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Combined Effect of Ultrasound and Manual Therapy on Cervical Pain after Maxillofacial Surgeries

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***Abstract*---**Cervical pain is a common complication post maxillofacial surgeries ranging from weeks to months. Purpose: to evaluate combined effect of ultrasound and manual therapy on cervical pain after maxillofacial surgeries in patients who had maxillofacial surgeries and had cervical pain. Methods: - forty five (23 males and 22 females) patients with cervical pain after maxillofacial surgeries were randomly divided into three equal group3. Group (A) received Ultrasound addition to Manual Therapy. Group (B) received Manual Therapy only. Group(C) received only Ultrasound treatment. Results: - The result showed that there was a significant decrease in cervical pain and a significant increase in cervical ROM using Manual Therapy combined with Ultrasound better than Manual Therapy or Ultrasound only. Conclusion: Both types (Manual Therapy and Ultrasound) are effective in deceasing cervical pain after maxillofacial surgeries that is reflected by decreasing cervical pain and increasing cervical ROM.

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***Keywords*---**Cervical ROM, Cervical, Goniometer, Manual therapy, Maxillofacial surgeries, Pain, Temporomandibular joint, Ultrasound, Visual Analogue Scale.

Introduction

Various surgical specialties are now embracing day-case surgery throughout the world. These include ophthalmology, ENT, general surgery, plastic surgery and orthopaedic surgery. Many operations are performed satisfactorily as day cases in developing countries, but there are few or no comprehensive reports in the literature of its acceptability among various specialties, particularly oral and maxillofacial surgery (Senapati et al., 1994).

Day-case surgery is becoming attractive worldwide to various surgical specialties. Invasive surgical procedures in temporomandibular dysfunction (TMD) may cause symptoms to worsen. Pain and dysfunction may persist and overall degeneration or remodeling of the TMJ (Jiburum & Akpuaka, 1996; Miernik et al., 2012).

Cervical spine disorders are frequently associated with temporomandibular disorders (TMDs). The head and neck is a complex anatomical region containing multiple general and specialised sensory structures. Dense sensory innervation can lead to a single structure being innervated by multiple nerves and/or multiple structures being served by a single nerve. This can make identifying the origin of a pain and ultimately, diagnosis, difficult (Storm Mienna & Wänman, 2012).

It was pointed out by many authors that pain in the upper quarter and masticatory motor system may be caused by cervical spine disorders (generally by dysfunction of muscular origin) and vice versa. It could be explained by specific functional and morphological connections between the cervical and temporomandibular regions. Orofacial pain requires a systematic approach including a thorough head and neck examination with assessment of the musculoskeletal system (Stegenga & Dijkstra, 2007).

According to the "pain adaptation model", TMD - related pain induces a paradoxical activity of masticatory muscles. This model may explain neck muscle activities and neck pain (NP), which is a very prevalent TMD comorbid condition. In neck pain, neck muscle antagonistic activity is increased, and agonistic activity is decreased as postulated by the pain adaptation model. However, synergistic and compensatory activity may occur and agonistic activity may be unchanged or even increased as postulated within the "vicious cycle theory". Psychological stress may also induce motor dysfunction in TMD and neck pain (Hagandora & Almarza, 2012).
In NP, rehabilitation may increase agonistic activity and decrease compensatory activity and antagonistic activity, thus inducing a switch from agonist/antagonist co-activation towards reciprocal inhibition. Thus, rehabilitation-induced motor activity changes constitute a new research field (Lövgren et al., 2018).
Patient-specific mobility therapy for TMJ, neck, and shoulder dysfunction can restore range of motion (ROM) and overcome functional limitations of

the temporomandibular joint (TMJ), neck, and shoulder. Cervical manual therapy or orofacial manual therapy show significant reduction in all aspects of cervical impairment after the treatment period (McNeely et al., 2006). Mobility of the upper cervical spine and muscle performance of the deep flexors improve cervical ROM and decrease disability and pain (Nicolakis et al., 2001).

Therapeutic ultrasound is a noninvasive modality widely utilized in the management of musculoskeletal disorders. Therapeutic ultrasound is frequently used in the treatment of neck pain and is often combined with other physiotherapeutic modalities. It does seem that ultrasound may be considered as part of a physical modality treatment plan that may be potentially helpful for short-term pain relief; however, it is undetermined which modality may be superior. In both pain syndromes, further trials are needed to define the true effect of low-intensity ultrasound therapy for axial back pain (Miernik et al., 2012).

Subjects and Method

Study Design

A prospective randomized controlled clinical trial was done to evaluate the therapeutic effect of manual therapy combined ultrasound in cervical pain after maxillofacial surgeries. The study was performed between February 2021 and December 2021.

Subjects

This study was carried out by 45 patients who had cervical pain after maxillofacial surgeries, their age was ranged from 25 to 50 years, they were free from any diseases that can affect treatment process and influence the results (no diabetes or blood problems). They were recruited from the outpatient clinic of department of oral and maxillofacial surgery unit at Zagazig University Hospitals in after signing consent form. The consent form has been recorded from all subjects involved in this study.

