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RESEARCH ARTICLE

Sustained natural apophyseal glides mobilization versus manipulation in the treatment of cervical spine disorders: a randomized controlled trial

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Abstract

The aim of the present study was to compare the effects between sustained natural apophyseal glides (SNAGs) mobilization and manipulation in the treatment of patients with cervical spine disorders. Forty-nine male patients participated and completed the study. They were randomly assigned into three groups: SNAGs group, manipulation group, and exercise group. Patients in all groups received exercise therapy. The SNAGs group received the specialized SNAGs mobilization. The manipulation group was treated with high-velocity, low-amplitude manipulation. The cervical range of motion (CROM) was measured using CROM device, with the pain assessed using the visual analogue scale (VAS) and the grade of functional recovery measured using the neck disability index (NDI). The patients received two sessions per week for 6 weeks. Evaluations were carried out before treatment, immediately after treatment, and at one month follow up. Repeated measures analysis, Friedman's test, and Wilcoxon signed ranked test respectively revealed a significant increase in ROM, pain reduction, and improved function after treatment and at one-month follow-up. The results showed significant difference in the ROM, VAS, and NDI between the exercise group and both the SNAGs group and the manipulation group. No significant difference was found between the SNAGs group and the manipulation group in terms of ROM, VAS, and NDI after treatment and after one month follow up. The SNAGs mobilization and manipulation were found to be effective treatments more than the exercises alone in the treatment of cervical spine disorders.

1. INTRODUCTION

Neck pain is a very common problem that can negatively affect the patient's quality of life, and may result in medical consumption, absenteeism, and disability. A neck pain that lasts more than 3 months is defined as chronic (Vonk et al., 2009). Neck pain is second only to low back pain in frequency. About 67% of all individuals suffered neck pain at some stage of their life which resolved within 1 month. However, the prevalence of chronic neck pain (CNP) approaches 14% (Vernon et al., 2007).

CNP may result in a substantial morbidity by affecting occupational and vocational activities of daily living and, in turn, the quality of life (Vernon et al., 2007). CNP as a result of postural stress can cause manifestations extending into the upper back and arms, and can contribute to nerve "entrapment," leading to numbness and pain extending into the arms (Lee, 1999). CNP may be associated with pain referred along myotomal patterns to the anterior chest, arm, and dorsal spine regions. Clinically, it is recognized that even in subjects with no evidence of nerve root irritation or compression, the neurological examination would, of course, be normal (Robert and Anthony, 2003). In addition to pain, a common feature of neck disorders is reduced cervical range of motion (CROM) (Peter et al., 2007).

Manual therapy has a variety of procedures directed to the musculoskeletal structures for the treatment of mechanical pain. It includes soft tissue therapies, such as the many types of massage, focal soft tissue therapy, such as trigger point therapy, shiatsu, acupressure, mobilization, manipulation, and manual traction (Vernon et al., 2007).

Brian Mulligan's concept of mobilizations with movement (MWM) was the result of this development with the concurrent cooperation of both therapist-applied accessory and patient-performed active physiological movements (Miller, 1999). The Mulligan concept includes natural apophyseal glides, sustained natural apophyseal glides (SNAGs), and MWM for the spine (Exelby, 2002). In particular, a cervical SNAG is applied with the patient seated, and thus, the spine is in a vertical (i.e. weight bearing or loaded) position (Exelby, 2002; Hearn and Rivett, 2002).

On the other hand, spinal manipulation (SM) is a commonly used treatment for neuromusculoskeletal condition, particularly for complaints of the low back (Assendelft et al., 2003). Interest of the researchers has grown to investigate its efficacy in the treatment of neck pain and headache (Hurwitz et al., 1996). Cervical manipulation has been used in the treatment of patients with head and neck disorders, including neck pain, stiffness, muscle tension, headache, and migraine (Coulter et al., 1996).

Information is scarce concerning which rehabilitative conservative management or therapy combination is most effective in treating chronic or acute cervical pain (Gross et al., 1996). Although cervical spine manipulation or mobilization is commonly employed in rehabilitation for symptoms from cervical neck disorders, controversy continues over the potential beneficial effects of the application of either treatment. Therefore, the aim of the present study was to compare between the effects of SNAGs mobilization and manipulation in the treatment of patients with cervical spine disorders.

