TOBY HALL, MSc, Post Grad Dip Manip Ther[1] • **HO TAK CHAN,** BSciPhysio, M Manip Ther, M Sports Physio[2]
LENE CHRISTENSEN, BSciPhysio, M Manip Ther[2] • **BRITTA ODENTHAL,** PT, M Manip Ther[2]
CHERIE WELLS, BAppSciPhysio, M Manip Ther[3] • **KIM ROBINSON,** BSc, Post Grad Dip Manip Ther[1]

Efficacy of a C1-C2 Self-sustained Natural Apophyseal Glide (SNAG) in the Management of Cervicogenic Headache

STUDY DESIGN: Randomized, double-blind, placebo controlled trial.

OBJECTIVES: To determine the effect of a C1-C2 self-sustained natural apophyseal glide (SNAG) on cervicogenic headache.

BACKGROUND: Cervicogenic headache is a common condition causing significant disability. Recent studies have shown a high incidence of C1-C2 dysfunction, evaluated by the flexion-rotation test (FRT), in subjects with cervicogenic headache. To manage this dysfunction, Mulligan has described a C1-C2 self-SNAG, though no studies have investigated the efficacy of this intervention approach.

METHODS: A sample of 32 subjects (mean ± SD age, 36 ± 3 years) with cervicogenic headache and FRT limitation were randomized into a C1-C2 self-SNAG or placebo group. After an initial instruction and practice visit in the clinic, interventions consisted of exercises applied independently by the subject twice daily at home on a continual basis. FRT range was measured twice, before and immediately after the instruction and practice visit. Headache symptoms were determined by a headache index over time, assessed by questionnaire preintervention, at 4 weeks postintervention, and at 12 months postintervention.

RESULTS: No differences were found in baseline measures between groups. Immediately after the initial instruction and practice visit performed with the supervision of the therapist, FRT range increased by 15° (SD, 9) for the C1-C2 self-SNAG group ($P<.001$), which was significantly more than 5° (SD, 5) for the placebo intervention ($P<.001$). There was also a significant interaction for the variable headache index between group and time ($P<.001$), indicating that group difference was dependent on time. There was no difference in headache index scores at baseline between groups. Headache index scores were substantially less in the C1-C2 self-SNAG group (mean ± SD points at 4 weeks, 31 ± 9; mean ± SD points at 12 months, 24 ± 9) compared to the placebo group (mean ± SD points at 4 weeks, 51 ± 15; mean ± SD points at 12 months, 44 ± 13) at 4 weeks ($P<.001$) and 12 months ($P<.001$), with an overall (±SD) reduction of 54% (±17%) for the individuals in the C1-C2 self-SNAG group.

CONCLUSIONS: These results provide evidence for the efficacy of the C1-C2 self-SNAG technique in the management of individuals with cervicogenic headache. *J Orthop Sports Phys Ther 2007;37(3):100-107. doi:10.2519/jospt.2007.2379*

KEY WORD: atlantoaxial joint, cervical spine, flexion-rotation test, joint mobilization, Mulligan

Headache is a common condition frequently encountered by physiotherapists in clinical practice.[18] Cervicogenic headache has been classified by the International Headache Society (IHS)[1] and accounts for 15% to 20% of all chronic and recurrent headaches.[20] Individuals with chronic cervicogenic headache experience considerable restriction of daily function, limitation of social participation, and emotional distress.[5] In addition, these individuals report a lower quality of life than healthy individuals[34].

The IHS[1] defines cervicogenic headache as "pain, referred from a source in the neck and perceived in 1 or more regions of the head and/or face." Headache can arise from a variety of structures of the cervical spine, including the zygapophyseal joints (occiput-C3).[6,29] Major signs and symptoms of cervicogenic headache usually include unilateral head pain without side-shift, combined with neck pain and restriction of neck movement.[28]

Despite the IHS classification, diagnosis of cervicogenic headache is difficult because up to 70% of individuals with frequent intermittent headache report accompanying neck pain.[9] It is therefore not unreasonable to suggest that individuals who suffer from headaches may receive unwarranted treatment to the neck unless an accurate evaluation is made.[38] Zito et al[38] have confirmed the importance of examination of the C1-C2 segment in cervicogenic headache diagnosis. The relative importance of C1-C2 as a primary cause of cervicogenic headache is also supported by Aprill et al.[3]

To assist in the diagnosis of cervicogenic headache and, in particular, C1-C2 segmental dysfunction, Hall and Robinson[8] have suggested using the cervical

[1] Adjunct Senior Teaching Fellow, School of Physiotherapy, Curtin University, Perth, Western Australia. [2] Private practitioner, School of Physiotherapy, Curtin University, Perth, Western Australia. [3] Private practitioner, Central City Physiotherapy, Perth, Western Australia. The protocol for this study was approved by the Curtin University of Technology. Two of the authors of this paper are members of the Mulligan Concept Teachers Association and provide educational workshops in the Mulligan Concept to postgraduate physiotherapists, for which they receive a teaching fee. Address correspondence to Toby Hall, School of Physiotherapy, Curtin University, Perth, Western Australia. E-mail: halltm@netspace.net.au

flexion-rotation test (FRT), as described by Dvorak et al.[7] This passive examination procedure involves fully flexing the cervical spine so that vertebral movement is theoretically constrained to C1-C2, then assessing cervical rotation range of motion in this position. Normal range of movement is 44° to each side.[8]

Hall and Robinson[8] have found that subjects with cervicogenic headache have an average of 17° less rotation toward the headache side in the FRT, in contrast to those with no headache or migraine with aura. Additional studies have supported these findings.[7,22] In addition, Ogince et al[22] found that movement impairment found on the FRT has high sensitivity (91%) and specificity (90%) to identify cervicogenic headache. Thus the FRT is a useful measure of cervical movement impairment and may be able to assist diagnosis of cervicogenic headache.