Randomization

A total of sixty five patients who had maxillofacial surgeries and complained from cervical pain were examined for eligibility. Twenty patients were excluded (fifteen patients didn't meet the inclusion criteria and five patients declined to participate in the study). Forty five patients were divided randomly into three equal groups. Group (1) received ultrasound treatment combined to manual therapy. Group (2) received only manual therapy. Group (3) (Control group) received only ultrasound. (figure 1). The patients were divided randomly by a blinded, independent research assistant who used a random card generated automatically by a computer.

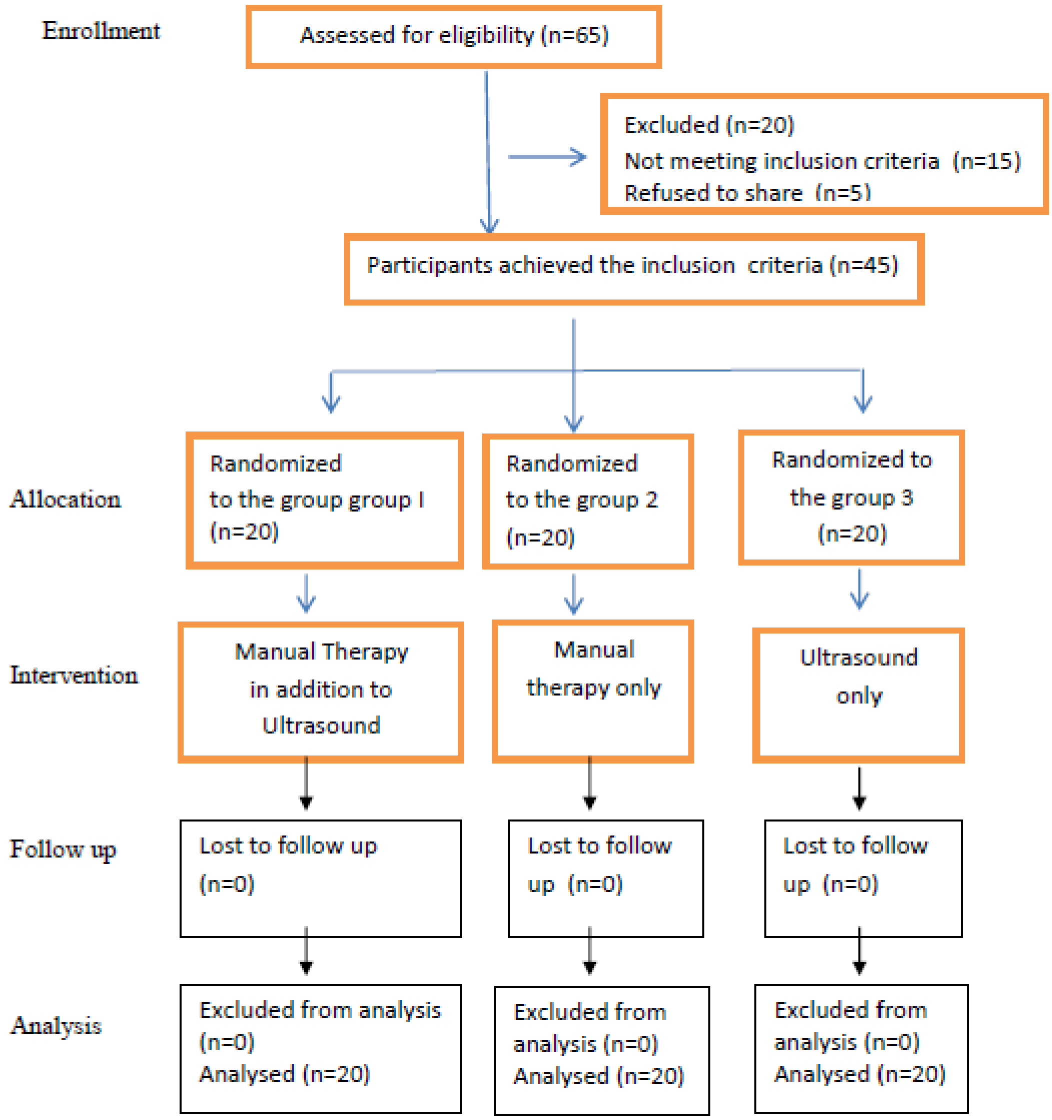

Figure 1. Flow diagram illustrating participating patients and dropout through the study

Intervention

Patients were randomly divided into 3 equal groups in number: 3 study groups.
Group 1: (first study group), this group was composed of 15 patients who received ultrasound treatment combined to manual therapy for two months.
Group 2: (second study group) that was composed of 15 patients who received only manual therapy for two months.
Group 3: (third study group) that was composed of 15 patients who received ultrasound only through the treatment period.
The treatment frequency was three sessions per week for two months.

Outcome measures
All measurements were done pre and post treatment by another assessor who was blinded about subject group allocation.

