Stomatologija, Baltic Dental and Maxillofacial Journal, 17: 84-8, 2015

Neuromuscular evaluation in young patients with unilateral posterior crossbite before and after rapid maxillary expansion

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SUMMARY

Objectives. The aim of this study is to analyze the electromyographic and electrognatographic exams of 55 patients before and after rapid palatal expansion, and to find out a relationship between the results.

Materials and methods. The sample consisted of 55 children (28 females and 27 males; age ranging between 6 and 10 years) with unilateral posterior crossbite, and subjected to an electromyographic and electrognatographic examination before and after a rapid palatal expansion.

Results. By analyzing the results, it is possible to observe an increased electrical activity of the masticatory muscles (right and left masseters and anterior temporalis) both in rest position and during activities after rapid palatal expansion.

Conclusions. Rapid palatal expansion produces important changes in the muscular tone and it increases the muscular activity of the masticatory muscles.

Key words: muscular activity, electrognatography, rapid palatal expansion, posterior crossbite.

INTRODUCTION

Unilateral posterior crossbite (UPCB) is normally accompanied by a lateral functional shift of the mandible from maximum opening to centric occlusion. In children if this malocclusion is untreated for long, skeletal remodelling may occur over time and the mandibular deviation toward the crossbite side may persist. An asymmetric muscular activity at rest (without cuspal interferences) may indicate a permanent displacement of the mandible.

Early treatment has been recommended because spontaneous correction is unusual and if not treated it may be associated with postural problems that may develop into musculoskeletal problems in adults (1,2).

Rapid maxillary expansion (RME) is a frequent treatment method to correct UPCB (3-5). Both clinical and experimental studies indicate that RME has many effects on craniofacial structures at the dentoalveolar, skeletal and sutural levels. However, few studies have investigated muscular response to expansion therapy. Some Authors examined the contraction of the temporal and masseter muscles electromyographically in children with crossbite during palatal expansion. They concluded that, when teeth are moved to a more advantageous and correct occlusal relationship by orthodontic therapy, a normal muscle pattern can be obtained (6-12). On the other hand, some studies reported that an inherent pattern of jaw movement is characteristic of unilateral posterior crossbite, and it did not change significantly with slow expansion treatment (13). Other authors in their study found that RME affected the electromyographic (EMG) activities of the anterior temporal and superficial masseter muscles during swallowing and unilateral chewing. These findings suggest that the alterations in the EMG activities of these muscles should be considered in both the treatment and the stability of maxillary transverse deficiencies. The aim of this study was to investigate the muscular response to RME.

EMG records were used to evaluate the activity of the anterior temporal and masseter muscles

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before and after RME and again after a 6-months observation period.

MATERIAL AND METHODS

55 children (27 boys, 28 girls) aged 6 to 10 years old with unilateral posterior crossbite were selected from the patients who underwent an orthodontic visit at the Orthodontic department of Milan University.

Inclusion criteria were:

- Skeletal class I
- Mesiofacial growth pattern
- Caucasian ethnicity.

Exclusion criteria were:

- Presence of skeletal asymmetries
- Craniofacial anomalies
- Temporomandibular joint dysfunction
- History of neuromuscular disease or disease affecting neuromuscular performance
- Previous or current orthodontic treatment.

All patients' parents were informed on the characteristics of the study and agree to participate by signing an EC-approved informed consent.

The subjects were treated with the Hyrax RME appliance to increase the tranverse maxillary diameter. The appliance was activated twice a day (0.25 mm per activation) until overcorrection of the posterior crossbite was achieved; then it was stabilized with a ligature wire. The EMG activities of the anterior temporal and masseter muscles were recorded as well as swallowing before RME (T0), after RME (T1), after 6 months in a follow up control (T2).

Two electromyographic examinations were carried out with two different electromyographic instruments: a Freely electromyography (De Gotzen, Legnano, Italy) and a K6-I electromyography (Myotronics, Tukwila, WA, USA). Every patient underwent a kinesiographic examination during mandibular movements. Before these examinations, the patients were asked if they were free of dental or skeletal pain.

The patients were examined in a specific, totally undisturbed and noiseless room. They sat on a rigid wood stool with an adjustable height, to provide an angle of 90◦ between the thigh and lower leg. The thighs were parallel to the floor, the back was upright, and the gaze was to beyond the horizon. The head was in a natural head position.

After thorough cleansing of the skin of the face with a wad soaked in Neoxinal (0.5% clorhexidine in ≥70% alcohol), to reduce the forehead impedance and to facilitate adhesiveness, the electrodes for the electromyographic acquisition were positioned on the patient. The electrode positions were the same for both of the electromyographic instruments, and were not modified between the use of the instruments. The electrodes used were disposable. These bipolar electrodes were positioned according to the following procedure:

- Masseter muscle: from behind the seated subject, the operator palpated the muscle mass while the patient clenched the teeth. To position the bipolar electrode parallel to the muscle fibers, a line was drawn that connected the commissural labiorum oris with the tragum, as well as one drawn following the esocanto-goniac line. The position of the electrode was such that the superior pole lay at the intersection point between these two lines, with its major axis along the esocanto-goniac line.
- Temporal muscle: the muscle mass was palpated while the patient clenched the teeth, thus localizing the major axis of the zygomatic process of the frontal bone. The bipolar electrode was positioned along the line parallel to this process. In this way, the electrode was positioned parallel to the muscle fibers, and positioned more or less superficially in comparison with the frontoparietal suture.
- A grounding earth electrode was positioned on a silent muscular area of the forehead.