Manual therapy is often advocated for managing cervicogenic headache,[13] although few randomized controlled trials have evaluated its efficacy in isolation.[5] One trial with strong methodological quality and a large sample size found that manual therapy was beneficial in reducing cervicogenic headache.[12]

Mulligan[17] has described a novel approach for the self-management of articular dysfunction in cervicogenic headache. In this approach an accessory motion combined with spinal active movement (C1-C2 self-sustained natural apophyseal glide [SNAG]) is used to restore normal range of C1-C2 rotation when the FRT reveals substantial rotation limitation at this segment. The C1-C2 self-SNAG targets C1-C2 dysfunction by emphasizing C1-C2 rotation using a cervical self-SNAG strap. Although the Mulligan concept is frequently used in clinical practice,[15] there is limited evidence for its effect and there are no clinical trials that have investigated this technique for the treatment of cervicogenic headache.

Therefore, the purpose of this study was to determine the efficacy of the C1-C2 self-SNAG in subjects with cervicogenic headache and a positive FRT test. It was hypothesized that the C1-C2 self-SNAG would have significant immediate effects on FRT range of motion, with long-term reduction in self-reported headache symptoms, when compared to a placebo intervention.

TABLE 1 Inclusion and Exclusion Criteria for Subjects With Cervicogenic Headache

Inclusion Criteria	Exclusion Criteria
Unilateral or side-dominant headache without side shift	Headache not of cervical origin[26]
Headache with neck stiffness and/or pain	Physiotherapy or chiropractic treatment in the past 3 mo
Headache for the past 3 mo at least once per wk	Headache with autonomic involvement, dizziness, or visual disturbance
Aged 18-66 y	Congenital conditions of the cervical spine
Positive flexion-rotation test and restriction greater than 10°	Contraindication to manipulative therapy
	Involvement in litigation or compensation
	Inability to tolerate the flexion-rotation test

METHODS

This study employed a double-blind, randomized, placebo-controlled trial design. We investigated the treatment efficacy of the C1-C2 self-SNAG on immediate change in FRT range of motion and long-term change in self-reported headache symptoms. Only immediate change in range of motion was evaluated, with long-term change in self-reported headache symptoms as the main outcome measure. Based on clinical experience, a large treatment effect was expected for improvement in rotation with the FRT (10° for the SNAG intervention, minimal change for the placebo). With power set to 80% and the level of significance for alpha at .05, a minimum of 9 subjects per group was determined to be required.[33]

Subjects were recruited from advertisements and medical clinics. A total of 122 participants expressed interest in participating in the study. These subjects were then screened by telephone for suitability according to inclusion and exclusion criteria shown in **TABLE 1.** Diagnostic criteria for cervicogenic headache were based on guidelines of the Headache Classification Subcommittee of the IHS[1] and Cervicogenic Headache International Study Group.[28]

Suitable subjects were also required to exhibit a "positive" FRT (**FIGURE 1**) as described by Stratton and Bryan,[31] with a reduction in rotation of at least 10°.[8] This definition compares favorably with a cut-off score of 32° reported by Ogince et al.[22]

Of the 122 subjects interested in joining the study, 43 were assessed by telephone as being suitable for potential participation. Subjects were principally excluded because they were receiving physical treatment for their headache. Of the 43 subjects found suitable for inclusion and then assessed using the FRT, 11 were excluded due to a lack of movement restriction at C1-C2 based on the FRT. The average amount of rota-

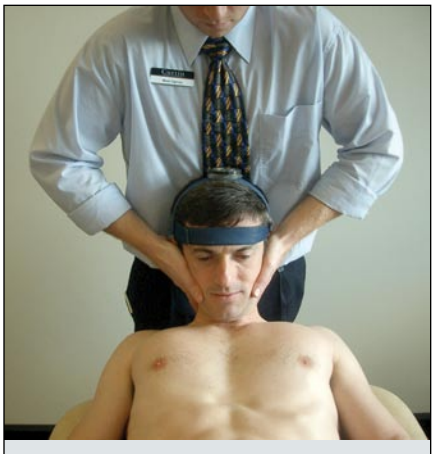

FIGURE 1. Flexion-rotation test using a modified cervical range of motion device.

SUPPLEMENTAL VIDEOS ONLINE

tion in these excluded subjects was 44° (SD, 3) to the right and 45° (SD, 5) to the left. Thus a total of 32 subjects were included in the study, 16 in each group, having fulfilled all entry criteria. All 32 subjects were able to complete the intervention and there were no dropouts. A flow chart indicating flow of participants through each stage of the study is shown in **FIGURE 2**.

