EFFECT OF ELECTROMYOGRAPHY BIOFEEDBACK CERVICAL TRACTION ON PATIENTS WITH CERVICAL RADICULOPATHY

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ABSTRACT

Background: Cervical radiculopathy is a problem that frequently encountered by physical therapists. Cervical traction is frequently used in patients with cervical radiculopathy. It is administered in a variety of techniques and is widely accepted therapeutic modality for treatment of cervical pain and cervical radicular syndromes.

Purpose of Study: This study was designed to investigate the effects of EMG biofeedback cervical traction on myoelectric activity of cervical para spinal muscles with CR.

Methods: : Sixty patients with CR 42 males and 18 Female were divided randomly into three equal groups. Group A received physical therapy program in the form of TENS and U.S. Group B received the same program as group A adding conventional traction, group C received the same program as group B adding EMG biofeedback. All groups received 3 sessions/ week for 4 weeks. Visual analogue scale (VAS) and myoelectric activity at C¬5-C6 para spinal level were used to evaluate patients at two intervals (pre-treatment and Post-treatment).

Results: Statistical analysis showed that there was a significant change within groups of VAS, CROM and myoelectric activity at groups A, B and C as (p < 0.05). Between group analysis there was no significant change in pre treatment values in all variables as (p > 0.05) while post-treatment, there was a significant changes in all variables as (p < 0.05).

Conclusion: EMG biofeedback to the conventional traction for C5-C6 cervical disc bulge at C5-C6 level can yield more improvement in the neck pain, cervical range of motion, and myoelectric activity of cervical para spinal muscles compared with conventional traction only.

Keywords: EMC Biofeedback, cervical Radiculopathy, cervical traction.

I. INTRODUCTION

Cervical Radiculopathy (CR) is a disorder of Peripheral nervous system where the resulting cervical nerve root (CNR) produces chronic pain and disability (Sava et al., 2020). It is mainly caused by a disc herniation or space occupying lesion that can result in CNR inflammation, impingement, or both (Woods and Hilibrand 2015). This disorder can produce sensory and motor deficits in the involved limb, including parasthesia, anasthesia, muscle weakness, along with a neuropathic pain usually described as a " Burning" or” shooting” pain (Broekema et al., 2017).

CR has an annual incidence estimated at 83 cases per 100 000 with an increase in prevalence noted in the fifth decade of life (Thoomes et al., 2018). In recent years, the incidence of CR increases gradually and presents a younger trend; its disorder seriously impacts the life quality of patients (Xiao et al., 2021).

Optimal treatment of CR has not been established (Thoomes, 2016; Wainner and Gill, 2020; Wei et al., 2015). Several non- operative treatment approaches have been reported to reduce CR pain and their analgesic effect has been investigated in randomized clinical trials with these in turn being analyzed in systematic reviews (Boyles et al., 2011; Rodine and Vernon, 2012; Zhu et al., 2016).
Biofeedback has been used for more than 50 years in rehabilitation to recover normal movement patterns after injuries. This procedure facilitates the improvement of accuracy during rehabilitation sessions, involves patients in their own rehabilitation tasks and reduces the need to consult the healthcare professional during the programme. Thus, biofeedback can be combined with different physical rehabilitation procedures to improve the efficacy of these methods. One such technique is EMG. While in conventional EMG, there is an electrical stimulation of the muscle of interest guided by an EMG signal, in biofeedback, a patient can self-identify his/her own muscle activity through the conversion of EMG signals to visual and/or auditory signals. Therefore, patients can control and regulate the muscle activity themselves (Gamez et al., 2019).

Traditionally EMG biofeedback has demonstrated its usefulness in improving muscle relaxation of cervical paraspinal muscles during cervical traction in patients with cervical radioculopathy (Atteya 2004).

II. AIM OF THE WORK
To compare the effect of cervical traction modality with and without electromyography (EMG) biofeedback for the neck muscles in patients with cervical radiculopathy.

III. PATIENTS AND METHODS
The Randomized controlled trial was conducted from September 2018 to August 2021 at outpatient clinic and laboratory of EMG at faculty of physical therapy, Cairo University. The study proposal was approved by the Research Ethical Committee of the faculty of physical therapy, Cairo University. Sixty patients of both sexes (42 males, 18 females), their age ranged from 25-50 years were divided into 3 equal groups: control group A conventional traction group B and EMG Biofeedback traction group C.

