Electromyographic Evaluation of neck Muscle Activity on Postural Changes in Class II Patients with Vertical Growth Pattern Undergoing Twin Block Appliance Therapy - An Observational Study

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Abstract

Introduction: Variations in facial skeletal morphology can influence electromyographic activity in masticatory, neck, and trunk muscles. While twin block appliance therapy has been shown to alter the neuromuscular pattern of the masseter and temporalis muscles, there is a lack of literature on its effects on neck muscles and postural changes in the mandible. This study aims to assess the electromyographic activity of neck muscles before and after twin block appliance therapy in growing patients with Class II malocclusion and hyper-divergent growth patterns.

Methods: A study was conducted on 15 growing patients (aged 9 - 14 years) diagnosed with skeletal Class II malocclusion and hyper-divergent growth patterns, who were undergoing twin block appliance therapy. Bilateral electromyographic activity of the sternocleidomastoid and trapezius muscles was recorded using bipolar surface electrodes. Measurements were taken during postural rest position, maximum voluntary clenching, and neck movements at the initiation of treatment and subsequently at one, three, six, and nine months of twin block appliance therapy.

Results: The changes in electromyographic activity of neck muscles were assessed using analysis of variance and a paired t-test. During the postural rest position and neck movement, the electromyographic activity of the sternocleidomastoid and trapezius muscles showed a tendency to decrease from baseline to the end of treatment; however, these changes were not statistically significant. Additionally, there was a non-significant increase in neck muscle electromyographic activity during maximum voluntary clenching.

Conclusions: Twin block appliance therapy does not significantly impact electromyographic activity of the sternocleidomastoid and trapezius muscles in patients with hyper-divergent Class II malocclusion.

INTRODUCTION

Skeletal Class II malocclusion is defined by sagittal dysplasia resulting from maxillary prognathism, mandibular retrognathism, or a combination of both.[1] This condition involves not only the skeletal structures but also the associated musculature of the craniomandibular complex.[2] Functional appliances, as advocated by Graber, are designed to retrain abnormal muscular patterns, thereby promoting favorable dentofacial growth and development.[3] Additionally, oral splints have demonstrated efficacy in reducing muscle tension within the craniofacial and cervical regions.[4]

Twin Block Appliance (TBA), a widely used myofunctional appliance, facilitates correction of mandibular positioning in growing individuals with Class II malocclusion. Previous studies have confirmed the neuromuscular interrelationship between cranial, craniocervical, and mandibular posture.[5,6] Dysfunction or alterations in muscular attachments within the craniocervical region can contribute to posterior mandibular rotation. Electromyographic (EMG) analyses have revealed neuromuscular adaptations in the masseter and temporalis muscles following TBA intervention.[7]

To date, no studies have evaluated the effects of TBA therapy on the EMG activity of the sternocleidomastoid (SCM) and trapezius muscles. Accordingly, the present study aims to investigate the EMG responses of the SCM and trapezius muscles in hyperdivergent skeletal Class II patients undergoing TBA therapy, during various voluntary functional activities.