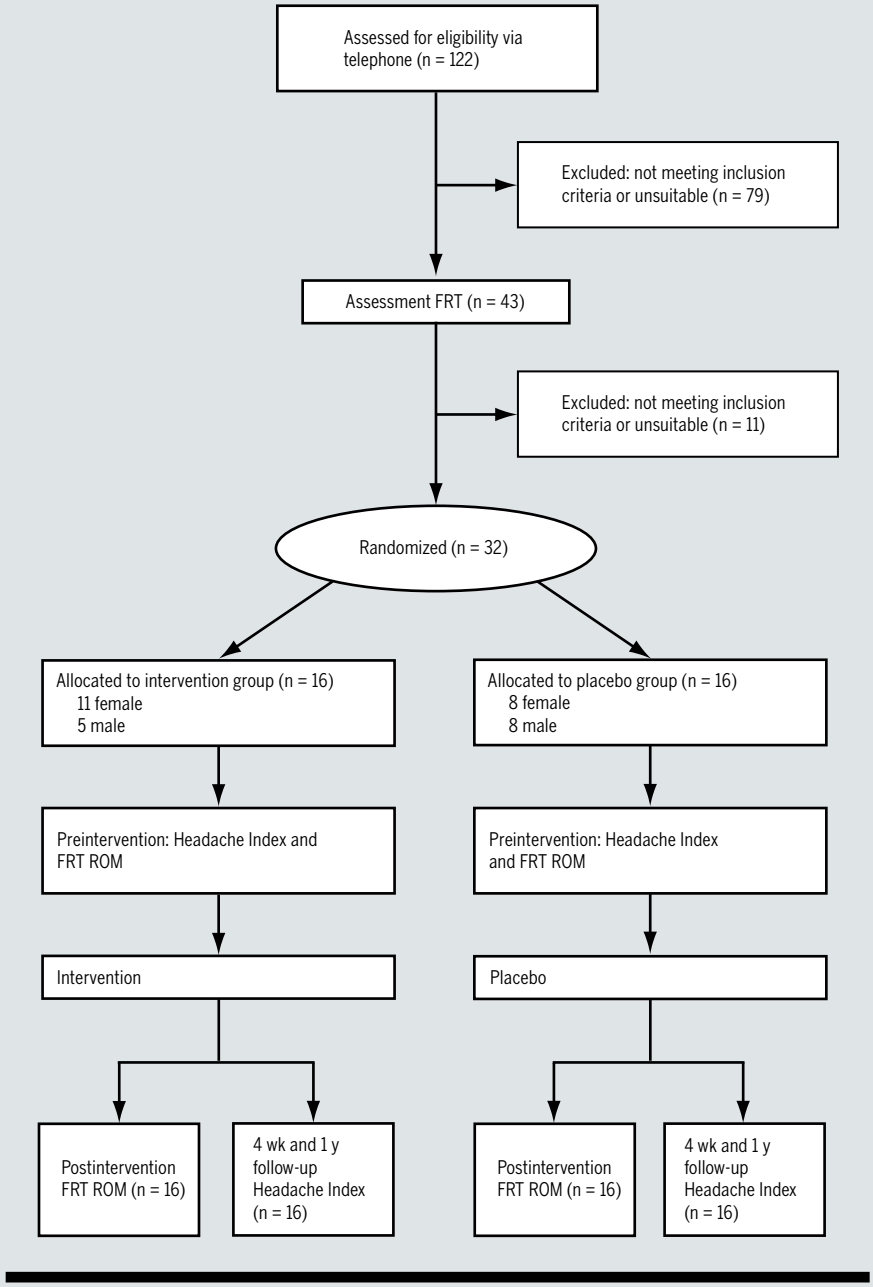

FIGURE 2. Flow of participants through the study. Abbreviation: FRT, flexion-rotation test; ROM, range of motion.

Materials and Measurements

The amount of rotation in the FRT was measured using a modified cervical range of motion (CROM) device (floating compass; Plastimo Airguide, Inc, Buffalo Groove, IL) according to the method described by Hall and Robinson[8] and Ogince et al.[22] Two Velcro straps (**FIGURE 1**) were fixed to the subject's head, traversing the transverse and coronal planes, respectively. The CROM was attached to the center of the coronal Velcro strap to measure cervical rotation in maximal flexion. This method of assessment has been shown to have high reliability both within and between examiners.[8,22] The FRT was performed with the subject supine on a physiotherapy treatment plinth. The cervical spine was fully flexed by the examiner and the head was passively rotated to the left and right. Range was determined by either the onset of pain or firm resistance (**FIGURE 1**). Pretreatment and immediate posttreatment values for rotation on the FRT were recorded.

To determine intratester reliability of the measurement of the FRT, 10 asymptomatic subjects were tested on 2 occasions, with a 15-minute rest between trials. During the rest, the modified CROM was removed and the subject was allowed to move freely around the room. Significant correlation between scores was demonstrated by a single-measure intraclass correlation coefficient ($ICC_{2,1}$). Left rotation ICC was 0.94 (95% CI: 0.76-0.98; SEM, 2.5°). Right rotation ICC was 0.92 (95% CI: 0.72-0.98; SEM, 3.3°).