Cervical pain: Visual Analogue Scale (VAS) calculates the cervical pain intensity**.** VAS is a continuous horizontal line of length (10 cm) starting with no pain at the left side and gradually increasing pain towards the end of the line at the right side. It is a subjective method. Patient determine pain intensity degree through the scale. A translated Arabic version of VAS was used. It was measured before the beginning of the experiment as a first record and at the end of the second month of therapy as a second final record **[11]**.
Cervical ROM: Goniometer measurement is used to record cervical ROM before the beginning of the experiment and at the end of the second months **[12].**

Methodology

Procedures of ultrasound device

During the 8 week intervention period, treatment program included a 10 minute sessions of 1 MHZ three times a week (30 min/week) under the supervision of physical therapist. The Ultrasound device allows the application of 1 MHz, and 20% or 50% or continuous modes. In the present study, US will be applied at 1 watt/cm for 10 minutes to the cervical paravertebral area.

Figure 2. Procedures of ultrasound device

Therapeutic exercises
Treatment protocol

The treatment protocol included only interventions directed at the cervical spine. The treatment techniques were applied by the same physical therapist. All patients received a total of 24 sessions over a 8-week period (3 times a week). During the 24 treatment sessions all patients were treated with the following techniques:

1- Upper cervical flexion mobilization

Figure 2. Upper cervical flexion mobilization

2 - C5 central posterior-anterior mobilization

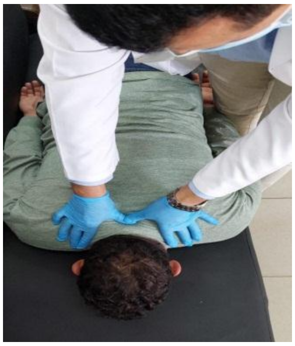

Figure 3. C5 central posterior-anterior mobilization.

3- Range of motion exercises

A-Passive ROM (PROM)

Figure 4. Passive ROM (PROM)

B-Active ROM (AROM)

Figure 5. Active ROM (AROM)

C-Active-assistive ROM (AAROM)

Figure 6. Active-assistive ROM (AAROM)

D –Stretching exercises

Figure 7. Stretching exercises

5-Strengthening exercises (Isometric strengthening exercise)

A- Isometric strengthening exercise for cervical flexors

Figure 8. Isometric strengthening exercise for cervical flexors

B- Isometric strengthening exercise for cervical extensors

Figure 9. Isometric strengthening exercise for cervical extensors

C- Isometric strengthening exercise for cervical side bending

Figure 10. Isometric strengthening exercise for cervical side bending

Data analysis

Descriptive statistics and ANOVA-test were conducted for comparison of the mean age between the three groups. One way ANOVA-test was conducted for comparison of VAS and neck ROM between groups. Paired t test for comparison between pre and post treatment mean values of VAS and neck ROM in each group. The level of significance for all statistical tests was set at $p < 0.05$. All statistical measures were performed through the statistical package for social studies (SPSS) version 25 for windows (Sullivan, 2017).

Results

Data analysis

Descriptive statistics and ANOVA test were conducted for comparison of subject characteristics between groups. Chi- squared test was used for comparison of sex distribution between groups. Normal distribution of data was checked using the Shapiro-Wilk test for all variables. Levene's test for homogeneity of variances was conducted to test the homogeneity between groups. Mixed MANOVA was conducted to investigate the effect of treatment on VAS and neck ROM. Post-hoc tests using the Tukey test were carried out for subsequent multiple comparison. The level of significance for all statistical tests was set at $p < 0.05$. All statistical analysis was conducted through the statistical package for social studies (SPSS) version 25 for windows (IBM SPSS, Chicago, IL, USA).

- *Subject characteristics*:
Table (1) showed the subject characteristics of the group A, B and C. There was no significant difference between groups in age and sex distribution ($p > 0.05$).

Table 1
Basic characteristics of participants

	Group A	Group B	Group C	p-value
	Mean ± SD	**Mean ± SD**	**Mean ± SD**	
Age (years)	36.13 ± 6.69	33.46 ± 6.25	34.13 ± 6.16	0.49
Sex, n (%)				
Females	8 (53%)	8 (53%)	7 (47%)	0.91
Males	7 (47%)	7 (47%)	8 (53%)	

SD, standard deviation; p-value, level of significance

Effect of treatment on VAS and neck ROM

There was a significant interaction of treatment and time ($F = 6.42$, $p = 0.001$). There was a significant main effect of time ($F = 176.87$, $p = 0.001$). There was a significant main effect of treatment ($F = 2.34$, $p = 0.01$).

Within group comparison

Within-group comparison revealed a significant decrease in VAS and a significant increase in neck ROM in the three groups post treatment compared with that pre treatment (p < 0.00). The percent of decrease in VAS in the group A, B and C were 86.44, 61.19 and 74% respectively. The percent of increase in flexion, extension, right and left bending, right and left rotation in the group A was 38.68, 53.40, 40.02, 37.51, 48.91 and 50% respectively and for group B was 25.5, 46.75, 35.98, 28.70, 39.04 and 36.53% respectively while in group C was 10.06, 19.7, 21.44, 22.48, 23.15 and 23.48% respectively (table 2-3).

