

Mobilization with Movement, Thoracic Spine Manipulation and Dry Needling for the Management of Temporomandibular Disorder: A Prospective Case Series

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ABSTRACT

Aims: The purpose of this case series was to describe the outcomes of patients with temporomandibular disorder (TMD) treated with mobilization with movement (MWM) directed at the temporomandibular joint (TMJ) and the cervical spine, thoracic manipulation and trigger point (TrP) dry needling.

Methods: Fifteen consecutive patients presenting to physical therapy with TMD participated. At baseline all patients completed the Steigerwald/Maher TMD disability questionnaire, the Visual Analog Scale (VAS), and maximal mouth opening (MMO). The VAS and MMO were also collected at 15 days post-treatment and at a 2-month follow-up, and the Steigerwald/Maher TMD disability questionnaire was completed at the 2-month follow-up. Treatment included MWM directed at the TMJ and cervical spine, thoracic spine manipulation and TrP dry needling for 4 weeks. Repeated measure ANOVAs were used to determine the effects of the intervention on each outcome. Within-group effect sizes were calculated in order to assess clinical effectiveness.

Results: Fifteen patients (60% female, age: 44 years; mean duration of symptoms: 20.3 months) participated in this case series. The ANOVA revealed significant decreases in pain scores and an increase in MMO and disability following the physical therapy management strategy (all, $P < .001$). Significant differences were found between pre-intervention and both follow-up periods ($P < .01$). Within-group effect sizes were large ($d > 1.0$) for all outcomes at both follow-up periods.

Conclusions: Patients with TMD treated with a multimodal treatment approach including MWM directed at the TMJ and the cervical spine, thoracic manipulation and TrP dry needling exhibited significant and clinical improvements in pain intensity, disability and MMO.

Key Words: Temporomandibular Disorder; Manipulation; Physical Therapy; Dry needling.

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INTRODUCTION

Temporomandibular disorder (TMD) is defined as “aching in the muscles of mastication, sometimes with occasional brief severe pain on chewing, often associated with restricted jaw movement and clicking or popping sounds.”¹ TMD often results in debilitating orofacial pain, restricted mandibular range of motion and headaches.² It has recently been reported that the prevalence of TMD is approximately 6.3% for females and 2.8% for males.³

Physical therapy is commonly utilized in the treatment of patients with TMD, toward the general goals of reducing adverse loading and pain, and facilitating a return to full, pain-free function.^{4;5} Physical therapy management often includes manual therapy techniques directed at the temporomandibular joint (TMJ) and the cervicothoracic spine in addition to exercise and postural correction. However, there is limited evidence to in support these techniques and studies to date have been of poor methodological quality.⁶ Therefore, further studies reporting the outcomes in patients with TMD who are treated with commonly used physical therapy interventions is needed.

Mulligan’s Mobilization with movement (MWM)⁷ is a form of manual therapy that is gaining popularity among clinicians.⁸ In this concept, the clinician applies a pain free manual glide force to the dysfunctional joint while the patient actively moves. The purpose of the technique is to improve range of motion while at the same time eliminating pain. With repetition, it is believed that permanent improvements can be gained. An underlying premise for this concept is that there is a positional fault at the joint causing pain and limitation of movement.⁹ There exists some evidence of such faults at least at the ankle.^{10;11} While MWM techniques have been described for the TMJ,¹² there is no evidence for their effect in TMD. In

contrast the efficacy of MWM at other peripheral joints has been demonstrated, with 96% of studies showing positive effects.⁸ The major benefits of MWM techniques are their pain free nature and ability to be applied as home exercises.

Mobilization with movement has also been described for the cervical spine (in the spine MWM are described as Sustained Natural Apophyseal Glides's or SNAG's) which may be used in the management of TMD. For example, there is evidence that long-term cervical dysfunction may influence the function of the temporomandibular region and vice versa.¹³⁻¹⁶ In fact, La Touche et al demonstrated that the application of manual treatment directed at the cervical spine decreased pain intensity and increased pain-free mouth opening in patients with myofascial TMD.¹⁷ Hence, correction of cervical movement impairment may be an important component of the management of TMD. A Mulligan C1/2 SNAG has previously been shown to have positive effects on patients with upper cervical joint dysfunction and cervicogenic headache.¹⁸ However, the effects of cervical SNAG's in patients with TMD are not known.