2. SUBJECTS AND METHODS

2.1 Subjects

Forty-nine subjects with cervical spine disorders participated in the study. The mean age (± SD) of the patients was 48.77 (±7.26) years. The inclusion criteria for the patients were (1) neck pain lasting more than 1 month; (2) hypomobility of the CROM; (3) non-discogenic neck pain, stiffness, muscle tension, headache, and migraine and without referred pain to shoulders and upper limbs; (4) comparable signs (pain associated with movement, or pain associated with specific functional activities); and (5) painful cervical extension, local tenderness, and restricted intersegmental motion (Exelby, 2002). Patients were excluded if they exhibited any of the following: (1) any contraindication to SM (e.g., inflammation, infection, advanced degeneration, congenital malformation, trauma, cerebrovascular abnormalities); (2) positive neurological examination (presence of positive motor reflex, or sensory abnormalities indicating spinal root compression); (3) cervical spine surgery or stenosis, metabolic or systemic disorders or cancer; and (4) associated pathology of the upper cervical region or upper limb that may cause overlapping with the clinical finding as referred pain from costotransverse joint, rotator cuff tendonitis, and cervical rib syndrome (Evans et al., 2002).

2.2 Randomization

A randomized controlled design was used in this study. Patients were randomized into three groups. Randomization was performed simply by assigning a specific identification number for each patient. These numbers were randomized into three groups using the SPSS program (IBM, USA). A randomized trial was used so the patients did not know to which group they were assigned and which treatment would be given.

Group 1 (SNAGs group) contained 18 patients and received the SNAGs mobilization technique and exercise program; Group 2 (manipulation group) involved 15 patients, received the cervical manipulation technique, and underwent the exercise program; and Group 3 (exercise group) involved 16 patients who received the exercise program. All patients were given a full explanation of the treatment protocol and written informed consent was provided for their participation in the study and publication of the results.

2.3 Treatment protocol

2.3.1 SNAGs mobilization

The patients in Group 1 received the specialized SNAGs technique (Miller, 1999; Exelby, 2002; Hearn and Rivett, 2002; Mulligan, 2005). During application, the patient was seated in a supportive low back chair, thus the cervical spine was in a vertical position (i.e. weight bearing position) with the therapist's position behind the patient. The current range of cervical spine was checked for range, rhythm, deviation, and limiting factors such as increasing pain during range, pain at end of the available range, or painless stiffness at the end of a reduced range of motion (comparable sign). The therapist used the medial border of one thumb's distal phalanx reinforced by the pad of the other thumb to apply an antero-superior accessory glide through the superior spinous process or articular pillar of the involved motion segment (i.e. the vertebra above the suspected site of the problem). The thumb nail would slope at approximately 45 degrees. Then the therapist moved the spinous process up in the direction that must follow the apophyseal joints plane under treatment, that is, toward the eyeball. While sustaining this pain-free accessory glide, the patient was instructed to actively perform the comparable sign. As the patient progressed through the increasing physiological range, the therapist tracked the spinous process to maintain his glide parallel to the changing treatment plane. The end-range physiological movement was sustained for several seconds. Overpressure was given at the end of the range by the patient to enhance the effect. The patient returned to the starting position actively while the therapist maintained the gliding and the procedures were repeated in sets of 5 to 10. When the spinal lesion involved one side, unilateral SNAGs was applied to the affected side. When the lesion was bilateral, a bilateral SNAGs technique through the spinous process was applied as both facets were equally glided.

2.3.2 Cervical manipulation

A cervical manipulation directed to the dysfunctional level was applied by an experienced therapist. As with all of the manual techniques, the patients were treated in a supine lying position. The techniques used were the cervical rotatory and lateral tilting techniques. The index finger of the therapist applied contact over the posterior lateral aspect of the articular pillar at the dysfunctional side of the identified vertebra. The therapist's other hand cradled the patient's head. For applying the cervical rotatory technique, the head and neck were simultaneously rotated and laterally flexed over the contact point superior to the restricted segment of the spinal segment to the end of passive CROM away from the painful side (John and Clive, 1997). A high-velocity, low-amplitude spinal manipulative thrust was delivered in the direction of the posterior joint plane. For application of lateral tilting manipulation, the neck was rotated and laterally flexed to the ipsilateral side. Manipulation was achieved by a sharp rotation with one hand rotating while the index finger of the other reinforced the movement with a corresponding thrust against the articular pillar.

