results of this study are encouraging to manual therapists. However, as discussed it has several limitations and the results therefore cannot be generalised to all patients experiencing CTS. The study has failed to show significant differences in the effectiveness between mobilization of the median nerve and carpal bone mobilization in the treatment of patients presenting with carpal tunnel syndrome. However, the results indicate that even after such a short period of time, some patients with no other contributing factors (see exclusion criteria), might benefit from a specific treatment with neurodynamic techniques, or with mobilization of carpal bones. This research has therefore demonstrated that patients experiencing CTS can improve after manual therapy, and therefore provides support for the use of manual therapy in the conservative management methods of treating patients with this condition with satisfactory results. However, more research needs to be carried out to further support these findings.

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