Thoracic spine thrust manipulation has been show to be beneficial in increasing range of motion, decreasing pain and improving function in individuals with mechanical neck pain.¹⁹⁻²¹ Considering the intimate inter-relationship between the TMJ and the neck,¹² some therapists have begun incorporating thoracic spine thrust manipulation into the management of patients with TMD. However, evidence for the benefits of including thoracic spine manipulation for the management of patients with TMD is anecdotal.

There has also been a recent trend for the utilization of trigger point (TrP) dry needling for a variety of musculoskeletal conditions.²² A TrP is a hyperirritable spot in a palpable taut band of a muscle that is often sensitive to palpation and stretch.²³ Evidence supporting the use of TrP dry needling (TrP-DN) to the muscle of mastication in patients with TMD is scarce. Fernández-Carnero et al. have found that the application of DN into active TrPs in the masseter muscle induced significant hypoalgesic effects and increased maximal jaw opening when compared to the sham dry needling in patients with myofascial TMD.²⁴ However, the application of an isolated intervention does not represent the common clinical

practice. Hence, the purpose of this case series is to report the outcomes of patients presenting with myofascial TMD and treated with a multimodal physical therapy management approach consisting of MWM, thoracic manipulation and TrP-DN.

MATERIALS and METHODS

Participants

Patients for this case series were recruited over a seven month period (September 2011 to March 2012) from one private physical therapy clinic in Spain. To be eligible to participate all patients had to have a diagnosis of myofascial TMD according to the Research Diagnostic Criteria for TMD (RDC/TMD)²⁵ The following signs/symptoms were assessed with the RDC/TMD criteria: location of pain, range of jaw motion and associated TMJ pain, clicking sounds, and pain upon muscle and TMJ palpation. Patients had to exhibit a history of symptoms of at least 3-months duration; and a pain intensity of at least 30 mm on a 100 mm visual analogue scale (VAS). Eligible patients could also exhibit cervical, thoracic or shoulder pain; however, their most bothersome area had to be the face. Exclusion criteria included signs or symptoms of disc displacement, osteoarthritis, or osteoarthritis of the TMJ according to categories II-III of the RDC/TM; post-surgical conditions involving the cervical or temporomandibular region; patients who made use of analgesics or muscle relaxant up to 8 hours before the physical therapy procedure, and those with hypermobility in the cervical region or mouth opening. Patients were also excluded if they reported that were not able to comply with the treatment schedule. The study was approved by Local Ethical Committee and all patients provided informed consent.

Outcomes

All individuals provided demographic information, health history, and completed the Visual Analog Scale (VAS). Further, they completed the Steigerwald/Maher TMD disability questionnaire to determine the patients' level of function.²⁶ This was followed by a physical examination which included measurements of maximal mouth opening (MMO). The VAS and MMO were collected at baseline, at the end of the

treatment, 15 days post treatment and 2-months post treatment. The Steigerwald/Maher TMD disability questionnaire was collected at baseline and the 2-month follow-up period

The primary outcome measure used in this study was the VAS. The VAS (a 10 centimeter line with 0 representing “no pain” and 10 representing “the worst pain imaginable”) was utilized to quantify the patient’s perceived level of pain. In the current study we recorded the patient’s current pain, the worst level of pain over the past 24 hours and the best level of pain over the past 24 hours. Patients placed a mark along the line, which corresponded with the intensity of their pain symptoms. The VAS has demonstrated to be a valid and reliable tool for measuring the intensity of pain.²⁷ In addition, the VAS exhibits a minimal clinically important difference (MCID) between 9 and 11 mms.^{28;29}

The secondary outcome included maximal mouth opening (MMO). Maximal mouth opening was measured with patients in seated position utilizing a 10 cm plastic ruler marked in millimetres. Patients were instructed to “open their mouth as wide as possible without causing an increase in her pain or discomfort”.³⁰ At the end position of MMO, the distance between the upper and lower central incisors was assessed in millimetres. Intra-rater reliability has shown to be acceptable when measuring mandibular opening in millimetres (ICC: 0.90 to 0.98).³¹

Additionally, all subjects completed the Steigerwald/Maher TMD disability questionnaire²⁶ at baseline as well as at the 2-month follow-up. This scale is divided into 3 components: the temporomandibular disability index (TDI), the temporomandibular symptom intensity scale (SIS), and the symptom frequency scale (SFS). A higher score is indicative of greater disability. The validity and reliability of this questionnaire has not yet been tested.

