Journal of Bodywork & Movement Therapies (2014) xx, 1–6

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/jbmt

FASCIA SCIENCE AND CLINICAL APPLICATIONS: RANDOMIZED CONTROLLED COMPARATIVE STUDY

Conservative treatment of carpal tunnel syndrome: Comparison between laser therapy and fascial manipulation®

Elena Pratelli, MD [a], Marco Pintucci, PT [b], Pina Cultrera, MD [c], Enrico Baldini, MD [d], Antonio Stecco, MD PhD [e,*], Antonio Petroncelli, MD [a], Pietro Pasquetti, MD [a]

[a] *Agenzia recupero e riabilitazione, University of Careggi, Florence, Italy*
[b] *Institution of Rehabilitation, Rede de Lucy Montoro, San Paulo, Brazil*
[c] *Azienda Socio Locale 10, Florence, Italy*
[d] *Centro di Reabilitazione, Florence, Italy*
[e] *Department of Internal Medicine, University of Padua, Padua, Italy*

Received 5 December 2013; received in revised form 30 July 2014; accepted 3 August 2014

KEYWORDS
Carpal tunnel syndrome;
Low level laser therapy;
Manual therapy;
Fascial manipulation

Summary The etiopathogenesis of Carpal Tunnel Syndrome (CTS) is multifactorial and most cases are classified as idiopathic (Thurston 2013). A randomized controlled trial was performed to compare the effectiveness of Fascial Manipulation® (FM) and Low-Level Laser Therapy (LLLT) for CTS. This prospective trial included 42 patients (70 hands with symptoms) with clinical and electroneuromyographic diagnosis of CTS. The patients were randomly assigned to receive multiple sessions of FM or multiple session of LLLT. The Visual Analogic Scale (VAS) and Boston Carpal Tunnel Questionnaire (BCTQ) were performed at baseline, end of treatment and after three months.

The group that received FM showed a significant reduction in subjective pain perception and an increased function assessed by BCTQ at the end of the treatment and follow-up. The group that received LLLT showed an improvement in the BCTQ at the end of the treatment but the improvement level was not sustained at the three month follow-up. FM is a valid alternative treatment for CTS.

* Corresponding author. Sports Medicine, Internal Medicine, University of Padova, Via Giustiniani 2, 35120 Padova, Italy.
E-mail address: antonio.stecco@gmail.com (A.Stecco).

http://dx.doi.org/10.1016/j.jbmt.2014.08.002
1360-8592/

Introduction

Carpal Tunnel Syndrome (CTS) is the most common compression neuropathy and is due to compression of the median nerve (Ibrahim et al., 2012). The main symptoms are pain and paresthesia in the first, second and third fingers along the innervations of the median nerve. The etiopathogenesis of the CTS is multifactorial and in most cases idiopathic (Marshall, 2001).

Trauma (including previous fractures of the wrist or joint deformity), arthritis and arthrosis may increase the chance of developing this syndrome (Mahoney and Dagum, 1992). Other causes are mechanical such as: deformation of median nerve (Hunter, 1991), stiffness and fibrosis of the transverse carpal ligament (Nakamichi and Tachibana, 1995), hypertrophy of thenar eminence with increased pressure into the carpal tunnel (Nakamichi and Tachibana, 1995; Rojviroj et al., 1990) and fibrosis that reduces median nerve mobility (Phalen, 1970).