A headache questionnaire[19] was used to determine an index of headache severity (score, 0-100; maximum score, 100). This index is based on a composite score of headache intensity, frequency, and duration, with equal weighting given to each element. This index has been shown to be reliable. Test-retest measures of 20 subjects with cervicogenic headache over 24 hours showed high levels of reliability, with an $ICC_{2,1}$ of 0.92.[19] In addition to this index, subjects were asked to indicate on a 10-cm visual analogue scale (VAS), beginning with "no change" and ending with "complete recovery," how much benefit they perceived as a result of the treatment. Niere and Robinson[19] recommended the combination of the headache index, together with estimation of treat-

ment benefit, to determine if a manual therapy treatment program had a beneficial effect for cervicogenic headache.

Exercise compliance was evaluated by the questionnaire using a scale ranging from 1 (no exercise) to 5 (daily exercise). Finally, using a questionnaire at 12 months, subjects were also asked whether they continued to do their prescribed exercise.

Procedures

The procedures were undertaken by qualified physiotherapists under the supervision of an accredited "Mulligan concept" teacher who had 15 years of experience in using the FRT and C1-C2 self-SNAG.

The researchers conducted the initial telephone interviews and screened for study entry criteria. Subsequently, an assessor evaluated suitable subjects using the FRT. Subjects with a reduction in range of more than 10° to 1 side were included in the study. Range of motion for the FRT was recorded and the headache questionnaire administered before subjects were randomly assigned to the C1-C2 self-SNAG or placebo group. Participants were allocated to treatment group using lottery ticket randomization chosen from a concealed container.

Appropriate treatment was then provided, where 1 researcher taught the C1-C2 self-SNAG while another researcher taught the placebo. Equal emphasis was given to both techniques to ensure that the patients were unaware of whether they received the active intervention or not.

The subjects in the experimental group were mobilized with a C1-C2 self-SNAG (**FIGURE 3**) using a cervical self-SNAG strap (Manual Concepts, Booragoon, Australia). The technique is described in detail by Mulligan.[17] Essentially, the thin, rubber-covered strap was positioned on the posterior arch of C1 and drawn horizontally forward across the face. The purpose of the strap is to facilitate rotation at C1-C2 in the same direction as found to be limited on the FRT (**FIGURE 1**). The subject applied forward pressure on the strap and turned the head toward the restricted side of rotation, sustaining end range for 3 seconds. The treating therapist assisted with positioning of the strap and applied end range overpressure in rotation. It is essential that the technique be performed in the pain-free range and no symptoms, other than stretching, are provoked. Subjects were given 3 trials to familiarize themselves with the treatment technique before 2 repetitions were performed.

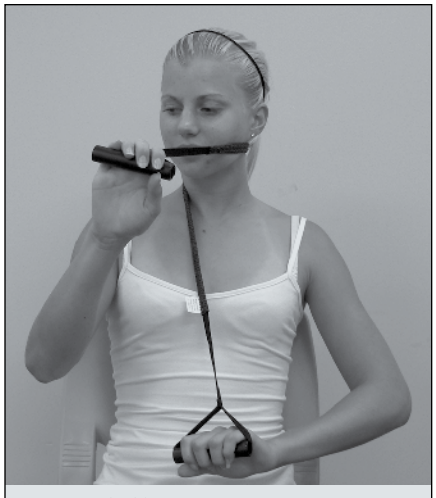

FIGURE 3. C1-C2 self-sustained natural apophyseal glide (SNAG) for cervical right rotation. Force is applied to the C1 level via horizontal pressure from the strap. At the same time, the subject actively turns his/her head to the right.

The placebo involved a sham mobilization at C1-C2 using the cervical self-SNAG strap. The strap was positioned as previously described. The subject was then asked to apply a 3-second sustained forward pressure at C1, without moving the head. Subjects were given 3 trials to familiarize themselves with the technique, before 2 repetitions were performed. Similar encouragement was given to both intervention groups.

An assessor, blind to group allocation, then remeasured the FRT immediately after the intervention in both groups. Both the assessor and the subjects were blinded to the group allocation. To determine treatment blinding, subjects were asked whether they thought they had received the sham mobilization or active treatment. Subjects were unable to determine correctly which treatment they had received. Only 18 of 32 subjects were able to correctly identify their group, which is not much better than chance.

Subjects were then asked to perform 2 repetitions of the exercise they had been shown, twice daily for the following 12 months. It was stressed to the patient that they should continue to exercise through the duration of the study and to ensure that the exercise was carried out, as demonstrated, without pain. While it is recognized that in normal clinical practice prescribed exercise should be checked at a short interval to ensure correct application, this was not undertaken in this study.

Exercise compliance was assessed at 4-week follow-up using a self-report scale ranging from 1 (no exercise) to 5 (daily exercise). In addition, at 12-month follow-up subjects were asked whether they continued to exercise (yes or no). Assessment of exercise compliance was incorporated with the headache index questionnaires.

Each subject was given 2 copies of the headache questionnaire that was to be completed and returned to the researchers at 4 weeks and 12 months following the initial visit. Subjects were contacted by telephone, sometimes on multiple occasions, when they did not return the questionnaire at the stated time. Subsequently, there was 100% compliance with respect to questionnaire return.

Approval for this study was granted by Curtin University Human Research Ethics Committee. Subjects were able to withdraw from the study at anytime and gave written informed consent prior to participation.