Interventions

Participants received a maximum of 9 treatments over a time frame ranging from 2 to 5 weeks at a frequency of 1-2 sessions per week. Treatment included mobilization with movement directed at the TMJ and cervical spine; thoracic spine thrust manipulation and TrP dry needling.

Mobilization with Movement

The MWM technique followed the principles described by Oliver.¹² The therapist stood behind the seated patient, placing their palms either side of the patient's head, with the thumbs over the zygomatic arches, to stabilize the head. The index fingers were placed parallel and immediately anterior to the posterior border of the mandible, passing over the TMJ. The third and fourth fingers of each hand were positioned behind the posterior border of the ramus of the mandible, just above the mandibular angle. This hand placement allowed the therapist to apply transverse force across the mandible as necessary, while at the same time allowing an anterior-inferior gliding force to the mandible on the side of restriction, whilst also controlling the unrestricted side, inhibiting any excessive mandibular forward gliding with the other hand (**Figure 1**). The combination of these manual forces allowed the mandible to maintain a midline position during mouth opening, enabling a larger range of jaw motion. The therapist could select one or several different glide directions, depending on the patient's clinical presentation and response to the application of the technique. Pain and movement was always the guide for technique modification. If increased pain free movement was achieved, then 3 sets of six movements were performed at each subsequent session. Once full-range, pain free movement was achieved, the patient applied overpressure into depression with his fingers on the chin, sustaining this force for three seconds.

SNAG C1-2

The cervical flexion-rotation test (FRT) was used to identify impairment of motion of the C1/2 motion segment and consequently an indicator to apply a C1/2 MWM technique.³² For the FRT, the patients were positioned in supine lying and the therapist passively flexed the cervical spine to end-range. The therapist then rotated the head to the left and to the right. A positive test was indicated by a limitation of rotation.³³ Range of rotation is usually 40-44° degrees to each side^{33:34} in asymptomatic subjects, whilst a range limited to 33° or less indicates a positive result.³⁵ Previous reports indicate high intra-rater reliability for ROM measured by trained examiners using the FRT (ICC: 0.95, 95%CI: 0.90-0.98).³⁵ Furthermore ROM

recorded during the test and examiner interpretation of the test has been shown to be consistent over time with a Kappa of 0.92 and a minimal detectable change of at most 7°.35 When a positive test was identified, a C1/2 SNAG was applied according to the guidelines suggested by Mulligan.7 A horizontal, anteriorly directed force was applied with the distal phalanx of the thumbs over the C1 transverse process on the contra-lateral side of the limited rotation. While sustaining this glide, the patient actively rotated the head in the direction of the limitation, based on the FRT (**Figure 2**). This procedure was repeated two times on the first occasion, and repeated six times on subsequent visits, ceasing when full range was achieved on the FRT.

Thoracic Manipulation

We will use the nomenclature suggested by Mintken et al³⁶ in the description of the thoracic spine thrust manipulation used in this case series. At each session all patients received a high-velocity, end-range, anterior-posterior force applied through the elbows to the upper thoracic spine on the mid-thoracic spine in cervico-thoracic flexion with the patient in supine (**Figure 3**). The therapist used the manipulative hand to stabilize the inferior vertebra bone of the motion segment targeted and used the upper trunk to apply a force through the patient's arms and performed a high-velocity, low-amplitude thrust. Patients received 2 manipulative interventions each session targeting thoracic segments T1-T4.

Trigger Point Dry Needling

During all treatment sessions, the patient received the TrP-DN technique directed at the temporalis and masseter muscles active TrPs. The TrP-DN procedure used was similar to the TrP injection described by Hong et al.^{37,38} The TrP was compressed by the index finger or middle finger of the non-dominant hand of the therapist to direct the placement of the needle tip while inserting the needle. An acupuncture needle, 0.2 inches in length, was held by the therapist's dominant hand. The needle was inserted into the skin at a point above the taut band over the TrP (**Figure 4**). After penetration of the needle into the skin tissue, it was directed to the muscle TrP until a first local twitch response was provoked. Then, the needle was inserted

and withdrawn from the TrP rapidly. With rapid movement of needle, a local twitch response can be elicited if the needle tip encounters a sensitive locus. The needle insertions were repeated to elicit as many local twitch responses as possible. On each session, 2-3 min. was approximately required for the procedure.