Between group comparison

There was no significant difference in all parameters between groups pre treatment (p > 0.05). Comparison between groups post treatment revealed that there was a significant decrease in VAS of group A compared with that of group B (p < 0.001) and group C (p < 0.05). Also, there was a significant decrease in VAS of group C compared with that of group B post treatment (p < 0.05) (table 2).

There was a significant increase in flexion, extension, right and left bending, right and left rotation of group A compared with that of group B (p < 0.01) and group C (p < 0.001). Also, there was a significant increase in neck ROM of group B compared with that of group B post treatment (p < 0.01) (table 3).

Table 2
Mean VAS pre and post treatment of group A, B and C

	Group A	**Group B**	**Group C**	**p-value**		
	mean ± SD	**mean ± SD**	**mean ± SD**	**A vs B**	**A vs C**	**B vs C**
VAS						
Pre treatment	4.13 ± 0.74	4.2 ± 0.7	4.23 ± 0.65	0.96	0.91	0.99
Post treatment	0.56 ± 0.32	1.63 ± 0.71	1.1 ± 0.51	0.001	0.02	0.02
MD	3.57	2.57	3.13			
% of change	86.44	61.19	74			
	p = 0.001	***p = 0.001***	***p = 0.001***			

SD, Standard deviation; MD, Mean difference; p-value, Level of significance

Table 3
Mean neck ROM pre and post treatment of group A, B and C

	Group A	Group B	Group C	p-value		
	mean ± SD	**mean ± SD**	**mean ± SD**	**A vs B**	**A vs C**	**B vs C**
Flexion						
Pre treatment	34.13 ± 5.91	34 ± 6.3	34.4 ± 7.21	**0.99**	**0.99**	**0.98**
Post treatment	47.33 ± 4.3	42.67 ± 3.73	37.86 ± 4.51	**0.01**	**0.001**	**0.009**
MD (% of change)	-13.2 (38.68%)	-8.67 (25.5%)	-3.46 (10.06%)			
	p = 0.001	***p = 0.001***	***p = 0.001***			
Extension						
Pre treatment	36.2 ± 6.62	34.93 ± 6.26	35.53 ± 6.03	**0.84**	**0.95**	**0.96**
Post treatment	55.53 ± 3.18	51.26 ± 3.32	42.53 ± 5.39	**0.01**	**0.001**	**0.001**
MD (% of change)	-19.33 (53.4%)	-16.33 (46.75%)	-7 (19.7%)			
	p = 0.001	***p = 0.001***	***p = 0.001***			
Right bending						
Pre treatment	32.66 ± 7.24	31.13 ± 6.28	32.33 ± 6.76	**0.81**	**0.99**	**0.87**
Post treatment	45.73 ± 2.18	42.33 ± 2.35	39.26 ± 3.17	**0.003**	**0.001**	**0.007**
MD (% of change)	-13.07 (40.02%)	-11.2 (35.98%)	-6.93 (21.44%)			
	p = 0.001	***p = 0.001***	***p = 0.001***			
Left bending						
Pre treatment	33.06 ± 7.16	32.06 ± 5.32	31.4 ± 6.67	**0.91**	**0.75**	**0.95**
Post treatment	45.46 ± 2.38	41.26 ± 2.63	38.46 ± 1.84	**0.001**	**0.001**	**0.005**
MD (% of change)	-12.4 (37.51%)	-9.2 (28.7%)	-7.06 (22.48%)			
	p = 0.001	***p = 0.001***	***p = 0.001***			
Right rotation						
Pre treatment	48.93 ± 4.18	49 ± 5.15	51.53 ± 6.49	**0.99**	**0.38**	**0.41**
Post treatment	72.86 ± 3.31	68.13 ± 3.94	63.46 ± 4.76	**0.007**	**0.001**	**0.008**
MD (% of change)	-23.93 (48.91%)	-19.13 (39.04%)	-11.93 (23.15%)			
	p = 0.001	***p = 0.001***	***p = 0.001***			
Left rotation						
Pre treatment	49.2 ± 4.61	49.66 ± 5.96	50.86 ± 7.33	**0.97**	**0.73**	**0.85**

Post treatment	73.8 ± 3.56	67.8 ± 3.8	62.8 ± 5	**0.001**	**0.001**	**0.006**
MD (% of change)	-24.6 (50%)	-18.14 (36.53%)	-11.94 (23.48%)			
	p = 0.001	***p = 0.001***	***p = 0.001***			

SD, Standard deviation; MD, Mean difference; p-value, Level of significance

Discussion

The study was conducted to investigate the effect of manual therapy combined with ultrasound in cervical pain after maxillofacial surgeries. Because of the clinical nature of the study some limitations were encountered. Pain and tenderness post operations hinder patients follow and cooperate with the Physical Therapy program for long period (2 months) resulting in using small sample size in the current study. In addition, some environmental factors such as infection or skeletal injuries during the treatment time that may affect the subjects' recovery and improvement in the measured variables.