Data Analysis

Statistical analysis was carried out using SPSS V12.0 (SPSS Inc, Chicago, IL). Alpha was set at .05 for each analysis. Age, headache history, headache severity index, and range of rotation in the FRT at baseline for both groups were analyzed with an independent *t* test.

A general linear model with a repeated-measures factor of time (preintervention, postintervention) and a between-subjects factor of group (C1-C2 self-SNAG, place-

TABLE 2 Subject Characteristics at Baseline Prior to Intervention*

	C1-C2 Self-SNAG Group	Placebo Group	*P* Value†
Age (y)	38 ± 14 (4)	33 ± 11 (3)	.21
Headache history (y)	6 ± 3 (1)	6 ± 4 (1)	.85
Headache severity index‡	52 ± 10 (2)	51 ± 9 (2)	.69
FRT preintervention (°)§	24 ± 8 (1.9)	27 ± 5 (1)	.23

Abbreviations: FRT, flexion-rotation test; SD, standard deviation; SEM, standard error of mean.
** Values presented as mean ± SD (SEM).*
† Difference between groups.
‡ Headache severity index (range, 0-100; larger scores indicate greater severity).
§ Rotation towards restricted side only is presented.

bo) was used to determine the difference between the 2 groups in the amount of rotation on the FRT immediately before and after the initial instruction and practice visit. Similarly, a general linear model with a repeated-measures factor of time (preintervention, 4 weeks postintervention, 12 months postintervention) and a between-subjects factor of group (C1-C2 self-SNAG, placebo) was used to test for change in the headache severity index. Assumptions underlying the repeated-measures general linear model were all met. The independent variable headache severity index and amount of rotation on the FRT had normal distributions (Shapiro-Wilk test, homogeneity of variance test, and the Mauchley test of sphericity were not significant).

RESULTS

Baseline characteristics across both groups were similar and are summarized in **TABLE 2**. No significant differences were detected between the 2 groups in terms of age, headache history, FRT range, and headache severity index score. In 13 of 16 subjects from both groups the direction of FRT restriction was to the right and the remainder to the left. Gender distribution in both groups was similar: 11 of 16 were female in the C1-C2 self-SNAG group and 8 of 16 were female in the placebo group.

Immediately following the intervention, the amount of rotation improved in both the C1-C2 self-SNAG (t = −7.03, df = 15, P<.001) and placebo group (t = −4.50, df = 15, P<.001). However, this improvement was significantly greater following the active treatment ($F_{1,30}$ = 15.91, P<.001). Change scores with 95% confidence intervals for amount of rotation during the FRT immediately following the intervention are shown in **FIGURE 4**. Rotation increased by 15° (SD, 9°) to 39° in the C1-C2 self-SNAG group, but only by 5° (SD, 5°) to 32° in the placebo group. Assessment of the confidence intervals for the change scores revealed with 95% certainty that the true mean difference in amount of rotation on the FRT following the application of a C1-C2 self-SNAG is between 11° and 20°, with a placebo effect of between 3° and 8°.

For the headache severity index there was a significant group-by-time interaction (P<.001). For the interaction, the F value and effect size were large ($F_{1,60}$ = 50.51, P<.001, partial η^2 = 0.77). **FIGURE 5** charts the estimated marginal means (predicted means for each dependent variable across levels of each factor) for the headache index preintervention and at 4 weeks and 12 months after the start of the intervention, indicating the interaction and change over time for both groups. Post hoc analysis revealed a significant difference between the C1-C2 self-SNAG and placebo group at 4 weeks ($F_{1,30}$ = 21.69, P<.001) and 12 months postintervention ($F_{1,30}$ = 26.74, P<.001). Descriptive statistics and change scores with 95% confidence intervals for headache severity index score at preintervention, 4 weeks postintervention, and 12 months postintervention are shown in **TABLE 3**. Assessment of these confidence intervals reveals with 95% certainty that the true mean difference in headache index after 12 months using a C1-C2 self-SNAG is between 22 and 35 points (mean ± SD change, 54% ± 17%), while the placebo had a change of between 1 and 12 points (mean ± SD change, 13% ± 21%).

Visual inspection of the subjects' reports of treatment benefit (**FIGURE 6**) shows the majority of responses towards the maximum perceived benefit for the individuals in the C1-C2 self-SNAG group and the reverse for those in the placebo group.

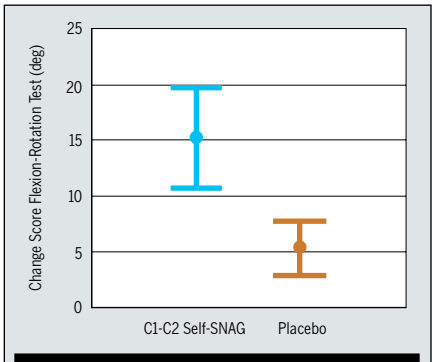

FIGURE 4. Change scores and 95% confidence intervals for cervical rotation range on the flexion-rotation test towards the restricted side immediately after the intervention.

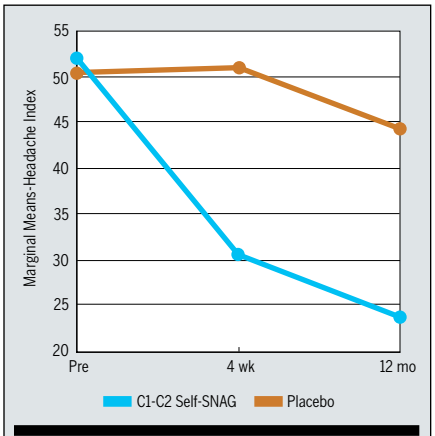

FIGURE 5. Estimated marginal means (predicted means of each dependent variable across levels of each factor) for headache index preintervention (Pre), 4 weeks postintervention, and 12 months postintervention.