Data Analysis

Mean baseline demographic values were calculated for continuous variables. Frequencies were calculated for categorical variables. A normal distribution of quantitative data was assessed by means of the Kolmogorov-Smirnov test ($P > .05$). A 1-way analysis of variance (ANOVA) for repeated measures was used to compare the within-patient scores for each dependent measure. The Bonferroni correction was used as the post hoc analysis. Dependent t-tests were used to determine if a significant difference existed between baseline and the 2-month follow-up for all 3 subscales of the Steigerwald/Maher TMD disability questionnaire. Within-group effect sizes were calculated using Cohen d coefficient (d).³⁹ An effect size greater than 0.8 was considered large, around 0.5 moderate, and less than 0.2 small. Data were analyzed with the PASW package version 18.0. A p value less than .05 was considered statistically significant.

RESULTS

Eighteen patients with myofascial TMD were screened for eligibility criteria. Four did not meet the eligibility criteria as made use of analgesics prior to any of the treatment procedures. Of the 15 subjects that participated in this case series 9 were female (60%) and the mean duration of symptoms was 20.3 months (SD: 20.4 month, range 3-72 months). Four patients (26.7%) reported bilateral pain and 12 (80%) reported experiencing headaches sporadically. They had been treated for an average of 5.6 (SD 1.8) visits (median 5.0, range 3-9) with previous interventions. Baseline characteristics for each patient can be found in **Table 1**.

A 1-way ANOVA of repeated measures revealed a significant decrease in VAS scores following the evidence-based management strategy ($F=40.5$; $P<.001$). Post hoc testing found that statistically significant differences existed between baseline measurements of the VAS and VAS at the final visit ($p<.001$).

Additionally there also existed a significant difference between the baseline VAS and the 2-month follow-up period ($P<.01$). Within-group effect sizes were large ($d>1.4$) for post-intervention and follow-up periods. Baseline and follow-up scores as well as the difference between pretest and posttest values can be found in **Table 2**. The change scores for the VAS scores for each individual patient can be found in **Figure 5**.

A 1-way ANOVA of repeated measures revealed a significant decrease in WVAS scores following the evidence-based management strategy ($F=48.9$; $P<.001$). Post hoc testing revealed statistically significant differences between baseline measurements of the WVAS and WVAS at the final visit ($p<.001$). Additionally, there also existed a significant difference between the baseline WVAS and the 2-month follow-up period ($P<.01$). Within-group effect sizes were large ($d>1.8$) for post-intervention and follow-up periods. Baseline and follow-up scores as well as the difference between pretest and posttest values can be found in **Table 2**.

A 1-way ANOVA of repeated measures revealed a significant decrease in BVAS scores following the evidence-based management strategy ($F=36.8$; $P<.001$). Post hoc testing showed that statistically significant differences existed between baseline measurements of baseline BVAS and BVAS at the final visit ($p<.001$). There also existed a significant difference between the baseline BVAS and the 2-month follow-up period ($P<.01$). Again, within-group effect sizes were large ($d>1.2$) for post-intervention and follow-up periods. Baseline and follow-up scores as well as the difference between pretest and posttest values can be found in **Table 2**.

The ANOVA revealed a significant increase in MMO following treatment ($F=18.9$; $P=.001$). Post hoc testing reported that statistically significant differences existed between baseline MMO and MMO at the final visit ($p<.001$). Again, there also existed a significant difference between the baseline MMO and the 2-month follow-up period ($P=.001$) with large effect sizes ($d=1.1$)

The dependent t-tests demonstrated a significant difference between baseline and the 2-month follow-up for the TDI ($p<.001$), SIS ($p<.001$), SFS ($p<.001$). Again, effect sizes were large.

DISCUSSION

The patients with myofascial TMD in the current case series exhibited significant and clinically important improvements in pain intensity, range of motion, and disability following the intervention period. The effect sizes were large for all of outcomes at both immediate and the 2 months follow up period. It should be noted that the reduction in pain was not only statistically significant but also clinically meaningful as it exceeded the MCID on the VAS, identified as 9-11mm.^{28;29} Further, even the lower bound estimates for the 95% confidence intervals fall above the MCID and provide evidence that the multimodal intervention applied in the current case series may be beneficial in the management of patients with TMD.