Inclusion criteria
The patients participated in this study according to the following criteria: Patients were diagnosed by the neurologist as cervical radiculopathy secondary to unilateral C5-C6 disc bulge. Duration of symptoms was more than three months. Patients' medications were in the form of analgesics and NSAIDs. The patients stopped the medications before included in the study by one week. Limitation of cervical range of motion due to neck pain and muscle spasm.

Exclusion Criteria
Thoracic outlet syndrome or cervical rib. Systematic disease as diabetes mellitus or rheumatoid arthritis. Multilevel or bilateral CR. Advanced generative changes. Manifestations of central cervical disc herniation (as there is clinical myelopathy). Vertebrobasilar insufficiency. History of whiplash injury. History of previous cervical spine surgery, fractures or tumors.

The three groups received the traditional physical therapy program.

With adding conventional traction and biofeedback traction to group B and group C respectively. All patients received 3 sessions/week for 4 weeks.

Assessment procedures.
VAS was used to determine the Intensity of pain. The patient was instructed to place a mark on line from 0 to 10 to indicate the intensity of pain.
The myoelectric activity was measured by using EMG device (Neuro-EMG-Micro-Neurosoft, Ivanovo, Russia). The patient was instructed to sit in a relaxed position. The surface recording electrode was applied at C3-C6 para spinal level the reference electrode was applied 2cm lateral to recording one while the ground electrode was applied on the wrist joint. While the patient was trying to relax as much as he/she can, the amplitude of myoelectric activity was recorded.

**Treatment procedures**

TENs device (gyman uniphy, Duo 200) was used to the whole patients. Type of wave was asymmetric with 100hz, electrodes were placed on the cervical region at para spinal level for 15 min.

US device (gymna uniphy, pluson 200) was used to the whole patients. The treatment was cervical out with continuous mode, 1 Hz, intensity 0.5 w/cm², and applied by circular moving technique for 5min.

The traction device (Hantleigh Akron model ATpg Traction unit, made in England) used for patients of group B and C. EMG biofeedback device (neurotrach simplex single channel with wireless software kit model ESS102, made in United Kingdom) used during traction for patients of group C.

The patients of group B was instructed to sit upright, relax their shoulders, rest his hands on his thighs, with hips and knees flexed at 90°.

The head halter was applied to the patient head. The traction force was adjusted at ¼ of total body weight at pull phase for 10sec, and 1/8 of total body weight at release phase for 5sec. The whole time was 20min for group C, EMG biofeedback was added to the patients. The recording electrode was 2cm lateral to the recording one, while ground electrode was at wrist joint. The patient was asked to relax the neck muscles as much as he/she can while watching the visual signals and hearing the auditory signals produced from EMG biofeedback device, the more relaxation, the lower visual and auditory signals.

**Data collection**

Data were screened, for normality assumption test and homogeneity of variance. Normality test of data using Shapiro-Wilk test was used, that reflect the data was normally distributed (P>0.05) after removal outliers that detected by box and whiskers plots. Additionally, Levene's test for testing the homogeneity of variance revealed that there was no significant difference (P>0.05). So, the data are normally distributed and parametric analysis is done.

**Statistical analysis**

The statistical analysis was conducted by using statistical SPSS Package program version 25 for Windows (SPSS, Inc., Chicago, IL). Data are expressed as mean and standard deviation for age, weight, height, BMI, VAS, EMG, flexion, extension, right lateral bending, left lateral bending, right rotation, and left rotation variables. Chi-square test used to compare gender among 3 groups. Multivariate analysis of variance (MANOVA) used to compare the tested major variables of interest at different tested groups and measuring periods. Mixed design 3 x 2 MANOVA-test was used, the first independent variable (between subject factors) was the tested group with 3 levels (group A, group B, and group C). The second independent variable (within subject factor) was measuring periods with 2 levels (before and after treatment). Bonferroni correction test was used to compare between pairwise within and between groups of the tested variables which P-value was significant from MANOVA test. All statistical analyses were significant at probability (P ≤ 0.05).

**IV. RESULTS**

In the current study, a total of 60 patients participated and they were randomly distributed into 3 groups (20 patients/group). No significant differences in age (P=0.963; P>0.05), weight (P=0.992; P>0.05), height (P=0.990; P>0.05), BMI (P=0.964; P>0.05), and gender (P=0.189; P>0.05) among groups A, B, and C (Table 1).