2.3.3 Exercises

Patients in all groups received an exercise program consisting of three stages: isometric exercises, stretching exercises, and postural exercises (Sarig-Bahat, 2003; Kay et al, 2012). The first stage started from the first session including isometric exercise and then after each four sessions, a new stage was added. The isometric exercises were composed of isometric neck extension, isometric neck side bending, and isometric neck flexion exercises. Stretching exercises were added from the fifth session, which involved unilateral passive stretching for the sternocleidomastoid muscle, passive stretching for the neck extensor muscles, and passive stretching of the neck side bending muscles. Postural exercises were added from the ninth session including postural rotation exercise, side bending postural exercise, rotation-side bending postural exercise, and raise arm postural exercise.

2.4 Outcome measures

2.4 .1 Assessment of CROM

CROM, neck function, and cervical pain were measured at baseline, then after six weeks of the treatment by observers blinded to patient treatment allocation. For the assessment of CROM, a CROM device was used. Patients were given verbal instructions concerning the purpose and procedure of the study. This was followed by a warm-up period consisting of three repetitions of each movement to increase the compliance of the soft tissues of the neck and to make the patient familiar with the movement. The neck mobility was assessed with the patient in a relaxed seated position on a chair with back support. Following this, the CROM device was mounted over the patient's nose bridge and ears then secured to the head by a Velcro strap. The subjects were instructed to move the head to the end point of active range of motion for each of the six movements of the cervical spine (Martı´nez-Segura et al., 2006**).** The CROM device measures the cervical range of motion for flexion, extension, lateral flexion, and rotation using separate inclinometers (Tousignant et al., 2000). A considerable number of reliability and concurrent validity studies have been published for CROM. The CROM device has undergone most evaluation and had been evaluated for reliability and validity of cervical spine ROM measurement and had also demonstrated favorable results and shown to be clinimetrically sound (Williams et al., 2010).

2.4 .2 Assessment of neck functional activities

For assessment of neck functional activity levels, the neck disability index (NDI) was used. The NDI is the most widely used and most strongly validated instrument for assessing self-rated disability in patients with neck pain. It has been used effectively in both clinical and research settings in the treatment of this very common problem (Vernon, 2008). The patient was asked to mark each section which most closely described his problem. Each patient considered that two of the statements in any one section may relate to him, but the patient should only mark the box which most closely described his problem.

2.4 .3 Assessment of neck pain

For assessment of pain, a visual analogue scale (VAS) was used. The VAS is a commonly used, validated tool for self-report of pain intensity to quantitate postoperative and other types of pain, as well as the effects of analgesics. Usually, VAS consists of a 10-cm line on paper on which the patient's pain intensity can be easily marked with a vertical line at a point between the extremes of 0 = ‘‘no pain at all’’ and 10 = ‘‘worst pain imaginable’’ (Martı´nez-Segura et al., 2006). Patients were asked to place a mark along the line to dent their level of pain. VAS is a valid and a reliable measure of chronic pain intensity (Bijur et al., 2001).

2.5 Statistical analysis

Analyses of data were performed using SPSS for Windows, version 20. One-way analysis of variance (ANOVA) was used to compare between the patients' age in the treatment groups. ANOVA with repeated measures was used to compare the mean values of CROM of the same group pre-treatment, post-treatment, and one month after completion of the treatment. One-way ANOVA to compare CROM mean values between groups. Frideman's test was used to compare the mean values of VAS and NDI for each group before the treatment, after the treatment, and one month after completion of the treatment. Kruskal-Wallis test was performed to determine the significant difference in the mean values of VAS and NDI among study groups pre-treatment, post-treatment, and one month after completion of the treatment. The level of significance was set at $P \leq 0.05$ for all tests.

