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Short term Efficacy of C0-C1 Mobilization in the Cervical Neutral Position in Upper Cervical Hypomobility: A Randomized Controlled Trial

The purpose of this study is to explore the effects of mobilization of C0-C1 and C7-T1 applied to asymptomatic individuals with reduced upper cervical rotation during the FRT. Design: parallel randomized controlled trial. 48 subjects(38.52 years±15.13) with C1-C2 rotation hypomobility in TFR joined the study and were randomized into three groups(C0, C7, control group). FRT in both directions was measured before and after the intervention. C0 intervention consisted of a dorsal translatoric mobilization of C0-C1 in the cervical neutral position. C7 intervention consisted of a ventral cranial translatoric mobilization of C7-T1 in neutral position and the control group maintained a supine position. C0 group experienced a FRT ROM to the restricted side increase of 17.64°(SD=4.55), that was significantly greater (P<0.001) than 5.95° (SD=4.81) of the C7 group and 2.45°(SD=5.05) of the control group. The results showed that a dorsal translatoric mobilization of C0-C1 in neutral position restored the physiological FRT mobility in subjects with C1-C2 hypomobility and experienced statistical significant improvement in FRT as compared to a C7-T1 translatoric mobilization and a control group. (Level of evidence: 1b).

Key words: *Cervical Vertebrae; Atlantoaxial Joint; Manipulation*

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INTRODUCTION

Spinal range of movement(ROM) is the largest in the cervical spine, especially in the upper cervical spine(C0-C1 and C1-C2 segments) where more than 60% of cervical axial rotation occurs. The vast majority of upper cervical rotation occurs at the C1-C2 segment(36-41.5° to each side) with a small amount of motion(1.0-2.8°) attributed to the C0-C1 segment(1).

It is estimated that upper cervical ROM impairments of at least 8° are present in 18.7 to 29.6% of the asymptomatic population(2). In addition, upper cervical impairments are also associated with headaches, and neck and orofacial pain(3,4), as well as atlantoaxial rotatory subluxation in pediatric populations(5).

A number of studies have investigated the effectiveness of treating upper cervical hypomobility with joint mobilization and manipulation. These studies used joint mobilization and manipulation applied directly to C1 at the end of the cervical rotation ROM(2)(6,7). This treatment is not without controversy within the literature. This is due to the unique ROM characteristics and vertebral artery angulation at the C1-C2 motion segment. The portion of the vertebral artery(V3 segment) between C1-C2 is considered by some to be the most vulnerable site for injury(8), especially during rotational manipulation(9), in addition to slow and repeated mobilization(10). Controversy over whether adverse events can be attributed to upper cervical rotation has led to the recommendation by the International Federation of Orthopedic Manual

Physical Therapists(IFOMPT) that end-range rotation and extension positions should be avoided during cervical spine mobilization and manipulation(11). Clinical examination of upper cervical rotation ROM may be measured using the flexion-rotation test(FRT). During the FRT the head and neck are placed in maximal flexion(theoretically to stabilize the lower cervical segments) and the head and neck are turned left and right. The FRT is considered a reliable, sensitive, specific and valid measure of upper cervical rotation(3)(12-16).

There is evidence that neck pain, ROM and disability may be improved by treatment of segments and spinal regions remote from the symptomatic segment(17-19). With the exception of the C1-C2 segment, there is little information regarding the effects of the treatment of other cervical segments on upper cervical rotation ROM examined using the FRT. The purpose of this study is to explore the effects of mobilization of C0-C1 and C7-T1 applied to asymptomatic individuals with reduced upper cervical rotation during the FRT.

METHODS

This study is registered in ClinicalTrials.gov with the identifier NCT02404766 and used a randomized controlled trial parallel design to investigate the treatment efficacy of mobilization of C0-C1, C7-T1 and a control group on FRT ROM. Based on previous studies and clinical experience, a clinically relevant improvement in rotation with the FRT of more than 10° for the intervention groups and minimal change with control group was expected(14,20). A power analysis based on pilot study findings, 10 degrees or greater ROM improvement, power set to 80%, and an alpha at 0.05 was used to determine a 16 participant group size. The local Ethics Committee of Clinical Research approved the protocol of this study.

Subjects

Participants were recruited from physical therapy clinics and from universitary students and personnel. A total of 257 participants were informed about the study and screened for potential C1-C2 hypomobility. Finally, 48 participants, 16 in each group, fulfilled the inclusion and exclusion criteria shown in Table 1.