One component of the intervention was MWM directed at the TMJ. To date there has only been one case report to describe the outcomes following MWM in the management of a patient with TMD.¹² The case report included a female patient who experienced chronic TMD, neck pain, and headaches which resulted in significant disability for many years. After 5 treatment sessions, comprising principally MWM and MWM home exercise, the patient was pain free and functioning normally and remained so at a 3-month follow up period. The proposed mechanism of action for MWM has been explored in-depth.⁹ One of the principle mechanisms is believed to be correction of a positional fault at the faulty joint with the MWM glide force. While there is evidence of a positional fault in pathologies affecting the ankle,^{10;11} the knee,⁴⁰ and the shoulder⁴¹, there is no such evidence for the TMJ. In addition there is only very preliminary evidence that MWM can influence a positional fault,⁴² or that such change is associated with improvement in range of motion, pain and disability.⁴³

It is possible that the thoracic manipulation might have contributed to the overall outcomes by improving biomechanical impairments. However, it has been recently suggested that the benefit of manipulation occurs through a neurophysiologic process rather than a biomechanical one.^{44;45} It is possible that spinal manipulation results in a hypoalgesic effect.⁴⁶ It has also been demonstrated that spinal manipulation results in improvements in thermal sensitivity or it is also plausible that the thoracic

manipulation resulted in a reduction of inflammatory cytokines. Nevertheless, the exact mechanism through which spinal manipulation exerts its effects remains to be determined.

To date there have been very few studies that have examined the effects or reported the outcomes of patients receiving TrP-DN techniques. A recent case series of 9 rock climbers with lateral epicondylalgia received a multimodal treatment approach including TrP-DN to the wrist extensor muscles.⁴⁷ All patients in that case series exhibited a clinically meaningful improvement in function and pressure pain thresholds over the wrist extensor muscles. However, a cause and effect between the outcomes and the intervention could not be determined since a comparison group was not included. The physiological mechanism by which TrP-DN exerts its effects is currently unknown. However, it has been speculated that DN may stimulate A δ fibers and perhaps can activate serotonergic and noradrenergic inhibitory systems.⁴⁸ It is also plausible that the needle may result in a quick stretch to the shortened muscle fibers resulting in a relaxation of the sarcomeres.²² Furthermore, it has also been demonstrated that substance P and calcitonin gene related peptide can be reduced in TrPs after being stimulated with a needle.⁴⁹

There are a number of limitations to this case series that must be considered. Perhaps most importantly is the fact that we did not include a control group and hence cannot be certain if patients improved because of the treatment. It is possible that the improvements observed in the patients may be related to the passage of time; however, we would expect this to be unlikely given the current duration of symptoms (20 month). Additionally, the small sample size may limit the generalizability of the findings to all patients with myofascial TMD. We only included a short term follow-up period of 2-months. We cannot be certain if the benefits achieved would be maintained beyond this point. Future randomized clinical trials should be carried out using larger sample sizes and long-term follow-up periods to determine if a cause and effect relationship exists.

CONCLUSION

Patients with TMD treated with a multimodal treatment approach including MWM directed at the temporomandibular joint and cervical spine, thoracic manipulation directed at the thoracic spine and TrP-DN exhibited significant and clinical important improvements in pain, disability and MMO. Furthermore, these changes were maintained 2 months after discharge. Future clinical trials are necessary to determine if a cause and effect relationship exists between the interventions utilized and the outcomes.