TABLE 3 Means, SD, SEM, and Change Scores for Headache Severity Index Before and After the Intervention

Characteristic	C1-C2 Self-SNAG Group	Placebo Group
Headache severity index baseline, mean ± SD (SEM)*	52 ± 10 (2)	51 ± 9 (2)
Headache severity index 4 wk, mean ± SD (SEM)*	31 ± 9 (2)	51 ± 15 (4)
Change score (95% CI) preintervention to 4 wk postintervention	22 (16, 27)	0 (–7, 6)
Headache severity index 12 mo, mean ± SD (SEM)*	24 ± 9 (2)	44 ± 13 (3)
Change score (95% CI) 4 weeks to 12 mo postintervention	7 (2, 12)	7 (–2, 16)
Change score (95% CI) preintervention to 12 mo postintervention	28 (22, 35)	6 (1, 12)

Abbreviations: CI, confidence interval; SD, standard deviation; SEM, standard error of mean.
** Headache severity index (range, 0-100; larger scores indicate greater severity).*

Exercise compliance was greater in the C1-C2 self-SNAG group than in the placebo group at the 4-week follow-up. Furthermore, at the 12-month follow-up 10 out of 16 subjects in the C1-C2 self-SNAG group continued to exercise, while only 2 of 16 in the placebo group continued to do so.

DISCUSSION

This study found that headache symptoms, when measured by a headache index, improved significantly more in subjects treated with a C1-C2 self-SNAG than in subjects treated with a placebo. This difference was noted at 4 weeks after the initiation of treatment and maintained at 1-year follow-up. In addition, subjects' self-report of treatment benefit favored the C1-C2 self-SNAG technique over the placebo treatment (**FIGURE 6**).

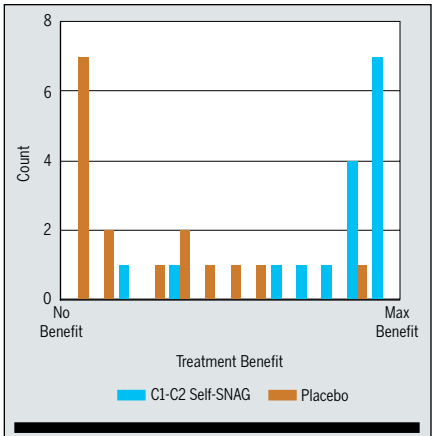

FIGURE 6. Frequency histogram of visual analogue scores for subject estimation of treatment benefit.

Our study employed a combination of measures to determine treatment effect. The IHS Committee on Clinical Trials[26] recommended that headache indices should not be used in the evaluation of headache trials. We used a measure of headache severity specifically developed by Niere and Robinson[19] to overcome the limitations suggested by the IHS, as well as a scale indicating the subjects' estimation of treatment effect. The index developed by Niere and Robinson[19] was shown to be sensitive to change; however, the authors suggested incorporating the additional treatment effect scale, which was used in this study.

Recommendations for determination of treatment response have included a greater than 50% reduction in headache symptoms.[1] Others have suggested a standard of 50% pain relief[16]; but this is no more than an arbitrary figure.[19] In this study we found a 54% reduction in headache symptoms at 12 months after subjects commenced using a C1-C2 self-SNAG, as compared to a 13% reduction for those subjects using a placebo intervention.

Exercise compliance was investigated at 4 weeks, and it was found that subjects taught the placebo exercised less often than those taught the C1-C2 self-SNAG. It is unclear whether this poor compliance was due to lack of diligence or weak response to the exercise itself.

It must be recognized that there are limitations to only using a headache index and self-report of treatment benefit. We recommend that in future studies parallel outcome measures be employed. These could include medication use or functional capacity. An additional limitation of this study is that no attempt was made to report on whether or not subjects sought alternative intervention. This should also be incorporated in future studies. However, it is logical that the group most likely to seek alternative treatment would be the placebo group. If individuals in the placebo group did seek alternative treatment, it did not appear to impact on the outcome of this study.

Jull et al[13] evaluated mobilization and specific exercise for the management of patients with cervicogenic headache. Combined interventions did not produce a significantly better effect than the single therapies across all outcomes. Nevertheless, there was a 10% better response for the participants who received the combined therapy, which was thought to be clinically relevant. In that study there was a 50% reduction in headache frequency in 71% of subjects receiving manual therapy alone. Direct comparison to our study cannot be made, as that study's outcome measures were not the same and its subjects received 12 treatment sessions, in contrast to only 1 treatment session in the present study. The results of both studies suggest a significant benefit of manual therapy in the management of patients with cervicogenic headache.