3. RESULTS

A sample of 42 patients was calculated by preliminary power analysis, using a power of 80% and $\alpha = 0.05$ to detect an improvement of 5 degrees with a standard deviation (SD) of 3.5 in CROM. One-way ANOVA was used in three study groups to produce an effect size of 0.50 with a correlation of 0.5 between measurements. The effect size chosen was based on a pilot study and on the results of previous studies (Evans et al., 2002; Hurwitz et al., 2002; Hoving et al., 2006; Martı´nez-Segura et al., 2006). Sample size was increased to 49 for possible drop out.

The patients' mean age (SD) was 50.05 (6.91) in the SNAGs group, 46.2 (7.08) in the manipulation group, and 49.75 (7.62) in the exercise group with no significant difference (P=0.26) between them. Also, there was no significant difference in ROM movements in all groups (Table 1). Similarly, the Kruskal-Wallis test revealed no significant difference in the VAS and NDI scores between the treatment groups before treatment (Table 2).

In order to compare the effect of each treatment on ROM in each group, ANOVA with repeated measures showed a significant increase in all ROM movements in all groups, and the effect of treatment was maintained during the follow up as shown by the post-hoc test (Table 1). ANOVA showed a significant difference between the treatment groups after treatment and during follow-up in all ROM movements. The post-hoc test showed no significant difference between the SNAGs group and the manipulation group, whereas there was a significant difference between the exercise group and both the SNAGs and manipulation groups in all ROM movements (Table 1).

Analysis of VAS and NDI showed a significant improvement in the VAS and NDI in all groups and this effect was kept during follow up (Table 3). The Kruskal-Wallis test was used, showing a significant improvement in the VAS and NDI after treatment, which was maintained during the follow-up period. Mann–Whitney U-test revealed that the greatest improvement in VAS and NDI occurred in the SNAGs and manipulation groups, whereas the least improvement was observed in the exercise group (Table 3).

4. DISCUSSION

The present study was conducted to compare the effects of SNAGs and manipulation in the treatment of patients with cervical spine disorders. Both SNAGs and manipulation were significant in increasing CROM, and in decreasing VAS score and NDI in the patients. Moreover, this study assessed a treatment regimen that began in the chronic stage, which included two sessions per week over a period of six consecutive weeks.

4.1 Effect of SNAGs

The SNAGs was effective in the treatment of locked lumbar facet joint syndrome (Exelby, 2001) as well as acute locked thoracic joint (Horton, 2002). The patient reported a 95% improvement and had maintained an upright posture. It was found that SNAGs had an immediate clinically and significant sustained effect in reducing dizziness, cervical pain, and disability caused by cervical dysfunction at post-treatment, and at 6- and 12-week follow up compared to pre-treatment (Reid et al., 2008).

The underlying mechanism of the effect of cervical SNAGs seems likely to be either purely mechanical, reflexogenic, or a combination of the two (Hearn and Rivett, 2002). The rapid pain-relieving mechanical effect was based on the presence of bony positional faults and the ability of mobilization with movement to correct these faults (Vicenzino et al., 2007).

For rotatory cervical movement, the axis of motion lies close to the ipsilateral zygapophyseal joint. This implies that when applying an ipsilateral cervical SNAG to treat painfully restricted right rotation, the contralateral (left) superior articular surface is sliding upward and forward in a flexion-like fashion, while its ipsilateral (right) equivalent may be limited in its postero-inferior movement by the manually applied superior-anterior force (Hearn and Rivett, 2002).

Mulligan suggested that the superior facet of the affected functional spinal unit (FSU) at the side of pain may be trapped postero-inferiorly in an extension or 'closed down' position; hence, ipsilateral rotation could cause pain due to excessive 'closing down' of the zygapophyseal joint. Application of the accessory glide component of a cervical SNAG may therefore reposition the superior facet supero-anteriorly, allowing a greater range of pain-free ipsilateral rotation (Hearn and Rivett, 2002). The accessory glide component of a cervical SNAG could potentially facilitate pain-free motion by distracting the ipsilateral FSU (Hearn and Rivett, 2002).