<table>
<thead>
<tr>
<th>Items</th>
<th>Group A (n=20)</th>
<th>Group B (n=20)</th>
<th>Group C (n=20)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (year)</td>
<td>42.27 ±5.91</td>
<td>42.04 ±6.49</td>
<td>42.56 ±5.62</td>
<td>0.963</td>
</tr>
</tbody>
</table>

Table 1: Comparison of general characteristics among 3 groups
Quantitative data are expressed as mean ± standard deviation (SD) and compared statistically by ANOVA test

Qualitative data are expressed as number (percentage) and compared statistically by Chi-square test

P-value: probability value  P-value > 0.05: non-significant

The statistical analysis using 3x2 mixed design MANOVA (Table 2) indicated that there was significant difference (F-value=41.092; P=0.0001; P<0.05) of the tested dependent variables (VAS, EMG, flexion, extension, right lateral bending, left lateral bending, right rotation and left rotation). In addition, there was significant difference (F-value=843.192; P=0.0001; P<0.05) of the measuring periods (the second independent variable) on the tested dependent variables. Moreover, the interaction between the two independent variables (Groups x Periods) was significant (F-value=72.716; P=0.0001; P<0.05), which indicates that the effect of the tested group (first independent variable) on the dependent variables was influenced by the measuring periods (second independent variable).

**Table 2: Main effects of independent variables by 3 x 2 MANOVA test for dependent measuring variables.**

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Wilk’s Lambda value</th>
<th>F-value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groups effect</td>
<td>0.060</td>
<td>41.092</td>
<td>0.0001*</td>
</tr>
<tr>
<td>Period effect</td>
<td>0.016</td>
<td>843.192</td>
<td>0.0001*</td>
</tr>
<tr>
<td>Groups x period interaction effect</td>
<td>0.024</td>
<td>72.716</td>
<td>0.0001*</td>
</tr>
</tbody>
</table>

P-value: probability value  * Significant (P-value < 0.05)

Multiple pairwise comparison tests (time effect) for outcomes variables within each group (Table 3) revealed there was significantly decreased (P<0.05) in VAS and EMG activity. This significant decrease VAS and EMG activity after-treatment is favor of biofeedback group than conventional group, and control group. Moreover, biofeedback group (group C) improved higher VAS and EMG than conventional group and control group.

Multiple pairwise comparison tests (treatment effect) for outcomes variables among groups A, B, and C (Table 3) showed no significant differences (P>0.05) in VAS and EMG before-treatment. In contrast, there were significant difference (P<0.05) among control group, conventional group, and biofeedback group after treatment in VAS, EMG, flexion, extension, right lateral bending, left lateral bending, right rotation, and left rotation.

**Table 3: Within and between group comparison for outcomes variables**

<table>
<thead>
<tr>
<th>Items</th>
<th>Items</th>
<th>Group A (n=20)</th>
<th>Group B (n=20)</th>
<th>Group C (n=20)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Items</td>
<td>Group</td>
<td>Mean ±SD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VAS</td>
<td>Before-treatment</td>
<td>7.54 ±0.91</td>
<td>7.91 ±0.55</td>
<td>7.68 ±0.79</td>
<td>0.154</td>
</tr>
<tr>
<td></td>
<td>After-treatment</td>
<td>4.22 ±0.45</td>
<td>4.02 ±0.50</td>
<td>2.32 ±0.23</td>
<td>0.0001*</td>
</tr>
<tr>
<td></td>
<td>Mean difference</td>
<td>3.32</td>
<td>3.89</td>
<td>5.36</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Improvement %</td>
<td>44.03%</td>
<td>49.18%</td>
<td>69.79%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P-value</td>
<td>0.0001*</td>
<td>0.0001*</td>
<td>0.0001*</td>
<td></td>
</tr>
<tr>
<td>EMG activity</td>
<td>Before-treatment</td>
<td>6.64 ±0.80</td>
<td>6.82 ±0.48</td>
<td>6.68 ±0.69</td>
<td>0.523</td>
</tr>
<tr>
<td></td>
<td>After-treatment</td>
<td>3.54 ±0.37</td>
<td>3.43 ±0.43</td>
<td>1.73 ±0.17</td>
<td>0.0001*</td>
</tr>
<tr>
<td></td>
<td>Mean difference</td>
<td>3.10</td>
<td>3.39</td>
<td>4.95</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Improvement %</td>
<td>46.69%</td>
<td>49.71%</td>
<td>74.10%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P-value</td>
<td>0.0001*</td>
<td>0.0001*</td>
<td>0.0001*</td>
<td></td>
</tr>
</tbody>
</table>