Reference List

- (1) Merskey H BN. Classification of Chronic Pain. Seattle, WA: IASP Press; 1994.
- (2) Dimitroulis G. Temporomandibular disorders: a clinical update. *BMJ* 1998; 317:190-194.
- (3) Isong U, Gansky SA, Plesh O. Temporomandibular joint and muscle disorder-type pain in U.S. adults: the National Health Interview Survey. *J Orofac Pain* 2008; 22:317-322.
- (4) Nicolakis P, Erdogmus B, Kopf A, Djaber-Ansari A, Piehslinger E, Fialka-Moser V. Exercise therapy for craniomandibular disorders. *Arch Phys Med Rehabil* 2000; 81:1137-1142.
- (5) Di Fabio RP. Physical therapy for patients with TMD: a descriptive study of treatment, disability, and health status. *J Orofac Pain* 1998; 12:124-135.
- (6) McNeely ML, Armijo OS, Magee DJ. A systematic review of the effectiveness of physical therapy interventions for temporomandibular disorders. *Phys Ther* 2006; 86:710-725.
- (7) Mulligan B. Manual Therapy, 'NAGS', 'SNAGS', and 'MWMS'. Wellington: Plane View Services; 2010.
- (8) Hing W, Bigelow, Bremner T. Mulligan's mobilization with movement: A systematic review. *Journal of Manual and Manipulative Therapy* 2009; 17::E39-E66.
- (9) Vicenzino B, Hing W, Rivett D, Hall T. Mobilisation with movement: The art and the science. Sydney: Elsevier; 2011.
- (10) Hubbard TJ, Hertel J, Sherbondy P. Fibular position in individuals with self-reported chronic ankle instability. *J Orthop Sports Phys Ther* 2006; 36:3-9.
- (11) Hubbard TJ, Hertel J. Anterior positional fault of the fibula after sub-acute lateral ankle sprains. *Man Ther* 2008; 13:63-67.
- (12) Oliver M. Tempromandibular joint dysfunction: an open and shut case. In: Vicenzino B, Hing D, Rivett D, Hall T, editors. Mobilisation with movement: The art and science. Sydney: Elsevier; 2011.
- (13) de WA, Steenks MH, de Leeuw J, Bosman F, Helders P. Symptoms of the cervical spine in temporomandibular and cervical spine disorders. *Journal of Oral Rehabilitation* 1996; 23:742-750.
- (14) Nicolakis P, Nicolakis M, Piehslinger E, Ebenbichler G, Vachuda M, Kirtley C et al. Relationship between craniomandibular disorders and poor posture. *Cranio* 2000; 18:106-112.

- (15) Olivo SA, Bravo J, Magee DJ, Thie NM, Major PW, Flores-Mir C. The association between head and cervical posture and temporomandibular disorders: a systematic review. *J Orofac Pain* 2006; 20:9-23.
- (16) Bevilaqua-Grossi D, Chaves TC, de Oliveira AS. Cervical spine signs and symptoms: perpetuating rather than predisposing factors for temporomandibular disorders in women. *J Appl Oral Sci* 2007; 15:259-264.
- (17) La TR, Fernandez-de-las-Penas C, Fernandez-Carnero J, Escalante K, ngulo-Diaz-Parreno S, Paris-Alemany A et al. The effects of manual therapy and exercise directed at the cervical spine on pain and pressure pain sensitivity in patients with myofascial temporomandibular disorders. *J Oral Rehabil* 2009; 36:644-652.
- (18) Hall T, Chan HT, Christensen L, Odenthal B, Wells C, Robinson K. Efficacy of a C1-C2 self-sustained natural apophyseal glide (SNAG) in the management of cervicogenic headache. *J Orthop Sports Phys Ther* 2007; 37:100-107.
- (19) Cleland JA, Mintken PE, Carpenter K, Fritz JM, Glynn P, Whitman J et al. Examination of a Clinical Prediction Rule to Identify Patients With Neck Pain Likely to Benefit From Thoracic Spine Thrust Manipulation and a General Cervical Range of Motion Exercise: Multi-Center Randomized Clinical Trial. *Phys Ther* 2010;90:1239-1250.
- (20) Gonzalez-Iglesias J, Fernandez-de-las-Penas C, Cleland JA, Gutierrez-Vega MR. Thoracic spine manipulation for the management of patients with neck pain: a randomized clinical trial. *J Orthop Sports Phys Ther* 2009; 39:20-27.
- (21) Gonzalez-Iglesias J, Fernandez-de-las-Penas C, Cleland JA, burquerque-Sendin F, Palomeque-del-Cerro L, Mendez-Sanchez R. Inclusion of thoracic spine thrust manipulation into an electro-therapy/thermal program for the management of patients with acute mechanical neck pain: a randomized clinical trial. *Man Ther* 2009; 14:306-313.
- (22) Dommerholt J M-DMO, Grobli C. Trigger point dry needling. *Journal of Manual and Manipulative Therapy* 2006; 14:E70-E87.
- (23) Simons DG. *Travel and Simons' Myofascial Pain and Dysfunction: The Trigger Point Manual*. 2nd ed. Baltimore: Williams and Wilkins; 1999.
- (24) Fernandez-Carnero J, La TR, Ortega-Santiago R, Galan-del-Rio F, Pesquera J, Ge HY et al. Short-term effects of dry needling of active myofascial trigger points in the masseter muscle in patients with temporomandibular disorders. *J Orofac Pain* 2010; 24:106-112.
- (25) Dworkin SF, LeResche L. Research diagnostic criteria for temporomandibular disorders: review, criteria, examinations and specifications, critique. *J Craniomandib Disord* 1992; 6:301-355.
- (26) Steigerwald DP, Maher JH. The Steigerwald/Maher TMD Disability Questionnaire. *Today's Chiropractic* 1997; July-August:86-91.