The range of age in groups was between 25-50 years. There was no significance difference between the 3 groups in their age as the mean age in group (A) was 36.13 ± 6.69 and in group (B) was 33.46 ± 6.25 where the p-value was (0.49)which are nearly the same in the 3 groups and this is better for fair comparison between the 3 groups.
Also, we selected this age group to withstand the training program and to exclude as much as possible any accompanying disease that always found in the old age subjects and may affect training program and the comparison. In addition, the sex distribution in the 3 groups are nearly similar, 8♂s in group (A), 8♂s in G (B) and 8♂s in G (C) also 7♀s in G (A) 7♀s in G (B) and 7♀s in G (C).

Wong et al. (2011), asserted that temporomandibular dysfunction (TMD) is considered to be associated with imbalance of the whole body. TMD therapy has influence on cervical spine range of movement (ROM) and cause reduction of spinal pain.
Wong et al. (2007), stated that recent years have seen a significant increase in the number of patients suffering from temporomandibular disorders (TMD). According to various sources, 8 out of 10 patients coming to the dentist are found to have bruxism or TMD**.**
In our study the selective physical therapy program for each group always begin often 2 weeks since the maxillofacial operation date to allow begin healing of the incision and the operative region of the patients, however a moderate type of activity was allowed after the surgery.
Blanpied et al. (2017), agreed that this incision needs to heal before beginning moderate exercises, although in most cases, patient can return to normal activity, including exercises, within one week of surgery according to type of surgery. The Physical therapist will guide the patient in post-surgical exercises and routines.
Won et al. (2019), said that there is common examination technique to identify the range of movement of the cervical spine. Due to common difficulties in

obtaining tools for cervical examination within the district, a standardised compilation of easy-to-replicate examination techniques are provided using different tools. Bedside instruments that can be used includes a measuring tape, compass, goniometer, inclinometer and cervical range of motion (CROM) instrument.

Correll et al. (2018), assessed reliability, validity, and responsiveness of devices applied in measurement of cervical mobility, including the CROM goniometer. Their research shows that, given its well-established clinimetric properties, the device may easily be used in daily clinical practice.

According to Hancock et al. (2018), given the emphasis on the importance of objective tools, the CROM goniometer may be recommended for use in assessing cervical mobility both for the needs of research and in rehabilitation contexts. The reported findings confirmed good reliability of the CROM goniometer; the authors also assessed error of measurements and reported good test-retest reliability of the device. Therefore we preferred this method of assessment in our research. VAS scores decreased post treatment for the 3 groups. The percentage of change of VAS post treatment of group A, B and C were 86.44 %, 61.19 and 7 respectively. The mean ± SD VAS post treatment of group A, B and C were 0.56 ± 0.32, 1.63 ± 0.71 and 1.1 ± 0.51 respectively. There was a highly significant difference in the VAS between the three groups post treatment (p = 0.0001) (Table 5, figure 36).

The mean difference between group A and B was -1.07. There was a highly significant decrease in VAS of the group A compared with that of group B post treatment (p = 0.0001). The mean difference between group A and C was -0.54. There was a significant decrease in VAS of the group A compared with that of group C post treatment (p = 0.02). The mean difference between group B and C was 0.53. There was a significant decrease in VAS of group C compared with group B post treatment (p = 0.02).

Roig-Maimo et al. (2006), mentioned that neck pain is one of the most important musculoskeletal conditions in prevalence and years lived with disability, as it becomes chronic in 30–50% of cases. The results of the present study were in agreement with Miernik et al. (2012), who mentioned that therapeutic ultrasound is a noninvasive modality widely utilized in the management of musculoskeletal disorders. Therapeutic ultrasound is frequently used in the treatment of neck pain and is often combined with other physiotherapeutic modalities. It does seem that ultrasound may be considered as part of a physical modality treatment plan that may be potentially helpful for short-term pain relief; however, it is undetermined which modality may be superior. In both pain syndromes, further trials are needed to define the true effect of low-intensity ultrasound therapy for axial back pain**.**

Furthermore, the work by Roig-Maimó et al. (2016), and others documented that the common treatment of neck pain includes conservative and pharmacological interventions. Conservative treatments often include therapeutic exercise, with the aim of improve mobility, pain, function and quality of life. Therapeutic exercise, usually supervised by a physiotherapist, includes mobility, strengthening, endurance and motor control exercises**.** However, several authors have advised against applying cervical spine mobilization techniques to patients who demonstrate either normal or excessive mobility of the cervical spine, which may include some patients with cervicobrachial syndrome as mentioned by Wong et al. (2016).

Physiotherapy techniques involving manual therapy, active and passive stretching, strengthening of involved muscles, and postural exercises seem to be effective for TMD treatment. According to a systematic review, manual therapy has been applied directly on TMJ structures, indirectly on the cervical or thoracic spine, or on both regions or structures when composing manual therapy protocols. Calixtre et al. (2015), stated that therapeutic approaches using manual therapy and exercises on the cervical spine have shown benefits for pain, maximum mouth opening (MMO), and pressure pain thresholds (PPTs). However, studies examining physical therapy interventions are still required to strengthen the evidence of their effect on complementing TMD treatment.