Group A: control group; Group B: Conventional group; Group C: Biofeedback group

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Data are expressed as mean ± standard deviation (SD)

P-value: probability value * Significant (P<0.05)

Bonferroni test and mean difference for VAS and EMG after-treatment between pairwise of the groups (Table 4). There were significant differences (P<0.05) in VAS, EMG, flexion, extension, right lateral bending, left lateral bending, right rotation, and left rotation after treatment between group A versus group C and group B versus group C, but no significant difference (P>0.05) between group A versus group B. Bonferroni test and mean differences between groups showed that the biofeedback group (Group C) gave the highest response of VAS, EMG, flexion, extension, right lateral bending, left lateral bending, right rotation, and left rotation.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Items</th>
<th>Group A vs. Group B</th>
<th>Group A vs. Group C</th>
<th>Group B vs. Group C</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAS</td>
<td>Mean difference</td>
<td>0.21</td>
<td>1.90</td>
<td>1.70</td>
</tr>
<tr>
<td></td>
<td>95% CI</td>
<td>-0.27 – 0.68</td>
<td>1.42 – 2.38</td>
<td>1.22 – 2.17</td>
</tr>
<tr>
<td></td>
<td>P-value</td>
<td>0.089</td>
<td>0.0001*</td>
<td>0.0001*</td>
</tr>
<tr>
<td>EMG activity</td>
<td>Mean difference</td>
<td>0.11</td>
<td>1.80</td>
<td>1.70</td>
</tr>
<tr>
<td></td>
<td>95% CI</td>
<td>-0.30 – 0.51</td>
<td>1.38 – 2.21</td>
<td>1.28 – 2.10</td>
</tr>
<tr>
<td></td>
<td>P-value</td>
<td>1.000</td>
<td>0.0001*</td>
<td>0.0001*</td>
</tr>
</tbody>
</table>

Group A: control group; Group B: Conventional group; Group C: Biofeedback group

CI: confidence interval  
P-value: probability value * Significant (P<0.05)

V. DISCUSSION

The current study was conducted to determine the effects of EMG biofeedback along with cervical traction on neck pain and myoelectric activity of cervical Paraspinal muscles in CR Patients.

Sixty patients of both gender with C5-C6 CR were divided into three equal groups, group A control group, group B conventional traction group and group C EMG Biofeedback group twenty per each group the three groups received traditional physical therapy program for neck pain. Additionally group B, received conventional cervical traction and group C received EMG biofeedback cervical traction.

The variables that measured and statistically analyzed to show the results of this study were: pain determined by VAS and myoelectric activity of cervical para spinal muscles at C5-C6 level measured by EMG device.

The results showed that, there was significant improvement in neck pain and myoelectric activity of cervical paraspinal muscles in the three groups post treatment compared with that of pre-treatment with more significant difference in group C than group B and A, while there was no significant difference between group A and B.

The improvement in neck pain and myoelectric activity of cervical para spinal muscles in the three groups may be returned to the possible therapeutic effects of various therapeutic modalities which used in the conventional program that was applied for three groups. This agree with the study conducted by Diab and Moustafa (2012) that reported that there was improvement in pain level in patients with CR treated with conventional therapy.

Also, Matijević-Mikelić et al. (2012) reported that in their study in which a group of patients suffering from neck pain without the exclusion criteria for discogenic neck pain received TENS, therapeutic ultrasound, and isometric exercises for the cervical spine, there were functioning improvement in some aspects such as reading, car driving and work.

The results of the current study showed that there were no significant differences between group A who received physical therapy program only and group B who received physical therapy program with conventional traction which agreed with the study that was conducted by Pinar et al. (2008) to examine the additive effects of conventional traction on standard physical therapy modalities in patients with chronic pain. It was found that traction therapy in addition to physical therapy modalities was not more favorable than standard physical therapy modalities.
Also, in another study that was conducted to examine the effect of cervical traction in decreasing neck and arm pain for patients with CR, with CR, Young et al. (2009) compared between intermittent cervical traction and traditional exercises. In their study, the patients were divided into two different groups: Intermittent cervical traction plus traditional exercises group and sham intermittent cervical traction plus traditional exercises group. It was concluded that there was no statistically significant difference the outcome measures between both groups at two weeks follow up or four weeks follow up.