- (27) Bijur PE SWGJ. Reliability of the visual analog scale for measurement of acute pain. *Academic Emergency Medicine* 2001; 8:1153-1157.
- (28) Gallagher EJ LMBP. Prospective validation of clinically important changes in pain severity measured on a visual analog scale. *Annals of Emergency Medicine* 2001; 38:633-638.
- (29) Bird SB DE. Clinically significant changes in pain along the visual analog scale. *Annals of Emergency Medicine*. *Annals of Emergency Medicine* 2001; 36:639-643.
- (30) Walker N, Bohannon RW, Cameron D. Discriminant validity of temporomandibular joint range of motion measurements obtained with a ruler. *J Orthop Sports Phys Ther* 2000; 30:484-492.
- (31) Dworkin S.F., LeResche L., DeRouen T, Von Korff M. Assessing clinical signs of temporomandibular disorders: Reliability of clinical examiners. *The Journal of Prosthetic Dentistry* 1990; 63:574-579.
- (32) Hall T, Briffa K, Hopper D. Clinical evaluation of cervicogenic headache: a clinical perspective. *J Man Manip Ther* 2008; 16:73-80.
- (33) Ogince M, Hall T, Robinson K, Blackmore AM. The diagnostic validity of the cervical flexion-rotation test in C1/2-related cervicogenic headache. *Man Ther* 2007; 12:256-262.
- (34) Hall T, Robinson K. The flexion-rotation test and active cervical mobility--a comparative measurement study in cervicogenic headache. *Man Ther* 2004; 9:197-202.
- (35) Hall T, Briffa K, Hopper D, Robinson K. Long-term stability and minimal detectable change of the cervical flexion-rotation test. *J Orthop Sports Phys Ther* 2010; 40:225-229.
- (36) Mintken PE, DeRosa C, Little T, Smith B. AAOMPT clinical guidelines: A model for standardizing manipulation terminology in physical therapy practice. *J Orthop Sports Phys Ther* 2008; 38:A1-A6.
- (37) Hong CZ. Lidocaine injection versus dry needling to myofascial trigger point. The importance of the local twitch response. *Am J Phys Med Rehabil* 1994; 73:256-263.
- (38) Hong CZ. Considerations and Recommendations Regarding Myofascial Trigger Point Injection. *J Musculoskeletal Pain. Journal of Musculoskeletal Pain* 1994; 2:29-59.
- (39) Cohen J. *Statistical power analysis for the behavioural sciences*. Hillsdale: Lawrence Erlbaum Associates; 1988.
- (40) Herrington L. The difference in a clinical measure of patella lateral position between individuals with patellofemoral pain and matched controls. *J Orthop Sports Phys Ther* 2008; 38:59-62.

- (41) Desmeules F, Minville L, Riederer B, Cote CH, Fremont P. Acromio-humeral distance variation measured by ultrasonography and its association with the outcome of rehabilitation for shoulder impingement syndrome. *Clin J Sport Med* 2004; 14:197-205.
- (42) Hing W, Hall T, Vicenzino B, Rivett D. Mulligan's Positional Fault Hypothesis: Definitions, Physiology and the Evidence. In: Vicenzino B, Rivett D, Hing W, Hall T, editors. *Mobilisation with Movement: The Art and the Science*. Sydney: Elsevier; 2011.
- (43) Hsieh CY, Vicenzino B, Yang CH, Hu MH, Yang C. Mulligan's mobilization with movement for the thumb: a single case report using magnetic resonance imaging to evaluate the positional fault hypothesis. *Man Ther* 2002; 7:44-49.
- (44) Bialosky JE, Bishop MD, Price DD, Robinson ME, George SZ. The mechanisms of manual therapy in the treatment of musculoskeletal pain: a comprehensive model. *Man Ther* 2009; 14:531-538.
- (45) Bialosky JE, George SZ, Bishop MD. How spinal manipulative therapy works: why ask why? *J Orthop Sports Phys Ther* 2008; 38:293-295.
- (46) Fernandez-de-las-Penas C, Perez-de-Heredia M, Brea-Rivero M, Miangolarra-Page JC. Immediate effects on pressure pain threshold following a single cervical spine manipulation in healthy subjects. *J Orthop Sports Phys Ther* 2007; 37:325-329.
- (47) Gonzalez-Iglesias J, Cleland JA, del RG-V, Fernandez-de-las-Penas C. Multimodal management of lateral epicondylalgia in rock climbers: a prospective case series. *J Manipulative Physiol Ther* 2011; 34:635-642.
- (48) Baldry PE. *Acupuncture, trigger points and musculoskeletal pain*. Edinburgh: Churchill Livingstone; 2005.
- (49) Shah JP, Danoff JV, Desai MJ, Parikh S, Nakamura LY, Phillips TM et al. Biochemicals associated with pain and inflammation are elevated in sites near to and remote from active myofascial trigger points. *Arch Phys Med Rehabil* 2008; 89:16-23.