Due to the high incidence and prevalence of this disability and its economic consequences, CTS remains a challenge for health systems worldwide. Currently, there is inadequate scientific evidence regarding conservative treatments. The benefits and risks related to the use of night time orthotic (Page et al., 2012a,b,c), exercises and mobilization (,,), therapeutic ultrasound (,,) and equipment, such as ergonomic computer keyboards (O'Connor et al., 2003), are not known. The injection of corticosteroids is effective in reducing edema and local inflammation (Marshall et al., 2007; Marshall, 2001). However, the beneficial effects are inconsistent and not devoid of collateral effects (for instance, reduced synthesis of collagen and proteoglycans with consequent tissue atrophy) (Tsai et al., 2003; Scutt et al., 2006). Low intensity laser therapy (LLLT) seems to be able to decrease the pain and associated symptoms and to increase the strength and function while also stimulating the proliferation of fibroblasts, the microcirculation and acetylcholinesterase activity (Kujawa et al., 2003) in mild cases of CTS (Chang et al., 2008; Dakowicz et al., 2011; Yagci et al., 2009; Elwakil et al., 2007).

Evidence based on the use of selected manual therapies appears to be more promising, for example relief of median nerve compression by chiropractic manipulation and manual therapy. Valente and Gibson, 1994; Maddali et al., 2013. A study carried out on a small group of patients affected by CTS, subjected to myofascial therapy and stretching, evaluating patients before and after treatment with nuclear magnetic resonance, demonstrated an increase in the size of the antero-posterior and transverse carpal tunnel (Sucher, 1994, 1993). The same author showed in cadavers that osteopathic manipulation was able to elongate the carpal tunnel ligament and suggested that such techniques may be of use in nonsurgical relief of pressure on the median nerve in patients with CTS (Sucher, 1993). Several other studies have shown that Fascial Manipulation® (FM) was able to decrease pain, restore the movement and muscle strength in a case of patellar tendinopathy (Pedrelli et al., 2009), post traumatic sub-acute neck pain (Picelli et al., 2011), chronic shoulder pain (Day et al., 2009) chronic ankle instability (Stecco et al., 2011) and temporomandibular disorders (Guarda-Nardini et al., 2012).

FM (Stecco., 2004) is a manual therapy that focuses on deep muscular fascia. This technique considers the fascia as a three-dimensional continuum. The mainstay of this manual technique lies in the identification and treatment of specific, localized areas of fascia. Fascia is formed by undulated collagen fibers and elastic fibers arranged in distinct layers, and within each layer the fibers are aligned in different directions. In FM the body is divided into 14 segments: head, neck, thorax, lumbar, pelvis, scapula, shoulder, elbow, forearm, hand, hip, knee, ankle and feet. Each body segment is served by six myofascial units (MFU). A MFU consists of monoarticular and biarticular muscle fibers and its surrounding deep fascia. Movement evaluation in FM is based on testing in spatial directions and are defined as: antemotion (AN), retromotion (RE), lateromotion (LA), mediomotion (ME), intrarotation (IR), extrarotation (ER).

Each of the 6 MFUs of every segment has specific locations in the deep fascia termed Centres of Coordination (CCs). Every CC is located at the point of convergence of the vectorial forces of the muscles involved in a specific movement.

The biarticular muscles join together the unidirectional MFU to form myofascial sequences (MFS) (Stecco et al., 2009, 2007). A sequence controls the movement of the different segments (i.e., shoulder, elbow, wrist) in one direction in the three planes of movement. Two sequences of the same plane for example, the sagittal (flexion/extension), frontal (medial/lateral), and the horizontal (internal/external) are reciprocal antagonists. These MFU/sequences are evaluated for CCs especially since they are involved in the alignment of the trunk and limbs. Other points termed Centers of Fusion (CFs) are localized in the intermuscular septa, retinacula controlling movements along intermediate directions, between different planes (Stecco, 2004; Ercole et al., 2010).

The purpose of our study was to compare the effectiveness of a manual therapy technique called Fascial Manipulation to Low-Level Laser Therapy in carpal tunnel syndrome.