In general, when cervical radiculopathy was caused by disc herniation, the nucleus pulposus compresses the nerve roots, which lead to an entrapment of the intervertebral foramine. As a result, the nerves are irritated producing a reflex response of the cervical muscles which may trigger muscle contraction and spasm leading to neck pain with limitation of cervical ROM (Kang and Park, 2015).

The contracted muscles increase pressure on the intervertebral discs and compression on the nerve roots, which may share in creating a vicious circle of aggravating pain (Kim, 2006; Andersson et al., 1983).

Ding et al. (2021) added that, after the occurrence of CR, a large number inflammatory factors are released from the damaged tissues, which stimulate the nerve root causing radicular pain and guarding cervical muscle spasm. Other pro-inflammatory cytokines are secreted to mediate inflammation that produce a vicious circle of inflammation.

Murphy (1991) declared that the simultaneous realization of an increase in intervertebral foraminal areas through spinal elongation and muscle relaxation during traction might interrupt the cycle of neck pain. From this prospective, Kang and Park (2015) reported that when a cervical traction force was applied from vertical position, spinal elongation may be occurred. However, the accompaniment of muscle contraction and spasm during this process may offset the traction effect.

Therefore, adding EMG Biofeedback to cervical traction may be considered as further explanation for more significant improvement of group C than group B and group A. As EMG biofeedback assisted patients to give more relaxation during traction via visual and auditory signals (Cikajlo el al., 2021).

In agreement with the current study, Lee et al. (1996) reported that EMG biofeedback cervical traction is more effective than conventional traction in patients with CR in their study twenty four subjects with C5-6 CR were divided into two equal groups, the first group received conventional traction while the second group received EMG biofeedback traction.

The results of this study showed that, there was significant improvement in myoelectric activity of cervical para spinal muscles in the group who received EMG biofeedback cervical traction. As myoelectric activity values were significantly decreased at EMG biofeedback traction group more than the conventional traction group (Lee et al., 1996).

In another study that conducted on patients with CR in which, the patients were divided to two equal groups the first group received conventional traction while the second group received EMG biofeedback traction. The result of the study showed that the myoelectric activity of C5-C6 para spinal muscles was significantly improved in the group who received EMG biofeedback traction more than the group who received conventional traction only. Also the traction force was raised from start to optimum at two weeks in the group who received EMG biofeedback traction while the traction force was raised at four weeks in the other group (Atteya, 2004).

It was reported that there was decrease of EMG activity during the pull phase as well as after traction in the neck muscles tension when EMG biofeedback used during traction. As a result (Atteya, 2004), declared that through the adaptive EMG biofeedback traction, patients could be in a more relaxed state during traction. In addition, the cumulative effects in the decrease of myoelectric activity where possibly related to reflex inhibition of muscle contraction or spasm by autogenic inhibition.

The success of traction depends on the proper stretch and elongation of cervical structures. It was concluded that involuntary muscle contraction and guarding muscle spasm could be avoided during continuous EMG monitoring or biofeedback which agreed with the results of the current study (Atteya, 2004).
In contrast, Kang and Park 2015 in their study that was conducted to analyze the cervical muscles activity at different traction forces of an air-inflatable neck traction device. Eighteen males were put on an air-inflatable neck traction device and the traction forces were 40, 80, and 120 mm Hg. The myoelectric act of splenius capitis and trapezius were measured. The results of this study showed that the myoelectric activity of splenius capitis and trapezius muscles were increased at 80 and 120mm HG while at 40 m Hg there was no change which disagreed with the results of the present study. This was due to a lot of differences between the two studies.

Among these differences, (Kang & Park 2015) used an air-inflatable traction device that was completely different from that was used in the present study which was electronic mechanical intermittent traction device.

Another difference was time periods that outcome measures were collected. (Kang & Park 2015) collected the outcome measures after one session only while in the current study, the outcome measures were collected after twelve sessions.

One of the biggest differences was that the previous study was conducted on eighteen healthy adult males without orthopaedic or neurological disorders in neck or shoulders, while the present study was conducted on mixed CR patients suffering from neck pain and muscle spasms.

VI. CONCLUSION
EMG biofeedback to the conventional traction for C5-C6 cervical disc bulge at C5-C6 level can yield more improvement in the neck pain and myoelectric activity of cervical para spinal muscles compared with conventional traction only.

Conflict of interest: there is no conflict of interest.

REFERENCES