METHODS

This prospective observational study was conducted in the Department of Orthodontics at the All India Institute of Medical Sciences (AIIMS), Ansari Nagar, New Delhi, India. The study comprised a single cohort of 15 patients, in whom EMG activity was assessed both before (pre-treatment) and after (post-treatment) TBA. The total study duration was two years, with each participant being followed for nine months. Ethical clearance was obtained from the Institutional Ethics Committee for Postgraduate Research at AIIMS, New Delhi, India (Ref No. IECPG-509/18.10.2018). Written informed consent was obtained from the parents or legal guardians of all participating subjects. Patients aged 9 to 14 years presenting with skeletal Class II Division 1 malocclusion, Point A - Nasion - Point B (ANB) angle ≥ 5°, a Frankfort Mandibular Plane Angle (FMA) between 28° and 35°, and cervical vertebral maturation stages 3 or 4, as defined by Baccetti's classification for identifying optimal treatment timing in growing individuals with functional appliances were included in the study.[8] Exclusion criteria included refusal of consent by parents or legal guardians, the presence of clinical signs or symptoms suggestive of neuromuscular or temporomandibular joint disorders, and a history of previous or ongoing orthodontic treatment. The sample size was determined using the formula: n = 2SD^2 (Zα + Zβ) / d^2, with Zα at a 95% confidence level (1.96) and Zβ at 80% power (0.84). The standard deviation (SD) was 3.20, based on muscle activity in the postural position of the mandible with TBA from a previous study by Aggarwal et al. The mean difference (d) in muscle activity at 0 months and one month in the anterior temporalis was 3.78. Hence, the desired sample size was calculated as 12 after rounding off. Considering an expected dropout rate of 25%, the final recruited sample size was 15 growing patients for the study. Before the initiation of TBA therapy, comprehensive pre-treatment diagnostic records were obtained and analyzed, including intraoral and extraoral photographs, as well as diagnostic dental casts. The TBA was fabricated following Clark's protocol.[9] For patients exhibiting vertical growth patterns, a high-bite design was employed. Bite registration was recorded at 2-3 mm beyond the freeway space, with an average vertical height of 6 mm in the premolar region. The inclined planes of the appliance were constructed at an angle of 70°, and the posterior bite blocks were extended to cover approximately two-thirds of the occlusal surface of the most posteriorly erupted molars. To mitigate the risk of lower incisor proclination during treatment, incisal capping was incorporated (Figure 1).

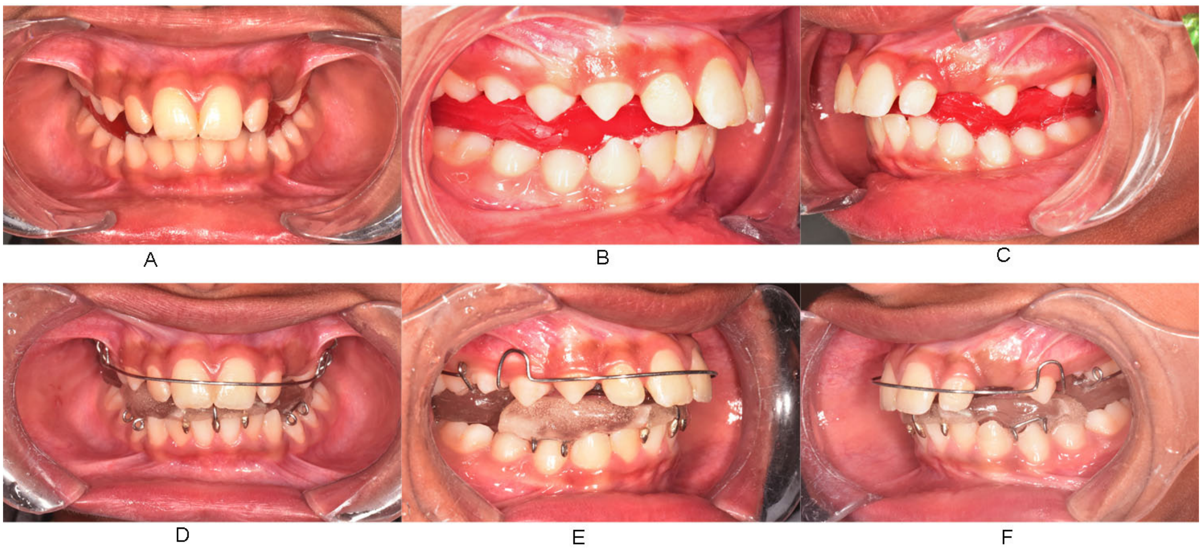

Fig 1: (A-C) - Illustrating intraoral photographs of the bite registration process for the TBA. A - Frontal view, B - Right lateral view, C - Left lateral view. (D-F) - Presenting intraoral photographs of the TBA. D - Frontal view, E - Right lateral view, F - Left lateral view.