A number of studies have shown manual therapy to be effective in the management of cervicogenic headache.[10,21,24,27,36] The majority have investigated a combination of manual therapy with exercise, as cervicogenic headache is a disorder of cervical muscular impairment as much as cervical joint dysfunction.[11,13,38] For the present investigation we chose not to incorporate exercise for re-education of muscular impairment so that we could evaluate the sole effect of the C1-C2 self-SNAG. We recognize the multidimensional nature of cervicogenic headache and that manual therapy for this con-

dition should incorporate management of all aspects of this disorder. However, the present study has demonstrated an effective self-management technique for the articular dysfunction of cervicogenic headache requiring minimal therapist assistance. In a cost-driven society, self-management must be seen as a desirable goal. This study has demonstrated some efficacy in that respect. Based on previous studies and our results, we would recommend that in clinical practice the C1-C2 self-SNAG be used as part of a treatment program that includes muscle re-education for overall management of cervicogenic headache.

The restriction of rotation in the FRT observed among the subjects with cervicogenic headache was similar to results found in other studies. While this study reported a mean rotation range of 25° toward the restricted side, Hall and Robinson[8] have reported 28° and Ogince et al[22] 20°. This restriction contrasts to range available in subjects without headache reported at approximately 44° in each direction.[7,8] Other studies have reported mean ranges of 42° in asymptomatic subjects[2] and 40° in subjects with migraine headache.[22]

This is the first published report demonstrating immediate change in range of rotation following a C1-C2 self-SNAG. Range improved by 15° in the C1-C2 self-SNAG group, and much less in the placebo group. As there was no long-term measurement of range of motion, it is not possible to directly relate immediate change in range of motion with reduction in headache symptoms. However, it would seem reasonable to propose—as headache severity has been shown to be directly related to the degree of restriction found on the FRT[22]—that improving range of motion would have a beneficial effect on symptoms. Indeed Reid et al[25] have reported improvements in range of movement, neck pain, and disability following the application of upper cervical SNAGs. These improvements were maintained at 3-month follow-up. Further studies are required to verify that reduction in headache symptoms following the C1-C2 self-SNAG are related to increased movement determined by the FRT.

The data from the subjects assessed for inclusion for the present study are in agreement with studies suggesting C1-C2 as the dominant symptomatic level in cervicogenic headache.[3,8,32,38] Of the subjects assessed for inclusion, 32 of 43 were deemed positive on the FRT. These finding give credence to the relevance of the FRT in cervicogenic headache management.

Research is limited in investigating the mechanism of effect of manual therapies. A placebo effect is a definite aspect of any intervention. Expectation is a major part of the placebo effect.[8] We ensured that the placebo was a credible alternative that would be difficult for the subject to identify. However, the change in the C1-C2 self-SNAG group was significantly larger than the placebo effect suggesting other mechanisms were responsible.

One possible mechanism by which the C1-C2 self-SNAG may have reduced headache symptoms is by the neuromodulation effect of joint mobilization. In the gate control theory, stimulation of mechanoreceptors within the joint capsule and surrounding tissues causes an inhibition of pain at the spinal cord.[14,37] In addition, descending pain-inhibitory systems may be activated, mediated by areas such as the periaqueductal gray of the midbrain.[14,23,30,35,37] The end range positioning in rotation with the C1-C2 self-SNAG may engage these inhibitory systems and reduce pain.

Perhaps a less plausible explanation of the increase in cervical rotation range on the FRT is that the C1-C2 self-SNAG decreased joint stiffness. Mobilization is thought to break down adhesions and stretch surrounding tissues. That the improvement in rotation range was immediate suggests that the effect of the C1-C2 self-SNAG technique is more likely related to a neurophysiological change in pain modulation rather than an effect on joint stiffness.

CONCLUSION

This study has demonstrated efficacy of the C1-C2 self-SNAG in reducing cervicogenic headache symptoms sustained over a 1-year period. That a patient can perform this exercise independently at home, without ongoing supervision, exemplifies the potential importance this technique may have in assisting self-management of cervicogenic headache.

ACKNOWLEDGEMENTS

We thank Dr Ritu Gupta and Dr Kathy Briffa.

REFERENCES

1. The International Classification of Headache Disorders: 2nd edition. *Cephalalgia*. 2004;24(Suppl 1):9-160.
2. Amiri M, Jull G, Bullock-Saxton J. Measuring range of active cervical rotation in a position of full head flexion using the 3D Fastrak measurement system: an intra-tester reliability study. *Man Ther.* 2003;8:176-179.
3. Aprill C, Axinn MJ, Bogduk N. Occipital headaches stemming from the lateral atlantoaxial (C1-C2) joint. *Cephalalgia*. 2002;22:15-22.
4. Bronfort G, Assendelft WJ, Evans R, Haas M, Bouter L. Efficacy of spinal manipulation for chronic headache: a systematic review. *J Manipulative Physiol Ther.* 2001;24:457-466.
5. Diener I. The impact of cervicogenic headache on patients attending a private physiotherapy practice in Cape Town. *S Afr J Physiother.* 2001;57:35-39.
6. Dreyfuss P, Michaelsen M, Fletcher D. Atlanto-occipital and lateral atlantoaxial joint pain patterns. *Spine.* 1994;19:1125-1131.
7. Dvorak J, Antinnes JA, Panjabi M, Loustalot D, Bonomo M. Age and gender related normal motion of the cervical spine. *Spine.* 1992;17:S393-398.
8. 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.
9. Henry P, Dartigues J, Puymirat C, Peytour P, Lucas J. The association cervicalgia-headaches: an epidemiologic study. *Cephalalgia*. 1987;7(Suppl 6):189-190.
10. Jensen OK, Nielsen FF, Vosmar L. An open study comparing manual therapy with the use of cold packs in the treatment of post-traumatic headache. *Cephalalgia*. 1990;10:241-250.
11. Jull G. Articular and muscular impairments in cervicogenic headache: a case report [invited