The mean ± SD flexion ROM post treatment of group A, B and C were 47.33 ± 4.3, 42.67 ± 3.73 and 37.86 ± 4.51 degrees respectively. The percentage of change of flexion ROM post treatment of group A, B and C were 38.68 %, 25.5 % and 10.06 % respectively. There was a highly significant difference in the flexion ROM between the three groups post treatment ($p = 0.0001$).

The mean difference between group A and B was 4.66 degrees. There was a significant increase in flexion ROM of the group A compared with that of group B post treatment ($p = 0.01$). The mean difference between group A and C was 9.47 degrees. There was a highly significant increase in flexion ROM of the group A compared with that of group C post treatment ($p = 0.0001$). The mean difference between group B and C was 4.81 degrees. There was a highly significant increase in flexion ROM of group B compared with group C post treatment ($p = 0.009$).

The mean ± SD extension ROM post treatment of group A, B and C were 55.53 ± 3.18, 51.26 ± 3.32 and 42.53 ± 5.39 degrees respectively. The percentage of change of extension ROM post treatment of group A, B and C were 53.40 %, 46.75 % and 19.70 % respectively. There was a highly significant difference in the extension ROM between the three groups post treatment ($p = 0.0001$).

The mean difference between group A and B was 4.27 degrees. There was a significant increase in extension ROM of the group A compared with that of group B post treatment ($p = 0.01$). The mean difference between group A and C was 13 degrees. There was a highly significant increase in extension ROM of the group A compared with that of group C post treatment ($p = 0.0001$). The mean difference between group B and C was 8.73 degrees. There was a highly significant increase in extension ROM of group B compared with group C post treatment ($p = 0.0001$). The percentage of change of right bending ROM post treatment of group A, B and C were 40.02 %, 35.98 % and 21.44 % respectively. The mean ± SD right bending ROM post treatment of group A, B and C were 45.73 ± 2.18, 42.33 ± 2.35 and 39.26 ± 3.17 degrees respectively. There was a highly significant difference in the right bending ROM between the three groups post treatment ($p = 0.0001$).

The mean difference between group A and B was 3.4 degrees. There was a highly significant increase in right bending ROM of the group A compared with that of group B post treatment (p = 0.003). The mean difference between group A and C was 6.47 degrees. There was a highly significant increase in right bending ROM of the group A compared with that of group C post treatment (p = 0.0001). The mean difference between group B and C was 3.07 degrees. There was a highly significant increase in right bending ROM of group B compared with group C post treatment (p = 0.007).

The percentage of change of left bending ROM post treatment of group A, B and C were 37.51 %, 28.70 % and 22.48 % respectively. The mean ± SD left bending ROM post treatment of group A, B and C were 45.46 ± 2.38, 41.26 ± 2.63 and 38.46 ± 1.84 degrees respectively. There was a highly significant difference in the left bending ROM between the three groups post treatment (p = 0.0001).

The mean difference between group A and B was 4.2 degrees. There was a highly significant increase in left bending ROM of the group A compared with that of group B post treatment (p = 0.0001). The mean difference between group A and C was 7 degrees. There was a highly significant increase in left bending ROM of the group A compared with that of group C post treatment (p = 0.0001). The mean difference between group B and C was 2.8 degrees. There was a highly significant increase in left bending ROM of group B compared with group C post treatment (p = 0.005).

The percentage of change of right rotation ROM post treatment of group A, B and C were 48.91 %, 39.04 % and 23.15 % respectively. The mean ± SD right rotation ROM post treatment of group A, B and C were 72.86 ± 3.31, 68.13 ± 3.94 and 63.46 ± 4.76 degrees respectively. There was a highly significant difference in the right rotation ROM between the three groups post treatment (p = 0.0001).

The mean difference between group A and B was 4.73 degrees. There was a highly significant increase in right rotation ROM of the group A compared with that of group B post treatment (p = 0.007). The mean difference between group A and C was 9.4 degrees. There was a highly significant increase in right rotation ROM of the group A compared with that of group C post treatment (p = 0.0001). The mean difference between group B and C was 4.67 degrees. There was a highly significant increase in right rotation ROM of group B compared with group C post treatment (p = 0.008).

The percentage of change of left rotation ROM post treatment of group A, B and C were 50 %, 36.53% and 23.48 % respectively. The mean ± SD left rotation ROM post treatment of group A, B and C were 73.8 ± 3.56, 67.8 ± 3.8 and 62.8 ± 5 degrees respectively. There was a highly significant difference in the left rotation ROM between the three groups post treatment (p = 0.0001).