All EMG recordings were carried out at the Institute of Pain Research and Transcranial Magnetic Stimulation (TMS) Laboratory, Department of Physiology, AIIMS, New Delhi. Bilateral EMG activity of the sternocleidomastoid and trapezius muscles was recorded using a six-channel BSL Pro system (Model MP30) during various voluntary functional activities, both with and without TBA. Recordings were obtained at five time points: baseline (before initiation of TBA therapy), and subsequently at 1 month, 3 months, 6 months, and 9 months following the commencement of treatment. Before each recording session, a comprehensive explanation of the procedure was provided to both the patient and their attendants. The skin overlying the targeted muscles was thoroughly cleaned using 95% ethanol and allowed to dry. To minimize external electrical interference, the patient was comfortably seated in a shielded room. Electrodes were then positioned parallel to the muscle fibers of the sternocleidomastoid and trapezius muscles, adhering to the atlas of Cram and Kasman protocol.[10] For the placement of electrodes over the sternocleidomastoid muscle, the patient was asked to rotate their head to the opposite side, and the muscle belly on the anterolateral aspect of the neck was palpated. Two active electrodes were placed at half the distance between the mastoid process and the sternal notch, separating 2 cm between them (Figure 2).

Fig 2: Illustrating the precise electrode placement on the sternocleidomastoid muscle.

As for the trapezius muscles, the first electrode was positioned at one cm lateral to the midpoint of the line connecting the acromion process and spinous process of C-7. The second electrode was situated 2 cm lateral to the first electrode (Figure 3).

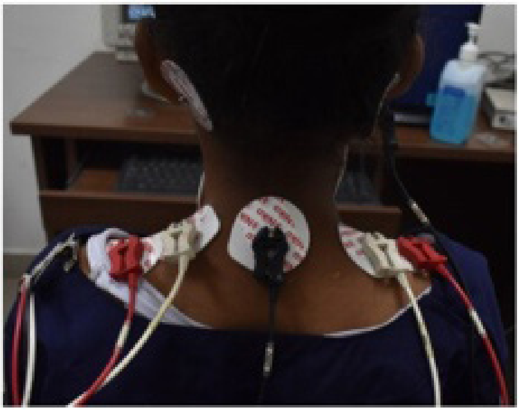

Fig 3: Illustrating the precise electrode placement on the trapezius muscle.

Recordings were obtained at various time points: just before fitting TBA, immediately after appliance delivery, at the end of 1 month, 3 months, 6 months, and 9 months post-appliance delivery. These recordings were taken during rest, maximum voluntary clenching, and side-to-side neck movements. EMG amplitude (peak-to-peak), frequency, and area under the curve (AUC) were measured for both the sternocleidomastoid (Figure 4) and trapezius muscles during the evaluation.

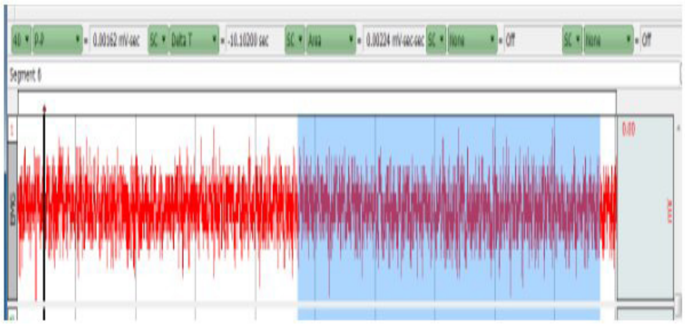

Fig 4: Illustrating the recording of electromyogram (EMG) activity of the sternocleidomastoid muscle.

The data was analyzed using SPSS version 14.0. Quantitative data with a normal distribution were presented as mean ± standard deviation (SD). Nonparametric analysis of variance (ANOVA) using the Friedman test11 was performed to compare the electromyographic (EMG) activity over nine months. An independent t-test was utilized to compare quantitative variables between groups. A P value of less than 0.05 was considered statistically significant.