Table 1. Inclusion and Exclusion Criteria

Inclusion criteria
- FRT with less than 32° or asymmetry of 10° between right and left, whenever one of the sides does not exceed physiological C1-C2 ROM(45°) - Indication of grade III mobilization in C0-C1 and C7-T1 segments - Aged 18-66 - Signed informed consent
Inclusion criteria
- Contraindication to manual therapy and red flags according to Rushton et al.(2012) - Pain presence at the beginning or during the study - Cervical treatment during the last three months - Inability to tolerate FRT - Involvement in litigation or compensation

Flexion-Rotation Test

The rotation ROM in the FRT was measured using a modified cervical range of motion(CROM) device(Plastimo Airguide, Inc, Buffalo Groove, IL), following the method described by Hall et al.(7). Using this method the participant was positioned in supine, and the cervical spine was flexed maximally and rotated three times to the right and to the left and an average was taken for each motion. Preintervention and immediate postintervention values for FRT ROM were recorded.

Interventions

Participants were randomly divided into three groups(C0, C7 and control) using a computer generated sequence of numbers and completed the study without dropouts(Figure 1).

Both the C0 and C7 group participants received a straight line/translatoric stretching mobilization21 in supine with the cervical spine positioned in neutral. Each mobilization was performed for 10 minutes using repeating cycles of 30 seconds of mobilization and 15 seconds of rest. The mobilizations were performed in the direction of motion which was most restricted during the FRT. Participant reaction was monitored throughout the procedure and all treatments were applied using a pain free force.

The participants of the C0 group were mobilized using a dorsal gliding mobilization of C0-C1. The technique is described in detail by Kaltenborn and Krauss(21,22). During this technique, the posterior arch of C1 was stabilized while the forehead was pushed dorsally and medially(Figure 2).