Methods

Forty-two patients (29 women and 13 men) were enrolled in the study. They had a mean age of 54.2 years (range 38—74 years) and among them were 70 symptomatic hands. The criteria for diagnosing CTS were clinical (Phalen and Tinel test positive) and electromyographic (positive EMG showing a decrease in nerve conduction within the last six months). The patients agreed to maintain their usual oral medical therapies during the period of this study. The exclusion criteria were: congenital coagulopathies, use of oral anticoagulant therapy, previous treatments that ended in less than 3 months, only weakness symptoms, concomitant tumors and systemic neurological and rheumatological pathologies. The patients were recruited consecutively in the out-patient office of Physical Medicine and Rehabilitation Department at the Recovery and Rehabilitation Agency AOU

Please cite this article in press as: Pratelli, E., et al., Conservative treatment of carpal tunnel syndrome: Comparison between laser therapy and fascial manipulation®, Journal of Bodywork & Movement Therapies (2014), http://dx.doi.org/10.1016/j.jbmt.2014.08.002

(University Hospital Company) Careggi, Florence. Written consent was collected by physicians P.P. and P.A. The 70 symptomatic hands were randomized into two groups: 35 hands were treated with FM (group A) and 35 with LLLT (group B). Each patient was given a consecutive number. If the patient presented bilateral CTS the investigator flipped a coin to determine whether the participant should go into group A or B. All patients were evaluated by physician P.C. who was blinded from the original patient group. Only one degree of blinding was possible due to the different modality of treatment.

Patients were evaluated before treatment (T0), 10 days after the last treatment (T1) and three months after the last treatment (T2) with the Italian clinical examination version of the self-assessment Boston questionnaire (BCTQ) (Padua et al., 1998), and visual analogue scale (VAS) of the mean pain or, in case no pain was felt, intensity of paresthesia felt in the last week.

This clinical trial was performed in accordance with ethical standards on human experimentation and with the Helsinki Declaration of 1975, as revised in 1983. The investigation and the use of patient data for research purposes was in accordance with the Declaration of the World Medical Association. The studies follow Good Clinical Practice. The patients were informed about every single treatment and the modality of evaluation.

Patients assigned to Group A received three sessions of FM for 45 min once a week for a total of 3 weeks. The technique involved deep friction over specific points (CCs CFs) selected by a clinical examination that involved specific movement and palpatory verification. The therapist used elbow and knuckles to create friction on the identified points. Each point has a surface smaller than 2 cm^2. The friction was maintained for a mean time of 3 min (range: 2–4 min) as indicated by the technique (Ercole et al., 2010). The number of points treated in each session ranged from 4 to 8 (mean value 6). They were chosen by the therapist based on palpation for fascial density and the patient's response and according to FM guidelines (Stecco, 2004). The location of the points are described in the method's textbook (Stecco, 2004) and reported in Figure 1. All the treatments were performed by the same trained therapist (M.P.) with more than five years of experience with this technique.

The patients of group B were treated with LLLT. The laser used was an infrared diode (M300 level laser) with a wavelength of 780–830 nm and a power between 1000 and 3000 mW. The patients in this group were subjected to five daily sessions lasting 10 min each supervised by E.P. The LLLT was applied along the course of the median nerve at the carpal level.

Each patient used the VAS scale to describe their pain level. All the participants completed the Italian version of the BTCQ, a self-administered tool that assesses the severity of the symptoms and the functional status. It is composed of two scales: the Symptoms Severity Scale (SSS) and the Functional Status Scale (FSS) containing 11 and 8 items respectively.

The Student *T* test for paired data was used to evaluate differences in groups at T0, T1, and T2. The Mann–Whitney test for unpaired data was used to compare the two groups at the different times. *P* value was considered significant for values <0.05. Data analysis was performed by using the SPSS statistical package for Windows.