The mean difference between group A and B was 6 degrees. There was a highly significant increase in left rotation ROM of the group A compared with that of group B post treatment (p = 0.001). The mean difference between group A and C was 11 degrees. There was a highly significant increase in left rotation ROM of the group A compared with that of group C post treatment (p = 0.0001). The mean difference between group B and C was 5 degrees. There was a highly significant increase in left rotation ROM of group B compared with group C post treatment (p

= 0.006).

Patient-specific mobility therapy for TMJ, neck, and shoulder dysfunction can restore range of motion (ROM) and overcome functional limitations of the temporomandibular joint (TMJ), neck, and shoulder. Cervical manual therapy or orofacial manual therapy show significant reduction in all aspects of cervical impairment after the treatment period. Nicolakis et al. (2001), stated that mobility of the upper cervical spine and muscle performance of the deep flexors improve cervical ROM and decrease disability and pain.

Some authors have suggested that patients with neck and arm pain should be treated more expeditiously in order to avoid the further negative impact on mental health status associated with chronic symptoms. Shacklock (2005), agreed that neck and arm pain may be associated with several factors including cervical disc disease, osteophyte formation, neural tissue mechanical sensitivity, and soft tissue dysfunction. Neural tissue mechanosensitivity is a condition where there is an elevated painful response (hyperalgesia) to mechanical stimuli, i.e. changes in tension and/or compression of the neural tissues.

Daffner et al. (2003), said that mechanical sensitivity of the neural structures of the upper limb may be related to impaired movement of the nerves as they glide past adjacent structures such as joints, discs, ligaments, muscles, and other soft tissue structures such as the intermuscular septum. For example, patients with non-specific arm pain and carpal tunnel syndrome demonstrate decreased movement of the median nerve at the wrist where it travels past the carpal bones and flexor retinaculum.

It has been suggested that neural mobilization, a treatment approach focusing on facilitating movement of the nerve and surrounding structures, may be beneficial for those who present with cervicobrachial syndrome. The goal of interventions is either to encourage gliding of the nerve by controlled angular movements or to allow more space for the nerve to move by improving mobility of the structures that surround the nerve (the neural container). An example of such an intervention includes the cervical lateral glide mobilization with the involved upper extremity placed in a position designed to take up the slack in the brachial plexus as mentioned by Shacklock (2005). However, several authors have advised against applying cervical spine mobilization techniques to patients who demonstrate either normal or excessive mobility of the cervical spine, which may include some patients with cervicobrachial syndrome.

Daffner et al. (2003), mentioned that hypermobility is a frequent finding in patients with whiplash-associated disorder, a group who commonly reports neck and arm pain. Furthermore, joint mobilization techniques may be contra-indicated in those who have recently undergone cervical surgery. For these patients, interventions other than cervical joint mobilization may be indicated.

Just as the bony structures may restrict movement of the neural tissues, restriction of the surrounding soft tissue may also impair movement of the nerve and compress the nerves as they course through the neural container. Wong et al. (2016), said that patients with decreased upper limb neural extensibility, as indicated by decreased range in the upper limb neurodynamic test (ULNT), demonstrated a reduced amount of length of the upper trapezii compared to those with greater extensibility.

Capó-Juan (2015), hypothesized that reduced sliding of the median nerve observed in patients with whiplash injury or non-specific arm pain (NSAP) may be related to shortening of the scalene muscle which may elevate the first rib and restrict sliding of the medial cord of the brachial plexus.

Wong et al. (2016), asserted that dysfunction of the soft tissue structures of the upper quarter (muscle and connective tissue) may also provide nociceptive input to the nervous system, contributing to the pain perceived by the patient. Tenderness on palpation, shortened length, and hyperirritable tender points within a palpable taut band of the upper quarter soft tissues are common findings in patients with neck pain.

There is preliminary evidence that soft tissue techniques may be beneficial for patients with carpal tunnel syndrome and with cervical radiculopathy. Burke (2000), investigated the effects of two different soft tissue mobilization (STM) techniques designed to address soft tissue restrictions in the forearm and hand of patients with carpal tunnel syndrome. Although clinical improvements were not different between them, both manually applied and instrument assisted STM techniques improved pain, range of motion (ROM), nerve conduction latencies, and function. De Koning (2008), recently reported clinically important reduction in hand pain in a case series of patients with carpal tunnel syndrome after a single application of STM followed by manual nerve sliders directed at the median nerve.

Both STM techniques and therapeutic ultrasound (US) are used in the management of upper quadrant conditions. A recent systematic review concluded that there is moderate evidence for the use of US in the management of carpal tunnel syndrome, a condition of localized neural mechanosensitivity. Animal research suggests that US may influence spinal nociceptive processing in models of peripheral inflammation as asserted by Daffner et al. (2003).

Wong et al. (2016), agreed that patients with neck and arm pain demonstrated greater improvements in ULNT ROM, GROC, and PSFS following a single session of STM compared to therapeutic US at both immediate- and short-term follow-up. These preliminary results suggest that STM may be a valuable intervention in the management of patients with neck and arm pain. Future research should investigate the effects of STM within multimodal management for neck and arm pain with evidence of neural mechanical sensitivity on measures such as long-term clinical outcome and cost of care.