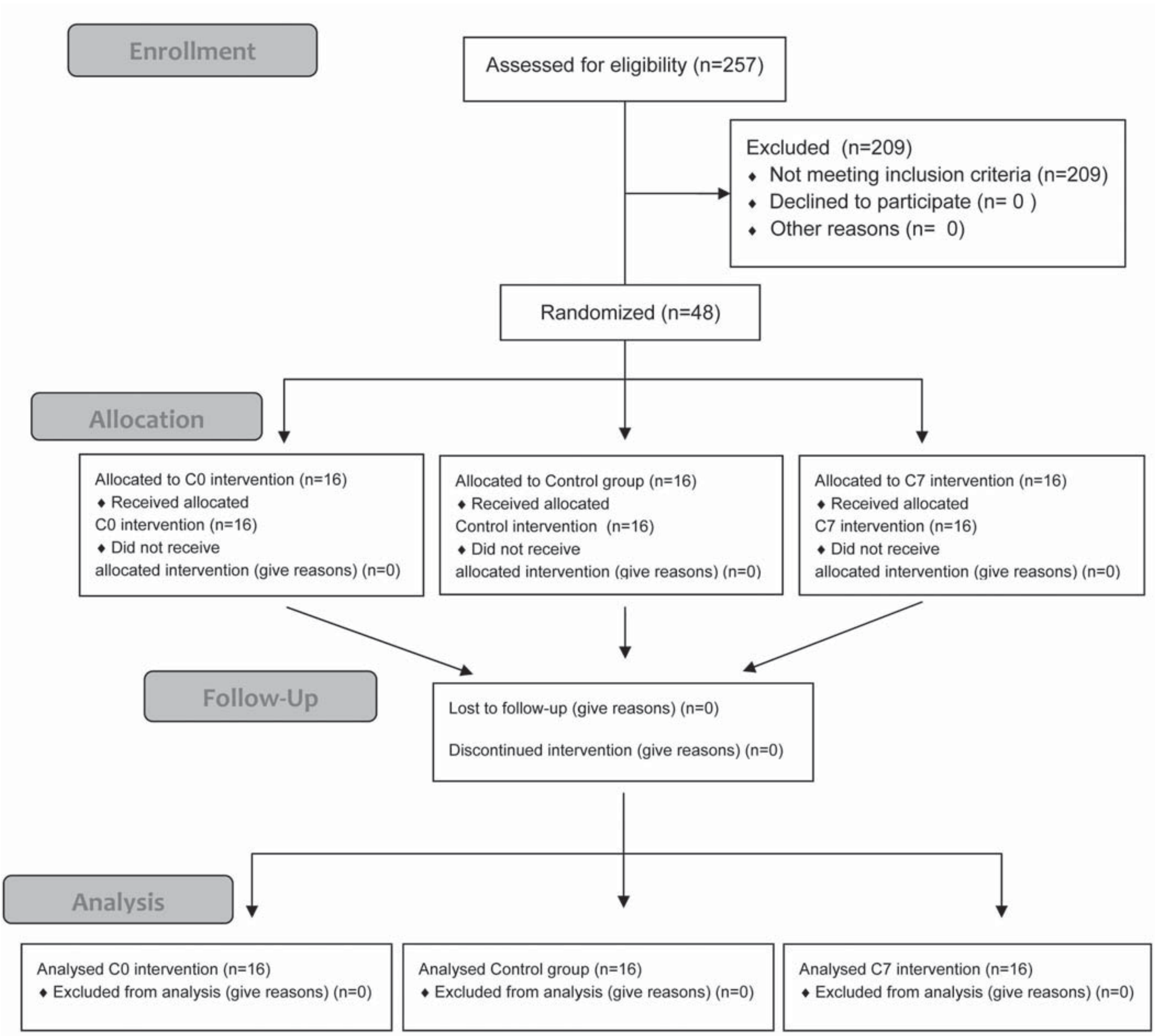

Fig. 1. Participants flow through the study.

The participants of the C7 group were mobilized using a ventral-cranial gliding mobilization of C7-T1. The technique is described in detail by Kaltenborn and Krauss(21,22). During this technique, T1 was stabilized indirectly by pressing the shoulder girdle dorsally while C7 was mobilized in a ventral cranial direction(Figure 3).

Participants in the control group were placed in supine with the head and neck in a neutral position without movement for 10 minutes.

FRT ROM in both directions was measured before and after the intervention by the same examiner. The evaluation procedures were carried out by a physical therapist and the intervention procedures were applied by another physical therapist. Both physical therapists had completed their OMT training. The examiner was blinded to participant group allocation and the researcher who applied the intervention was blinded to the FRT results.

Statistical analysis was carried out using SPSS 15.0 for Windows. Alpha was set at 0.05 for each

Fig. 2. Passive dorsal gliding mobilization directed to C0-C1. Posterior arch of C1 was stabilized with radial border of second metacarpal and index finger of the caudal hand. Head was supported by the therapist with the cranial hand on occipital bone and with ventral side of shoulder on the opposite side of the patient's forehead. Translatoric mobilization was applied by pushing forehead dorsally and medially to the stabilized atlas with the shoulder of the therapist.

Fig. 3. Ventral-cranial gliding mobilization directed to C7-T1. T1 was stabilized indirectly by pressing the shoulder girdle dorsally with the caudal hand. The cranial hand contacted posterior surface of the transverse process, the lamina and inferior articular process of C7. Mobilization was applied to C7 in a ventral cranial direction by the radial border of the craneal hand.

analysis. The ANOVA, Kruskal Wallis and chi-square tests were performed to test differences among three groups in terms of the FRT in both directions before and after treatment and patient characteristics. The three groups were compared pairwise with a Bonferroni adjustment or U-Mann Whitney test for multiple comparisons. The non-parametric Wilcoxon test or parametric paired-samples t test were used to compare groups with regard to parameters obtained before and after intervention.

RESULTS

Prior to intervention characteristics across C0, C7 and control groups are shown in Table 2. No significant differences were present among the groups regarding age, gender distribution, FRT ROM to the restricted side and FRT ROM to the non restricted side at baseline(all $P>.05$).

FRT to the restricted side

After intervention, although the degrees in the FRT to the restricted side increased in the two intervention groups(C0 [$P<.001$];C7 [$P=.001$] and in the control group[$P=.04$])(Table 3), the C0 group experienced significantly($P<.001$) greater increases in FRT ROM to the restricted side(17.64° [SD=4.55]), as compared to the C7 group(5.95° [SD=4.81]) and the control group(2.45° [SD=5.05])(Figure 4). The C7 group also experimented a significantly greater increase compared to control group($P=.009$).