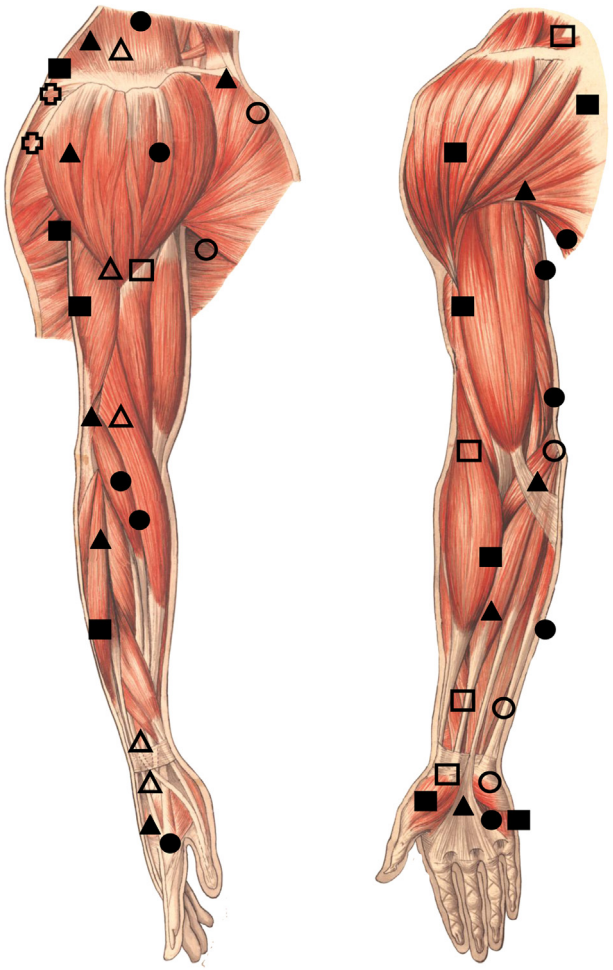

Figure 1 Anatomical location of the points (CCs and CFs) where Fascial Manipulation was applied (group A). We acknowledge Piccin nuova Libraria for the kind permission.■ = sagittal plane; ●= orizontal plane; ▲= frontal plane; □= ANME diagonal; ✪= RE-ME diagonal; △= RE-LA diagonal; ○= ANME diagonal.

Results

The analysis of the data reported that 82% of the patients had pain symptoms in the dominant limb. The two groups were homogeneous at T0 both in BTCQ (symptoms) ($p = 0.803$) and function ($p = 0.487$) as well in VAS scale ($p = 0.144$) (Table 1).

In Group A (FM treatment), at T0, the mean score of the BCTQ Symptomatic, Functional and VAS scale were of 3.027, 3.097 and 6.00 respectively. At T1 those values were 1.362, 1.40 and 0.80. At T2 those values were 1.27, 1.31 and 0.714. In this group there was a statistically significant improvement between T0 and T1 ($p < 0.0001$) and also between T0 and T2 ($p < 0.0001$) in both BTCQ and VAS scale. In Group B (LLLT treatment), at T0, the BTCQ Functional and Symptomatic and VAS values were 3.52, 2.90

Please cite this article in press as: Pratelli, E., et al., Conservative treatment of carpal tunnel syndrome: Comparison between laser therapy and fascial manipulation®, Journal of Bodywork & Movement Therapies (2014), http://dx.doi.org/10.1016/j.jbmt.2014.08.002

Table 1 Mean values± standard deviation for each measurement and *p* value of the comparisons between groups at each single times. (T0: visit pre treatment; T1: visit 10 days after the end of the treatment; T2: visit at 3 months after the end of the treatment; FM: Fascial Mnipulation group; LLLT: Low intensity laser therapy group; BS: Boston symptomatic scale; BF: Boston Functional scale; VAS: visual analogical scale; SD standard deviation).