RESULTS

The EMG activity of the sternocleidomastoid (SCM) muscle during various activities: postural rest position of the mandible, maximum voluntary clenching, and side-to-side neck movement were recorded (Table 1).

Table 1: A comparative analysis of EMG activity in the sternocleidomastoid muscle during various activities, with and without the TBA. (N=15)

Activity	0 month	1 month	3 months	6 months	9 months	P value
PRPWOTB	0.24 ± 0.03 uV	0.05 ± 0.02 uV	0.07 ± 0.02 uV	0.08 ± 0.05 uV	0.17 ± 0.06 uV	0.23
PRPWTB	0.10 ± 0.02 uV	0.07 ± 0.02 uV	0.08 ± 0.03 uV	0.09 ± 0.06 uV	0.09 ± 0.09 uV	0.19
MVCWOTB	0.18 ± 0.03 uV	0.23 ± 0.03 uV	0.28 ± 0.09 uV	0.28 ± 0.09 uV	0.34 ± 0.02 uV	0.09
MVCWTB	0.29 ± 0.04 uV	0.31 ± 0.05 uV	0.31 ± 0.05 uV	0.40 ± 0.04 uV	0.43 ± 0.03 uV	0.06
NMWOTB	0.63 ± 0.01 uV	0.57 ± 0.04 uV	0.58 ± 0.06 uV	0.60 ± 0.04 uV	0.57 ± 0.01 uV	0.21
NMWTB	0.44 ± 0.02 uV	0.43 ± 0.05 uV	0.42 ± 0.04 uV	0.42 ± 0.03 uV	0.41 ± 0.04 uV	0.1

PRPWOTB - Postural rest position without TBA, PRPWTB - Postural rest position with TBA, MVCWOTB - Maximum voluntary clenching without TBA, MVCWTB - Maximum voluntary clenching with TBA, NMWOTB - Neck movement without TBA, NMWTB - Neck movement with TBA

During the postural rest position, the SCM activity decreased immediately from 0.24 ± 0.03 uV to 0.10 ± 0.02 uV with the insertion of the TBA. Subsequently, on follow-up, the SCM activity continued to decrease from 0 months to 9 months, both without (0.17 ± 0.06 uV) and with (0.09 ± 0.09 uV) the appliance, remaining below the normal baseline data at 0 months. However, the changes in EMG activity without TBA (P value: 0.23) and with TBA (P value: 0.19) were not statistically significant. In the 15 patients, EMG evaluation was done before wearing the TBA and after wearing the TBA in the same subjects. On maximum voluntary clenching, the SCM EMG activity increased immediately from 0.18 ± 0.03 uV to 0.29 ± 0.04 uV with TBA insertion at 0 months and continued to increase over nine months, both without (0.34 ± 0.02 uV) and with (0.43 ± 0.03 uV) the appliance. The activity during clenching was slightly higher with TBA (P value: 0.06) therapy compared to without TBA (P value: 0.09), but these differences were not statistically significant.

During side-to-side neck movement, the muscle activity decreased immediately from 0.63 ± 0.01 uV without appliance to 0.44 ± 0.02 uV with TBA therapy at 0 months. This decreased activity was sustained below the baseline data after nine months, both without (0.57 ± 0.01 uV) and with (0.41 ± 0.04 uV) TBA therapy. The changes in EMG activity without TBA (P value: 0.21) and with TBA (P value: 0.1) therapy were not statistically significant. The EMG activity of the trapezius muscles during various activities: postural rest position of the mandible, maximum voluntary clenching, and shoulder elevation were recorded (Table 2).