The SNAGs mobilizations allow the therapist to directly "attack" the painfully restricted movement, even in the acute stage, by using a movement that would normally increase the patient's symptoms but are now pain-free or the pain would be centralized through the successful application of SNAGs. The phenomenon of centralization is well recognized as a positive prognostic change and should be used to guide the treatment used by therapists employing SNAGs in clinical practice. The physiological movement that peripheralizes symptoms may, in fact, centralize pain when combined with the appropriate SNAGs to the correct segment (Miller et al., 1999).

4.2 Effect of cervical manipulation

Based on the literature, manipulation helps to remove this mechanical restriction and eliminate the excessive strain (Watkinson et al., 1991), resulting in an increase in ROM of the joint (Lehman and McGill, 1999) with reduction of pain and disability (Whittingham and Nilsson, 2001; Wood et al., 2001). The short-term improvement in pain associated with head and neck disorders after manipulation was due to stimulation of the mechanoreceptors, which helps to block the impulses from nociceptive afferent, from being transmitted along the spinothalamic tracts to the thalamus (Borghouts, et al., 1998). In addition, cervical manipulation may influence the activity of the gamma motor neurons and, in turn, the normalization of muscle tone (Murphy, 2000).

4.3 Effect of exercises combined with manual therapy

Exercise therapy is the most important, or even mandatory, especially in locomotor disturbances. Strengthening exercises of the cervical muscles are very important in cases of mechanical neck pain (Silverman et al., 1991). Exercises increase muscle strength, elasticity, range of motion, and endurance (Borestein et al., 1996).

The available literature showed that manipulation, manual traction, and manual therapy to tender muscles or trigger points showed similar results to passive mobilization, massage, traction, proprioceptive neuromuscular facilitation, heat, ultrasound, and patient education at 12 sessions over a 6-week treatment and at a 10-week follow-up in patients with chronic mechanical neck disorders (Jordan et al., 1998). Furthermore, neck resistance training has a great effect in increasing the neck muscle torque during rotation, flexion, and extension, and in reducing pain and function disability in middle-aged women workers with a high prevalence of neck disorders (Berg et al., 1994).

The use of strengthening exercise, in combination with manipulation, appears to be more beneficial than the use of manipulation alone in patients with CNP (Bronfort et al., 2001). Hoving et al. (2006) compared the effectiveness of spinal mobilization and exercise in patients with neck pain. It was found that there were no significant differences between spinal mobilization and exercise in perceived recovery after 13 weeks of treatment, whereas manipulation had higher improvement scores in perceived recovery, severity of physical dysfunction, pain intensity, and functional disability as measured by NDI (Hoving et al., 2006). The previous results support the use of combined mobilization, manipulation, and exercise in achieving clinically important but modest pain reduction, global perceived effect, and patient satisfaction in acute and chronic neck disorder with or without cervicogenic headache (Miller et al., 2010). For the optimal combined treatment approaches, D'Sylva et al. (2010) mentioned in their systemic review that the use of manipulation or mobilization alone provided only a short-term pain relief with no advantage at long-term follow-ups.

The combination of mobilization or manipulation with exercise therapy produces a greater increase in CROM and a greater reduction of pain, which in turn cause an improvement of function in patients with chronic cervical disorders, both after treatment and at short-term follow up (D'Sylva et al., 2010; Miller et al., 2010).

Recovery outcomes of the present study were evaluated using CROM device, VAS, and NDI. Although these tools are considered valid and reliable measures, electrophysiological measurements may be needed to support these findings in future research.

5. CONCLUSION

Both SNAGs mobilization and manipulation were effective in the treatment of cervical spine disorders, where no one was superior to the other as they yielded approximately the same results. In addition, the combination of mobilization or manipulation with exercise therapy produced greater increase in CROM and greater reduction of pain, which in turn caused an improvement of function in patients with chronic cervical disorders both after treatment and at short-term follow up.

References

Assendelft WJ, Morton SC, Yu EI, Suttorp MJ, Shekelle PG. Spinal manipulative therapy for low back pain. A meta-analysis of effectiveness relative to other therapies. Ann Intern Med. 2003 Jun 3; 138(11):871-81.