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It has been suggested by Perinetti (2009), that neural mobilization, a treatment approach focusing on facilitating movement of the nerve and surrounding structures, may be beneficial for those who present with cervicobrachial syndrome. The goal of interventions is either to encourage gliding of the nerve by controlled angular movements or to allow more space for the nerve to move by improving mobility of the structures that surround the nerve (the neural container). An example of such an intervention includes the cervical lateral glide mobilization with the involved upper extremity placed in a position designed to take up the slack in the brachial plexus.

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Miernik et al. (2012), reported that therapeutic ultrasound is a noninvasive modality widely utilized in the management of musculoskeletal disorders. Therapeutic ultrasound is frequently used in the treatment of neck pain and is often combined with other physiotherapeutic modalities. It does seem that ultrasound may be considered as part of a physical modality treatment plan that may be potentially helpful for short-term pain relief; however, it is undetermined which modality may be superior. In both pain syndromes, further trials are needed to define the true effect of low-intensity ultrasound therapy for axial back pain.

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Watson (2008), suggested that during the inflammatory phase, US has a stimulating effect on the mast cells, platelets, white cells with phagocytic roles and the macrophages. For example, the application of ultrasound induces the degranulation of mast cells, causing the release of arachidonic acid which itself is a precursor for the synthesis of prostaglandins and leukotreine – which act as inflammatory mediators. By increasing the activity of these cells, the overall influence of therapeutic US is certainly pro-inflammatory rather than anti-inflammatory. The benefit of this mode of action is not to 'increase' the inflammatory response as such (though if applied with too greater intensity at this stage, it is a possible outcome, but rather to act as an 'inflammatory opimiser' argued the scientific basis for this issue coherently**.**

Many papers have concentrated on the thermal effectiveness of ultrasound, and much as it can be used effectively in this way when an appropriate dose is selected (continuous mode > 0.5 W cm-2), the focus of this paper will be on the non thermal effects. Both Ter Haar (1999), have provided some useful review material with regards the thermal effects of ultrasound. Comparative studies on the thermal effects of ultrasound have been reported by several authors with some interesting, and potentially useful results. Further work continues in our research centre with a comparison of contact heating and longwave ultrasound and comparison of different US regimes combined with US (Aldridge and Watson – in preparation).

It is too simplistic to assume that with a particular treatment application there will either be thermal or non-thermal effects. It is almost inevitable that both will occur, but it is furthermore reasonable to argue that the dominant effect will be influenced by treatment parameters, especially the mode of application i.e. pulsed or continuous. Baker et al. (2001), have argued the scientific basis for this issue coherently.

Sahlani et al. (2016), suggests that the desirable effects of therapeutic heat can be produced by US. It can be used to selectively raise the temperature of particular tissues due to its mode of action. Among the more effectively heated tissues are periosteum, collagenous tissues (ligament, tendon & fascia) & fibrotic muscle. If the temperature of the damaged tissues is raised to 40-45°C, then a hyperaemia will result, the effect of which will be therapeutic. In addition, temperatures in this range are also thought to help in initiating the resolution of chronic inflammatory states. Most authorities currently attribute a greater importance to the non-thermal effects of US as a result of several investigative trials in the last 15 years or so.

Wong et al. (2007), reported that therapeutic ultrasound (UZ) is a physical modality that has the broadest application and is commonly used in clinical practice. In the last decade its use has changed. Earlier, it was primarily used for its thermal effect, and is now it increasingly used for nonthermal effects, especially in the reconstruction of soft tissue, wound healing and the healing of bone fractures**.**

Wong et al. (2007), also mentioned that thermal effects are attributed to the continuous UZ and nonthermal effects to the pulsed UZ of small intensity (LIPUS Low-Intensity Pulsed Ultrasound). In addition to these biophysical effects of therapeutic UZ, his secondary physiological effects must not be forgotten, among which is the first analgesic effect, followed by a spasmolytic, anti-inflammatory, simpaticolitic , tissue regulation and trophic effects, improving microcirculation, increasing permeability of the cell membrane, increasing the biosynthesis of proteins , the regulation of muscle tone and improving the cell metabolism.

Chipchase et al. (2007), mentioned that the greatest analgesic effect is attributed to the thermal effect of ultrasound because it leads to increased metabolic activity in the tissue, improving circulation and relaxation of rigid structure of the soft tissues, especially in degenerative musculoskeletal system.

Furthermore, the statistical analysis of the subject physical characteristics would suggest that the randomization technique used adequately nullified any potential differences that may have been apparent between the groups tested; however, this could not be stated with complete confidence. Randomization minimized the differences noted between the groups but did not minimize differences that might be observable within groups or individual difference that can affect the results. There may be subgroups of individuals that behaved differently than the group as a whole confounding results. The sample size in this study was insufficient to perform a secondary analysis of potential subgroups. On the otherside, there were no side effects reported.

Conclusion

It can be concluded that manual therapy combined ultrasound is effective in decreasing cervical pain and improving neck ROM after maxillofacial surgeries.

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