Table 1: Baseline characteristics for each patient

Subject	Sex	Duration of symptoms (months)	Age	Physical Therapy Treatments	Baseline VAS	Baseline WVAS	Baseline BVAS	TDI	SIS	SFS
1	M	3	26	3	62	89	28	48	32	47
2	M	6	39	5	70	95	45	52	36	56
3	W	24	33	6	48	63	25	56	42	54
4	M	18	54	4	36	61	18	41	33	42
5	M	60	49	8	57	77	34	53	27	52
6	W	72	53	7	47	85	38	59	41	49
7	W	12	28	5	64	92	48	54	18	51
8	W	3	46	3	42	72	25	47	25	49
9	M	6	63	7	38	65	24	48	36	53
10	W	8	57	5	58	79	31	47	36	46
11	W	9	44	6	55	74	18	28	27	29
12	M	30	38	9	61	78	43	39	34	43
13	W	12	55	7	64	87	35	42	37	41
14	W	24	43	5	35	63	21	38	29	38
15	W	18	41	4	46	87	37	47	25	44

VAS= Visual Analogue Scale, WVAS= Worst level of pain over the past 24 hours Visual Analogue Scale, BVAS= Best level of pain over the past 24 hours Visual Analogue Scale.

TDI= Temporomandibular Disability Index, SIS= Temporomandibular symptom intensity scale, SFS= Symptom Frequency Scale.

Table 2: Mean outcomes and baseline and each follow-up period along with change scores and 95% confidence intervals.

	Baseline	Final Visit	2-Month Follow-up Period	Difference Between Baseline and Final Visit (95% CI)	Difference Between Baseline and 2 Month Follow-up (95% CI)
VAS mean (SD)	52.2 (11.3)	26.5 (14.0)	23.9 (15.7)	25.7 (17.7, 33.8)	28.3 (18.8, 37.9)
WVAS mean (SD)	77.8 (11.3)	44.6 (19.7)	41.7 (20.7)	33.2 (23.4, 43.0)	36.1 (25.0, 47.3)
BVAS mean (SD)	31.3 (9.7)	12.9 (11.2)	11.6 (13.7)	18.4 (12.1, 24.7)	19.7 (12.8, 26.7)
MMO	37.5 (4.4)	48.9 (7.8)	47.7 (8.4)	11.4 (6.9, 15.9)	10.2 (5.2, 15.2)
TDI	46.6 (8.0)	-----	24.87 (12.1)	-----	21.7 (16.1, 27.4)
SIS	31.9 (6.6)	-----	17.8 (9.5)	-----	14.7 (10.0, 18.1)
SFS	46.3 (7.1)	-----	24.3 (11.7)	-----	(15.8, 28.2)

VAS= Visual Analogue Scale, WVAS= Worst level of pain over the past 24 hours Visual Analogue Scale, BVAS= Best level of pain over the past 24 hours Visual Analogue Scale, MMO= Maximal mouth opening, TDI= Temporomandibular Disability Index, SIS= Temporomandibular symptom intensity scale, SFS= Symptom Frequency Scale.

Figure 1: Mobilization with Movement (MWM) intervention targeted to the TMJ joint.

Figure 2: Sustained Natural Apophyseal Glides's applied over the upper cervical spine (SNAG C1-2).

Figure 3: Thoracic spine thrust manipulation.

Figure 4: Trigger point dry needling (TrP-DN) over the masseter muscle.

Figure 5: Change scores between baseline/final visit and baseline/2 month follow-up for the Visual Analog Scale.