Berg HE, Berggren G and Tasch PA. Dynamic neck strength training effect on pain and function Arch. Phys. Med. Rehabil. 1994 Jun; 75(6):661-5.

Bijur PE, Silver W, Gallagher EJ. Reliability of the visual analog scale for measurement of acute pain. Acad Emerg Med. 2001 Dec;8 (12):1153-7.

Borestein DG, Wiesel SW and Boden SD. Neck pain: Medical diagnosis and Comprehensive management. 1st ed. Philadelphia, W.B. Saunderes Co.; 1996. p. 445-58.

Borghouts JA, Koes BW, Bouter LM. The clinical course and prognostic factors of non-specific neck pain: a systematic review. Pain. 1998 Jul; 77(1):1-13.

Bronfort G, Evans R, Nelson B, Aker PD, Goldsmith CH, Vernon H. A randomized clinical trial of exercise and spinal manipulation for patients with chronic neck pain. Spine (Phila Pa 1976). 2001 Apr 1; 26(7):788-97; discussion 798-9.

Coulter ID, Hurwitz EL, Adams AH, Meeker WC, Hansen DT, Mootz RD, Aker PD, Genovese BJ, Shekelle PG. The Appropriateness of Manipulation and Mobilization of the Cervical Spine. Santa Monica (Calif): RAND Corporation; 1996. p. 7-9.

D'Sylva J, Miller J, Gross A, Burnie SJ, Goldsmith CH, Graham N, Haines T, Brønfort G, Hoving JL; Cervical Overview Group. Manual therapy with or without physical medicine modalities for neck pain: a systematic review. Man Ther 2010; 15(5):415-33.

Evans R, Bronfort G, Nelson B, Goldsmith CH. Two-year follow-up of a randomized clinical trial of spinal manipulation and two types of exercise for patients with chronic neck pain. Spine (Phila Pa 1976). 2002 1; 27(21):2383-9.

Exelby L**.** The locked lumbar facet joint: intervention using mobilizations with movement. Manual Therapy 2001; 6 (2):116–21.

Exelby L. The Mulligan concept: Its application in the management of spinal conditions. Manual Therapy 2002; 7(2): 64–70.

Gross AR, Aker PD, Goldsmith CH and Peloso P. Conservative management of mechanical neck disorders. A systematic overview and meta-analysis. Online J Curr Clin Trials 1996 Jul 30; Doc No200-201.

Hearn A, Rivett DA. Cervical SNAGs: a biomechanical analysis. Manual Therapy 2002; 7(2): 71–9.

Horton SJ. Acute locked thoracic spine: treatment with a modified SNAG. Manual Therapy 2002; 7(2): 103–107.

Hoving JL, de Vet HC, Koes BW, Mameren Hv, Devillé WL, van der Windt DA, Assendelft WJ, Pool JJ, Scholten RJ, Korthals-de Bos IB, Bouter LM. Manual therapy, physical therapy, or continued care by the general practitioner for patients with neck pain: long-term results from a pragmatic randomized clinical trial. Clin J Pain. 2006 May ; 22(4):370-7.

Hurwitz EL, Aker PD, Adams AH, Meeker WC and Shekelle PG. Manipulation and mobilization of the cervical spine: a systematic review of the literature. Spine. 1996; 21:1746-59.

Hurwitz EL, Morgenstern H, Harber P, Kominski GF, Yu F, Adams AH. A randomized trial of chiropractic manipulation and mobilization for patient with neck pain, clinical outcomes from the UCLA, Neck pain study. American public Am J Public Health. 2002 Oct; 92(10):1634-41.

Jordan A, Bendix T, Nielsen H, Hansen FR, Høst D, Winkel A. Intensive training, physiotherapy, or manipulation for patients with chronic neck pain. A prospective, single-blinded, randomized clinical trial. Spine (Phila Pa 1976). 1998 Feb 1;23(3):311-8; discussion 319.

Kay TM, Gross A, Goldsmith CH, Rutherford S, Voth S, Hoving JL, Brønfort G, Santaguida PL. Exercises for mechanical neck disorders. Cochrane Database Syst Rev. 2012 Aug 15;8:CD004250. doi: 10.1002/14651858.CD004250.pub4.