Table 2. Subject Characteristics prior to intervention*

Pre-intervention variables	C0 Group (n=16)	C7 Group(n=16)	Control Group(n=16)	p†
Age (y)	40.74 ± 15.75	39.19 ± 15.96	35.44 ± 14.07	.508
Gender M/F (n)	8/8	7/9	2/14	.059
FRT - restricted side (°)	27.22 ± 6.54	28.98 ± 2.51	27.29 ± 4.96	.598
FRT - non restricted side (°)	37.39 ± 5.35	37.16 ± 4.79	38.79 ± 5.74	.69

Abbreviations: FRT, flexion-rotation test; SD, standard deviation.
*Values presented as mean ± SD
†Difference among groups

Table 3. Pre and Post-intervention values of FRT to the restricted side among groups*

	Pre-intervention	Post-intervention	p†
C0	27.22 ± 6.54	44.93 ± 6.69	<.0001
C7	28.98 ± 2.51	34.93 ± 4.49	.001
Control	27.29 ± 4.96	29.75 ± 6.71	.04

Abbreviations: FRT, flexion-rotation test; SD, standard deviation.
*Values presented as mean ± SD

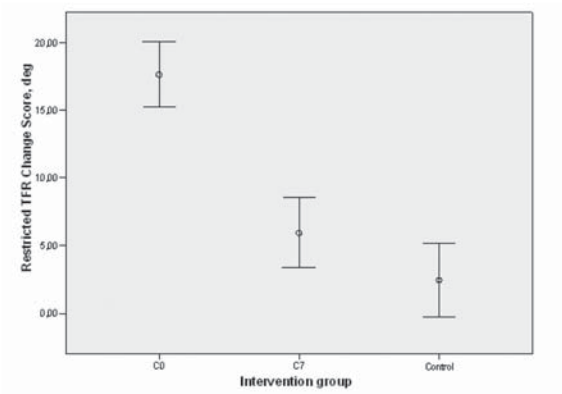

Fig. 4. Within-group mean change score in Flexion-Rotation Test(TFR) to the restricted side with 95% confidence interval for the C0, C7 and control groups(P<.001).

FRT to the non restricted side

The C0 group experienced a significant(P=.002) increase in FRT ROM to the non restricted side (8.35° [SD=6.52]) compared to C7 group(2.16° [SD=4.43]) and control group(-.04° [SD=2.65]).

DISCUSSION

The three groups of our study increased their ROM during the FRT after intervention. The C0 group improved the FRT ROM to the restricted side by an average of 17.64°(SD=4.55), exceding the minimal detectable change (MDC) described by Hall23 and the clinically relevant improvement for the FRT(10° or more)(14,20). In contrast, the C7 group overcame the MDC but did not demonstrate clinically meaningful improvement in the FRT. The control group did not reach the MDC. Furthermore, the C0 group was the only group that reached the typical ROM for the upper cervical during the FRT(15,20) immediately following one mobilization session.

While the ROM improvements of 17.64° is far greater than the 1.0-2.8° ROM in rotation attributed to the C0-C1 segment the authors believe that the effects may be due to the articular(1), muscular and ligamentous relationships between C0, C1 and C2(18,24). In addition, other non-biomechanical mechanisms such as spinal cord and central nervous system mechanisms may account for this unexpected degree of improvement(6,25,26).

The results of this study support the notion that mobilization of C0-C1 is an effective treatment for restoring upper cervical rotation as measured by the FRT. These results are consistent with other studies examining the effect of mobilization and manipulation treatments targeting the C1-C2 segment(2,6,7). However, in contrast to the C1-C2 treatment studies, this study did not position the upper cervical in an end range rotational position. This technique follows IFOMPTs recommendation against end range rotational mobilization or manipulation of the upper cervical spine(11).

This study presents with several limitations. While participants in this study were experiencing hypomobility, they were also painfree. Lluch et al. concluded that this same C0-C1 mobilization can provide immediate pain relief and reduced pressure sensitivity in the cervical spine for patients with chronic neck pain(27). However, these results cannot be generalized to other C0-C1 techniques or symptomatic clinical subgroups. In addition, this study examined only the immediate effects of C0-C1 and C7-T1 mobilizations and provide no information regarding the long term effects of these techniques. Several authors have suggested that upper cervical spine ROM is directly related to deep cervical flexor muscles strength and coordination(4,28,29). Further study of the combination of exercise and passive mobilization could prove beneficial.

CONCLUSIONS

The results of the current study demonstrate that a dorsal glide mobilization of C0-C1 in the neutral position may be beneficial in improving upper cervical rotation measured with the Flexion Rotation Test in participants with C1-C2 hypomobility compared to a C7-T1 mobilization and a control group.

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