Table 2: A comparative study of electromyogram (EMG) activity in the trapezius muscle during different activities, with and without the twin block appliance, over a nine-month duration. (N=15)

Activity	0 month	1 month	3 months	6 months	9 months	P value
PRPWOTB	0.28 ± 0.07 uV	0.26 ± 0.07 uV	0.27 ± 0.03 uV	0.28 ± 0.03 uV	0.27 ± 0.06 uV	0.29
PRPWTB	0.29 ± 0.02 uV	0.26 ± 0.03 uV	0.28 ± 0.09 uV	0.28 ± 0.07 uV	0.27 ± 0.07 uV	0.21
MVCWOTB	0.25 ± 0.03 uV	0.26 ± 0.02 uV	0.27 ± 0.05 uV	0.27 ± 0.07 uV	0.27 ± 0.03 uV	0.19
MVCWTB	0.27 ± 0.04 uV	0.27 ± 0.06 uV	0.28 ± 0.05 uV	0.28 ± 0.08 uV	0.28 ± 0.03 uV	0.08
SEWOTB	1.02 ± 0.03 uV	0.97 ± 0.04 uV	0.98 ± 0.06 uV	0.97 ± 0.07 uV	0.96 ± 0.08 uV	0.31
SEWTB	0.98 ± 0.02 uV	0.92 ± 0.05 uV	0.98 ± 0.05 uV	0.97 ± 0.08 uV	0.97 ± 0.07 uV	0.2

Abbreviations: PRPWOTB-Postural rest position without TBA, PRPWTB-postural rest position with TBA, MVCWOTB-Maximum voluntary clenching without TBA, MVCWTB-Maximum voluntary clenching with TBA, SEWOTB-Shoulder elevation without TBA, SEWTB-Shoulder elevation with TBA

During postural rest position, the mean and standard deviation of Trapezius EMG activity at 0 months without the appliance were 0.28 ± 0.07 uV, and it increased immediately after the insertion of the TBA (with the appliance) to 0.29 ± 0.02 uV. The activity remained below the baseline data after nine months of follow-up, both without (0.27 ± 0.06 uV) and with (0.27 ± 0.07 uV) the appliance. However, the change in EMG activity without TBA (P value 0.29) and with TBA (P value: 0.21) therapy was not statistically significant. On maximum voluntary clenching, the mean and standard deviation of trapezius activity increased without TBA therapy from 0.25 ± 0.03 uV to 0.27 ± 0.04 uV with the TBA. The activity remained above the baseline data after nine months, both without (0.27 ±

0.03 uV) and with (0.28 ± 0.03 uV) the appliance. However, the changes in muscle activity without TBA (P value: 0.19) and with TBA (P value: 0.08) therapy were not statistically significant.

During shoulder elevation, trapezius muscle activity decreased from 1.02 ± 0.03 uV without the appliance to 0.98 ± 0.02 uV with the appliance at 0 months. After nine months, the EMG activity further decreased without (0.96 ± 0.08 uV) and with (0.97 ± 0.07uV) the appliance. The changes in trapezius muscle activity without TBA (P value: 0.31) and with TBA (P value: 0.2) therapy were not statistically significant.

DISCUSSION

Functional appliances lead to new physiological adaptations in the muscles of the orofacial regions, accompanied by skeletal changes in the jaws.[12] According to Moss, any alteration in morphology is linked to functional modifications and the adaptation of soft tissues.[13] There exists a mutual relationship between head posture, cervical spine posture, facial morphology, and maxilla-mandibular relationships, as well as the muscles of the jaw and neck.[6] Cervical column posture changes with mandibular advancement through TBA therapy, as suggested by Aglarci.[14]

This study aimed to objectively monitor the impact of TBA on the EMG activity of neck muscles in patients exhibiting vertical growth patterns. Functional appliances like TBA can trigger various neuromuscular adaptation mechanisms.[15] Previous studies have shown changes in muscles not only in the orofacial region but also in the neck muscles due to oral splint therapy.[5]

The mandible closely interacts with a chain of muscles in the jaw and neck, contributing to the overall balance in the craniocervical region.[3] Alterations in mandibular position, such as changes in occlusal contact and vertical dimension of occlusion, can impact both masticatory and cervical muscles.[16]

TBA enables greater freedom of mandibular movement in anterior and lateral excursions without disturbing oral functions.[17] The response of neck muscles was observed throughout the active period of functional correction, during which skeletal components underwent remodeling. Therefore, the EMG activity of neck muscles was meticulously monitored over 1, 3, 6, and 9 months.