Time	Scale	Group	Mean	SD	*P* value
TO	BS	MF	3.03	0.77	0.803
		LLLT	3.05	0.35	
	BF	MF	3.1	0.98	0.487
		LLLT	2.9	0.89	
	VAS	MF	6.00	2.6	0.144
		LLLT	5.51	2.24	
T1	BS	MF	1.36	0.27	<0.0001
		LLLT	2.67	0.47	
	BF	MF	1.41	0.3	<0.0001
		LLLT	2.58	0.79	
	VAS	MF	0.8	0.96	<0.0001
		LLLT	5.00	2.07	
T2	BS	MF	1.28	0.28	<0.0001
		LLLT	3.00	0.31	
	BF	MF	1.32	0.32	<0.0001
		LLLT	2.63	0.94	
	VAS	MF	0.71	0.93	<0.0001
		LLLT	5.03	2.02	

and 5.51 respectively. At T1 these values were 2.66, 2.58 and 5.00. At T2 the values were 2.99, 2.63 and 5.02 respectively. Therefore in group B there was a statistically significant improvement ($p < 0.001$) between T0 and T1 that decreased at T2 (Table 2). None of the patients dropped out of the study and no collateral effects were observed in patients after the application of FM and LLLT.

Table 2 Mean values± standard deviation of the different between T0-T1 and T0-T2. *P* value of the different between T0-T1 and T0-T2 in each group for each evaluation. (T0: visit pre treatment; T1: visit 10 days after the end of the treatment; T2: visit at 3 months after the end of the treatment; FM: Fascial Manipulation group; LLLT: Low intensity laser therapy group; BS: Boston symptomatic scale; BF: Boston Functional scale; VAS: visual analogical scale; SD standard deviation).

Comparison	Groups	Evaluation	Mean	SD	*p* value
T0-T1	MF	BS	1.67	0.69	<0.0001
		BF	1.69	0.88	<0.0001
		VAS	5.2	2.41	<0.0001
	LLLT	BS	0.38	0.44	<0.0001
		BF	0.32	0.16	<0.0001
		VAS	0.51	0.51	<0.0001
T0-T2	MF	BS	1.75	0.74	<0.0001
		BF	1.78	0.95	<0.0001
		VAS	5.29	2.42	<0.0001
	LLLT	BS	0.06	0.11	0.0054
		BF	0.27	0.59	0.0107
		VAS	0.49	0.98	0.006

Discussion

This study supports the conclusion that FM is more effective than LLLT in the conservative treatment of patients affected by CTS. The patients (Group A), treated with FM showed improvement of the BCTQ and VAS that was maintained at the follow up (T2) with a high level of significance ($p < 0.001$).

The success of FM in CTS in our study also supports the theory of myofascial continuity between the flexor carpi retinaculum, palmar aponeurosis and antebrachial and brachial fascia (Stecco et al., 2010). This fascial continuity can explain why a proximal treatment over the brachial fascia can affect the antebrachial fascia as well as the flexor retinaculum of carpi. In addition, Piyawinijwong et al. (2011) reported two anatomical cases of median nerve entrapment related to thickening of brachial fascia and of the bicipital aponeurosis that the authors note as possible causes of carpal tunnel syndrome. We assume that in the pathogenesis of carpal tunnel syndrome repetitive micro trauma and overuse activity cause a transformation of the extracellular matrix of the deep fascia from a sol to a gel in multiple regions of the arm and forearm (Stecco et al., 2013). This transformation would cause a reduction of fascial adaptability and gliding resulting in an abnormal stress to the intramuscular septa. This increase of viscosity of the extracellular matrix may involve also the epineurium of the medial nerve with its telescopic structure (Lundborg and Rydevik, 1973), which would, in turn, create an impairment of intrafascicular gliding. Loss of intrafascicular gliding has been shown to create an internal stretch lesion (Abe et al., 2005; Lundborg and Dahlin, 1996) that could alter afferent signals.