Lee SA. Cervical spine disorders: a textbook for rehabilitation sciences students. Springer; 1999. pp.22-54.

Lehman GJ, McGill SM. The importance of normalization in the interpretation of surface electromyography: a proof of principle. J Manipulative Physiol Ther. 1999 Sep; 22(7):444-6.

Martı´nez-Segura R, Ferna´ndez-de-las-Pen˜as C, Ruiz-Sa´ez M, Lo´ pez-Jime´nez C, Rodrı´guez-Blanco C. Immediate effects on neck pain and active range of motion after a single cervical high-velocity low-amplitude manipulation in subjects presenting with mechanical neck pain: a randomized controlled trial. J Manipulative Physiol Ther 2006; 29(7):511-517.

Miller J, Gross A, D'Sylva J, Burnie JS, Goldsmith CH, Graham N, Haines T, Brønfort G, Hoving JL. Manual therapy and exercise for neck pain: A systematic review. Manual Therapy 2010; 15(4): 2010 334-354.

Miller J. The mulligan concept: the next step in the evolution of manual therapy. Published Orthopaedic Division Review May/June1999.

Murphy DR. Conservative Management of Cervical Spine Syndromes. 1st ed. McGraw-Hill Professional, 2000. p 468-470.

Peter J, McNair, Portero P, Chiquet C, Mawston G, Lavaste F. Acute neck pain: Cervical spine range of motion and position sense prior to and after joint mobilization. Manual Therapy 2007; 12(4):390–394.

Reid SA, Rivett DA, Katekar MG, Callister R. Sustained natural apophyseal glides (SNAGs) are an effective treatment for cervicogenic dizziness. Manual therapy 2008; 13:(4): 357-366.

Robert F, Anthony SR. Neck pain Best Practice & Research. Clinical Rheumatology 2003;17(1): 57-70.

Sarig-Bahat H. Evidence for exercise therapy in mechanical neck disorders. Man Ther. 2003 Feb;8(1):10-20.

Silverman JL, Rodriquez AA, Agre JC. Quantitative cervical flexor strength in healthy subjects and in subjects with mechanical neck pain. Arch Phys Med Rehabil. 1991 Aug; 72(9):679-81.

Tousignant M, de Bellefeuille L, O'Donoughue S, Grahovac S. Criterion validity of the cervical range of motion (CROM) goniometer for cervical flexion and extension. Spine 2000; 25:324-30.

Vernon H, Humphreys K, Hagino C. Chronic mechanical neck pain in adults treated by manual therapy: a systematic review of change scores in randomized clinical trials. J Manipulative Physiol Ther 2007; 30:215-227.

Vernon H. The neck disability index: state-of-the-art, 1991-2008. J Manipulative Physiol Ther 2008; 31:491-502.

Vicenzino B, Paungmali A, Teys P. Mulligan's mobilization-with-movement, positional faults and pain relief: Current concepts from a critical review of literature. Manual Therapy 2007; 12: 98–108.

Vonk F, Arianne P. Verhagen, Jos W, Twisk, Albère JA, Marlies WC, Luiten, Bart W. Koes. Effectiveness of a behavior graded activity program versus conventional exercise for chronic neck pain patients. European Journal of Pain 2009; 13(5):533–541.

Watkinson A, Gargan MF, Bannister GC. Prognostic factors in soft tissue injuries of the cervical spine. Injury. 1991 Jul;22(4):307-9.

Whittingham W, Nilsson N. Active range of motion in the cervical spine increases after spinal manipulation (toggle recoil). J Manipulative Physiol Ther. 2001 Nov-Dec; 24(9):552-5.

Williams MA, McCarthy CJ, Chorti A, Cooke MW, Gates S. A systematic review of reliability and validity studies of methods for measuring active and passive cervical range of motion. J Manipulative Physiol Ther. 2010 Feb; 33(2):138-55.

Wood TG, Colloca CJ, Matthews R. A pilot randomized clinical trial on the relative effect of instrumental (MFMA) versus manual (HVLA) manipulation in the treatment of cervical spine dysfunction. J Manipulative Physiol Ther. 2001 May; 24(4):260-71.