Muscle activity during postural rest position: The comparative evaluation of neck muscle EMG activity with TBA therapy at the beginning of treatment and after nine months did not reveal any significant changes. The study indicates that the EMG activity of the sternocleidomastoid and trapezius muscles decreased from the baseline data (0 months) to the nine months of wearing TBA. These findings are consistent with previous studies by Tecco et al.[12] The reduction in EMG activity of cervical muscles may be attributed to the decreased muscle tension resulting from the altered mandibular posture with TBA therapy. While the sternocleidomastoid and trapezius muscles are not directly involved in mandibular retraction or protrusion, they play a balancing role in the craniocervical region. Forward posturing of the mandible can influence the upper and middle cervical vertebrae, leading to changes in neck posture, subsequently affecting the EMG activity of functional neck muscles. The change in muscle activity could be due to the cross innervation of the trigeminal nerve and neck muscles. According to Santander et al, trigeminal inputs from various sources, such as periodontal, lingual, temporomandibular joint, and muscular receptors, may influence the motor neuron pools of cervical muscles.[18] Ahlgren, Haupl, and Woodside demonstrated that the height of the working bite, stretching beyond the freeway space, played a role in eliciting the response of orofacial muscles.[18,19] High bite blocks in TBA (mean 6mm) may induce viscoelastic tension in neck muscles and trigger the myotatic reflex.

Muscle activity during voluntary clenching: The EMG activity of both muscles increased immediately after the insertion of TBA during clenching and subsequently showed a gradual increase. However, these changes were not statistically significant. This phenomenon can be attributed to active muscle contraction during clenching, resulting in increased muscle tension and a subsequent decline in EMG activity. The observed increase in activity may be linked to neuromuscular adaptation, where greater pressure is exerted during clenching. The study suggests that the slowly adapting receptors in the tendon organs were not adequately stimulated to inhibit the generation of further tension during clenching, as supported by Miralles et al.[20] The activity of muscles was higher with TBA, as after one month of wearing the appliance, the posterior teeth were not in proper occlusion and could not cleanse properly, leading to occlusal instability without TBA. The maintenance of the vertical opening of the posterior bite block in TBA allowed patients to comfortably clench on the bite block, resulting in an increased number of occlusal contacts, as proposed by Woodside.[19] However, this study's findings differed from those of the study by Ingervall et al, where clenching activity without an appliance increased from the first to the end of nine months.[21]

Muscle activity during neck movement and shoulder elevation: The mean activity of the sternocleidomastoid and trapezius muscles decreased immediately after the insertion of TBA during neck movement and shoulder elevation. These muscles play a crucial role in neck movement and are considered the balancing muscles of the craniocervical region. They are intricately connected to the cervical spine and the skull, forming the cranio-cervical-mandibular system.

The high bite blocks of TBA cause the lower jaw to move forward and downward, resulting in changes to the posture of the cervical vertebrae and the chain of muscles attached to the cervical column. As suggested by Al-Abbasi et al, the function of muscles that posture the head seems to be influenced by the position of the mandible and the vertical dimension.[22] Previous studies by Aglarci et al have shown an increase in cervical curvature angle along with sagittal mandibular correction after TBA.[14] Consequently, the muscles associated with the cervical spine exhibited non-significant changes in EMG activity.

The primary limitation of this study was the absence of a control group; EMG activity of both muscles was compared solely with baseline values from the same cohort of patients. Future investigations incorporating a control group and a larger sample size would be valuable in more comprehensively evaluating the effects of TBA therapy on the EMG activity of cervical musculature.

CONCLUSIONS

TBA therapy does not significantly impact sternocleidomastoid and trapezius muscle electromyographic activity in hyper-divergent Class II malocclusion patients.

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