commentary]. *J Orthop Sports Phys Ther.* 2003;33:21-30; discussion 30-22.
12. Jull G. Management of cervicogenic headache. In: Grant R, eds. *Physical Therapy of the Cervical and Thoracic Spine.* New York, NY: Churchill Livingstone; 2002:239-272.
13. Jull G, Trott P, Potter H, et al. A randomized controlled trial of exercise and manipulative therapy for cervicogenic headache. *Spine.* 2002;27:1835-1843; discussion 1843.
14. Katavich L. Differential effects of spinal manipulative therapy on acute and chronic muscle spasm: a proposal for mechanisms and efficacy. *Man Ther.* 1998;3:132-139.
15. Konstantinou K, Foster N, Rushton A, Baxter D. The use and reported effects of mobilization with movement techniques in low back pain management; a cross-sectional descriptive survey of physiotherapists in Britain. *Man Ther.* 2002;7:206-214.
16. Moore A, McQuay H, Gavaghan D. Deriving dichotomous outcome measures from continuous data in randomised controlled trials of analgesics. *Pain.* 1996;66:229-237.
17. Mulligan BR. *Manual Therapy NAGS SNAGS MWMS etc.* Wellington, New Zealand: Plane View Services; 2004.
18. Nicholson GG, Gaston J. Cervical headache. *J Orthop Sports Phys Ther.* 2001;31:184-193.
19. Niere K, Robinson P. Determination of manipulative physiotherapy treatment outcome in headache patients. *Man Ther.* 1997;2:199-205.
20. Nilsson N. The prevalence of cervicogenic headache in a random population sample of 20-59 year olds. *Spine.* 1995;20:1884-1888.
21. Nilsson N, Christensen HW, Hartvigsen J. The effect of spinal manipulation in the treatment of cervicogenic headache. *J Manipulative Physiol Ther.* 1997;20:326-330.
22. 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.* In press.
23. Petersen N, Vicenzino B, Wright A. The effects of a cervical mobilisation technique on sympathetic outflow to the upper limb in normal subjects. *Physiother Theory Pract.* 1993;9:149-156.
24. Petersen SM. Articular and muscular impairments in cervicogenic headache: a case report. *J Orthop Sports Phys Ther.* 2003;33:21-30; discussion 30-22.
25. Reid SA, Rivett DA. Manual therapy treatment of cervicogenic dizziness: a systematic review. *Man Ther.* 2005;10:4-13.
26. Schoenen J. Guidelines for trials of drug treatments in tension-type headache. First edition: International Headache Society Committee on Clinical Trials. *Cephalalgia.* 1995;15:165-179.
27. Schoensee SK, Jensen G, Nicholson G, Gossman M, Katholi C. The effect of mobilization on cervical headaches. *J Orthop Sports Phys Ther.* 1995;21:184-196.
28. Sjaastad O, Fredriksen TA, Pfaffenrath V. Cervicogenic headache: diagnostic criteria. The Cervicogenic Headache International Study Group. *Headache.* 1998;38:442-445.
29. Smith KL, Horn C. Cervicogenic headache part 1: an anatomic and clinical overview. *J Man Manip Ther.* 1997;5:158-170.
30. Sterling M, Jull G, Wright A. Cervical mobilisation: concurrent effects on pain, sympathetic nervous system activity and motor activity. *Man Ther.* 2001;6:72-81.
31. Stratton SA, Bryan JM. Dysfunction, evaluation, and treatment of the cervical spine and thoracic inlet. In: Donatelli R, Wooden M, eds. *Orthopaedic Physical Therapy.* New York, NY: Churchill Livingstone; 1994:77-122.
32. Treleaven J, Jull G, Atkinson L. Cervical musculoskeletal dysfunction in post-concussional headache. *Cephalalgia.* 1994;14:273-279; discussion 257.
33. University of California Los Angeles, Department of Statistics. Power Calculator. Available at: http://www.stat.ucla.edu. Accessed 2004.
34. van Suijlekom HA, Lame I, Stomp-van den Berg SG, Kessels AG, Weber WE. Quality of life of patients with cervicogenic headache: a comparison with control subjects and patients with migraine or tension-type headache. *Headache.* 2003;43:1034-1041.
35. Vicenzino B, Collins D, Benson H, Wright A. An investigation of the interrelationship between manipulative therapy-induced hypoalgesia and sympathoexcitation. *J Manipulative Physiol Ther.* 1998;21:448-453.
36. Whorton R, Kegerreis S. The use of manual therapy and exercise in the treatment of chronic cervicogenic headache. *J Man Manip Ther.* 2000;8:193-203.
37. Wright A. Hypoalgesia post-manipulative therapy: a review of a potential neurophysiological mechanism. *Man Ther.* 1995;1:11-16.
38. Zito G, Jull G, Story I. Clinical tests of musculoskeletal dysfunction in the diagnosis of cervicogenic headache. *Man Ther.* 2006;11:118-129.