Standard electroneuromyographic evaluation can demonstrate a decrease in the velocity of signal transmission from the proximal part of the forearm to the hand, but it is not able to discriminate the exact location of the entrapment. Unfortunately, multiple segmental evaluations of nerve transmission is not a routine procedure. For this reason, the entrapment of the nerve may occur in other areas, far from the most common regions. Nakajima et al. (2009) demonstrated an ulnar nerve conduction block at the medial intermuscular septa, 7.5—10 cm proximal to the medial epicondyle. We speculate that many cases of CTS are a consequence of multiple sites of increased viscosity of the extracellular matrix and as a consequence, of the fascia and epineurium. We assume that group A obtained a better result thanks the multiple sites of treatment, based on an accurate clinical exam.

This study has limitations due to the lack of long-term follow-up dates and post-treatment electroneuromyographic evaluation. Double blinding was impossible given the use of different modalities of treatments.

Conclusion

FM appears to be an appropriate treatment not only for musculoskeletal dysfunction but also for common nerve

Please cite this article in press as: Pratelli, E., et al., Conservative treatment of carpal tunnel syndrome: Comparison between laser therapy and fascial manipulation®, Journal of Bodywork & Movement Therapies (2014), http://dx.doi.org/10.1016/j.jbmt.2014.08.002

entrapments as in carpal tunnel syndrome. The method is effective and non-invasive. It gives excellent results for the relief of local symptoms and for restoring functionality with benefits that remain at three month follow up.

Due to treatment failure of 1%—25% and complications of carpal tunnel releases (Neuhaus et al., 2012) we suggest that a conservative treatment of FM should be prescribed first. This manual treatment allows the operator to assess and treat alteration of fascial viscosity in multiple areas of the arm and forearm. As stated, we suggest the importance of a global treatment by way of a deep manipulation on specific points (CCs and CFs) to resolve alterations that may extend along a myofascial sequence.

References

Abe, Y., Doi, K., Kawai, S., 2005. An experimental model of peripheral nerve adhesion in rabbits. J. Plast. Surg. Br. 58, 533—540.

Chang, W.D., Wu, J.H., Jiang, J.A., Yeh, C.Y., Tsai, C.T., Dec 2008. Carpal tunnel syndrome treated with a diode laser: a controlled treatment of the transverse carpal ligament. Photomed. Laser Surg. 26 (6), 551—557.

Dakowicz, A., Kuryliszyn-Moskal, A., Kosztyła-Hojna, B., Moskal, D., Latosiewicz, R., 2011. Comparison of the long-term effectiveness of physiotherapy programs with low-level laser therapy and pulsed magnetic field in patients with carpal tunnel syndrome. Adv. Med. Sci. 56 (2), 270—274.

Day, J.A., Stecco, C., Stecco, A., 2009. Application of fascial manipulation & technique in chronic shoulder pain—Anatomical basis and clinical implications. J. Body Work Mov. Ther. 13, 128—135.

Elwakil, T.F., Elazzazi, A., Shokeir, H., 2007. Treatment of carpal tunnel syndrome by low-level laser versus open carpal tunnel release. Lasers Med. Sci. 22 (4), 265—270.

Ercole, B., Stecco, A., Day, J.A., Stecco, C., 2010. How much time is required to modify a fascial fibrosis? J. Bodyw. Mov. Ther. 14, 318—325.

Guarda-Nardini, L., Stecco, A., Stecco, C., Masiero, S., Manfredini, D., Apr 2012. Myofascial pain of the jaw muscles: comparison of short-term effectiveness of botulinum toxin injections and fascial manipulation technique. Cranio 30 (2), 95—102.

Hunter, J.M., Aug 1991. Recurrent carpal tunnel syndrome, epineural fibrous fixation, and traction neuropathy. Hand Clin. 7 (3), 491—504.

Ibrahim, I., Khan, W.S., Goddard, N., Smitham, P., 2012. Carpal tunnel syndrome: a review of the recent literature. Open. Orthop. J. 6, 69—76.

Kujawa, J., Zavodnik, L., Zavodnik, I., Bryszewska, M., 2003. Low intensity near infrared laser radiation induces changes of acetyl — choline esterase activity of human erythrocytes. Lasers Surg. Med. 21 (6), 351—355.

Lundborg, G., Dahlin, L.B., 1996. Anatomy, function, and pathophysiology of peripheral nerves and nerve compression. Hand Clin. 12, 185—193.

Lundborg, G., Rydevik, B., 1973. Effects of stretching the tibial nerve of the rabbit. A preliminary study of the intraneural circulation and the barrier function of the perineurium. J. Bone Jt. Surg. Br. 55, 390—401.

Maddali Bongi, S., Signorini, M., Bassetti, M., Del Rosso, A., Orlandi, M., De Scisciolo, G.A., May 2013. Manual therapy intervention improves symptoms in patients with carpal tunnel syndrome: a pilot study. Rheumatol. Int. 33 (5), 1233—1241.

Mahoney, J.L., Dagum, A.B., Nov 1992. Carpal tunnel syndrome: diagnosing and treating the mostcommon hand disorder. Can. Fam. Physician 38, 2681.

Marshall, S., 2001. Carpal tunnel syndrome. Clin. Evid. 5, 717—728.

Marshall, S., Tardif, G., Ashworth, N.L., 2007. Local corticosteroid injection for carpal tunnel syndrome. Cochrane Database Syst. Rev. 18.

Nakajima, M., Ono, N., Kojima, T., Kusunose, K., May 2009. Ulnar entrapment neuropathy along the medial intermuscular septum in the midarm. Muscle Nerve 39 (5), 707—710.

Nakamichi, K., Tachibana, S., 1995. Restricted motion of the median nerve in carpal tunnel syndrome. J. Hand Surg. Br. 20, 460—464.

Neuhaus, V., Christoforou, D., Cheriyan, T., Mudgal, C.S., Oct 2012. Evaluation and treatment of failed carpal tunnel release. Orthop. Clin. North Am. 43 (4), 439—447. http://dx.doi.org/10.1016/j.ocl.2012.07.013. Epub 2012 Aug 30. Review.

O'Connor, D., Marshall, S., Massy-Westropp, N., 2003. Non-surgical treatment (other than steroid injection) for carpal tunnel syndrome. Cochrane Database Syst. Rev. 1, CD003219.

Padua, R., Padua, L., Romanini, E., et al., 1998. Boston carpal tunnel questionnaire: Italian version. It J. Orthop. Traumatol. 24, 121—129.

Page, M.J., Massy-Westropp, N., O'Connor, D., Pitt, V., Jul 11 2012a. Splinting for carpal tunnel syndrome. Cochrane Database Syst. Rev. 7, CD010003.

Page, M.J., O'Connor, D., Pitt, V., Massy-Westropp, N., Jun 13 2012b. Exercise and mobilization interventions for carpal tunnel syndrome. Cochrane Database Syst. Rev. 6, CD009899.

Page, M.J., O'Connor, D., Pitt, V., Massy-Westropp, N., Jan 18 2012c. Therapeutic ultrasound forcarpal tunnel syndrome. Cochrane Database Syst. Rev. 1, CD009601.

Pedrelli, A., Stecco, C., Day, J.A., 2009 Jan. Treating patellar tendinopathy with fascial manipulation. J. Bodyw. Mov. Ther. 13 (1), 73—80.

Phalen, G.S., 1970. Reflections on 21 years' experience with the carpal- tunnel syndrome. JAMA 212, 1365—1367.

Picelli, A., Ledro, G., Turrina, A., Stecco, C., Santilli, V., Smania, N., 2011 Dec. Effects of myofascial technique in patients with subacute whiplash associated disorders: a pilot study. Eur. J. Phys. Rehabil. Med. 47 (4), 561—568.

Piyawinijwong, S., Khampremsri, N., Ongsiriporn, M., Roongruangchai, J., Nov 2011. Cadaveric study of median nerve entrapment in the arm: report of two anatomical cases. J. Med. Assoc. Thai 94 (11), 1405—1409.

Rojviroj, S., Sirichativapee, W., Kowsuwon, W., Wongwiwattananon, J., Tam- nanthong, N., Jeeravipoolvarn, P., 1990. Pressures in the carpal tunnel. A comparison between patients with carpal tunnel syndrome and normal subjects. J. Bone Oint Surg. Br. 72, 516—51815.

Scutt, N., Rolf, C.G., Scutt, A., 2006. Glucocorticoids inhibit tenocyte pro- liferation and tendon progenitor cell recruitment. J. Orthop. Res. 24, 173—182.

Stecco, L., 2004. Fascial Manipulation, first ed. Piccin, Padua.

Stecco, C., Gagey, O., Macchi, V., Porzionato, A., De Caro, R., Aldegheri, R., Delmas, V., Mar 2007. Tendinous muscular insertions onto the deep fascia of the upper limb. First part: anatomical study. Morphologie 91 (292), 29—37. PubMed PMID: 17574470.

Stecco, A., Macchi, V., Stecco, C., Porzionato, A., Ann Day, J., Delmas, V., De Caro, R., 2009 Jan. Anatomical study of myofascial continuity in the anterior region of the upper limb. J. Bodyw. Mov. Ther. 13 (1), 53—62.

Stecco, C., Macchi, V., Lancerotto, L., Tiengo, C., Porzionato, A., De Caro, R., May 2010. Comparison of transverse carpal ligament and flexor retinaculum terminology for the wrist. J. Hand Surg. Am. 35 (5), 746—753.

Stecco, A., Stecco, C., Macchi, V., Porzionato, A., Ferraro, C., Masiero, S., De Caro, Dec 2011. MRI study and clinical correlations of ankle retinacula damage and outcomes of ankle sprain. Surg. Radiol. Anat. 33 (10), 881—890.

Please cite this article in press as: Pratelli, E., et al., Conservative treatment of carpal tunnel syndrome: Comparison between laser therapy and fascial manipulation®, Journal of Bodywork & Movement Therapies (2014), http://dx.doi.org/10.1016/j.jbmt.2014.08.002

Stecco, A., Gesi, M., Stecco, C., Stern, R., 2013. Fascial components of the myofascial pain syndrome. Curr. Pain Headache Rep. 17, 32.

Sucher, B.M., 1993. Myofascial manipulative release of carpal tunnel syndrome: documentation with magnetic resonance imaging. J. Am. Osteopath Assoc. 93, 1273–1278.

Sucher, B.M., 1994. Palpatory diagnosis and manipulative management of carpal tunnel syndrome. J. Am. Osteopath Assoc. 94, 647–663.

Thurston, A., October 2013. Carpal tunnel syndrome. Orthop. Trauma 27 (5), 332–341. ISSN 1877–1327.

Tsai, W.C., Tang, F.T., Wong, M.K., Pang, J.H., Mar 2003. Inhibition of tendon cell migration by dexamethasone is correlated with reduced alpha-smooth muscle actin gene expression: a potential mechanism of delayed tendon healing. J. Orthop. Res. 21 (2), 265–271.

Valente, R., Gibson, H., 1994. Chiropractic manipulation in carpal tunnel syndrome. J. Manip. Physiol. Ther. 17, 246–249.

Yagci, I., Elmas, O., Akcan, E., Ustun, I., Gunduz, O.H., Guven, Z., Sep 2009. Comparison of splinting and splinting plus low-level laser therapy in idiopathic carpal tunnel syndrome. Clin. Rheumatol. 28 (9), 1059–1065.

Please cite this article in press as: Pratelli, E., et al., Conservative treatment of carpal tunnel syndrome: Comparison between laser therapy and fascial manipulation®, Journal of Bodywork & Movement Therapies (2014), http://dx.doi.org/10.1016/j.jbmt.2014.08.002