Table 1. Statistical analysis with Student's t test for paired samples

AMR T0/ T1 MM DX	0.66
AMR T0/T1 MM SX	0.04
AMR T0/T1 TA DX	0.03
AMR T0/T1 TA SX	0.91
COTTON TO/T1 MM DX	0.37
CLENCH T0/T1 MM DX	0.04
COTTON T0/T1 MM SX	0.26
CLENCH T0/T1 MM SX	0.46
COTTON T0/T1 TA DX	0.86
CLENCH T0/T1 TA DX	0.04
COTTON T0/T1 TA SX	0.92
CLENCH T0/T1 TA SX	0.29
AMR TENS T0/T1 MM DX	0.05
AMR TENS T0/T1 MM SX	0.05
AMR TENS T0/T1 TA DX	0.2
AMR TENS T0/T1 TA SX	0.2

Legend: MM – masseter muscle; TA – temporal muscle; sx – left; dx – right; T0 – pre-treatment period; T1 – post-treatment period; AMR – muscular activity at rest; AMR TENS – muscular activity at rest after transcutaneal electrical neural stimulation; COTTON – force exerted on the maximum voluntary clenching on cotton rolls; CLENCH – force exerted on the maximum voluntary clenching on teeth.

According to the protocol, the electromyographic evaluation was carried out with the Freely instrument.

During this electromyographic evaluation, the patients made a maximum voluntary clench on cotton rolls positioned around the first molar, for 5 sec (the ‘cotton clench’), and a maximum voluntary clench without the interposed rolls for 5 sec (the ‘clench’). This procedure followed the Sforza et al. protocol.

With the K6-1 electromyographic instrument, an analysis of the neuromuscular system at rest was carried out to provide an objective measurement of the electrical activity of the examined muscle at rest, and to evaluate any eventual muscle hyperactivity, which is typical of temporomandibular dysfunction. Low levels of electric activity were analyzed during the maximum voluntary clench and the clench on cotton rolls (cotton clench), to evaluate the linear correlations between the electromyographic signal, recruit of the motor unit, and the force expressed in the isometric contraction.

The indexes recorded and monitored were the temporal, masseter, the mean percentage overlapping coefficients (POC), the index of symmetrical distribution of the muscular activities; the asymmetry, activation, and torque coefficients; and the cotton clench, clench, and percentage impact. These electromyographic evaluations were carried out with the K6-1 instrument equipped with a ‘sensor-cage’ fitted to the head of the patient and with a magnet positioned intraorally. The examination was taken with the two electromyographic instruments in the same position. The magnet used (Myotronics, Tukwila, WA, USA) was specifically made for these kinesiographic instruments. To allow correct adhesiveness of the magnet, Bioadhesive Stomatohesive was used (Myotronics, Tukwila, WA, USA).

Table 2. Mean values (μV) and standard deviations resulting from the study

	MM R	MM L	TA R	TA L
AMR T0	2.1±0.8	2.1±0.6	2.4±0.9	3.3±0.5
AMR T1	2.4±1.5	3.2±1.7	4.4±2.4	3.3±1.1
AMR TENS T0	1.4±0.4	1.6±0.3	2.2±0.6	3.0±0.5
AMR TENS T1	2.1±1.1	2.8±1.6	3.1±1.3	3.8±1.5
COTTON T0	55.4±46.8	46.1±28.8	58.2±48.9	64.7±41.1
COTTON T1	48.4±27.7	53.4±14.5	56.1±31.2	65.3±25.4
CLENCH T0	66.1±45.5	48.3±26.7	75.9±47.4	76.0±49.9
CLENCH T1	47.4±40.6	54.7±32.9	53.3±41.9	63.1±37.2

Legend: MM – masseter muscle; TA – temporal muscle; L – left; R – right; T0 – pre-treatment period; T1 – post-treatment period; AMR – muscular activity at rest; AMR TENS – muscular activity at rest after transcutaneal electrical neural stimulation; COTTON – force exerted on the maximum voluntary clenching on cotton rolls; CLENCH – force exerted on the maximum voluntary clenching on teeth.

For the mandibular kinesiography, the examination included: maximum mouth opening; opening and closing speeds; maximum protrusion of the mandible on the antero-posterior plane; maximum right laterality; maximum left laterality; mandible rest position; centric occlusion; freeway space at rest; freeway space after transcutaneous electrical nerve stimulation (TENS); and distance between centric occlusion and maximum opening.

After the kinesiographic analysis (EKG) of the mandible, the TENS, which relaxes the muscles innervated by the V and VII pair of cranial nerves was applied. The TENS lasted 45 min to 50 min and needed two bipolar electrodes. (Myotrode SG, and Myomonitor J5; Myotronics, Tukwila, WA, USA). A second EMG and EKG examination were performed on the muscle at rest, to determine the expected muscular electric activity reduction and the efficacy of the therapy.

The whole examination was repeated twice, taking into consideration only the values obtained in the second trial. Furthermore, it should be noted that whenever an electromyographic evaluation or a kinesiographic examination was carried out, each scan or electromyographic trial was repeated at least twice, to determine its reliability and its repeatability. In cases of discrepancy, the same evaluation was performed again, until repeatable results were obtained.

The swallowing mandibular movement was recorded during the intake of water. The distance the trace travelled from the endpoint of deglutition to maximum intercuspidation represents the amount of space between the teeth (vertical space mm).

All the EMG and EKG data obtained in the different phases of the treatment were then statistically analysed in order to know if there were modifications after palatal expansion on the EMG or EKG values.

Statistical tests

Data analysis was carried out with Student’s t test (Table 1) where the null hypothesis assumes that the differences between the EMG and EKG values at the beginning and at the end of the active expansion and after six months were due to chance, while according to the alternative hypothesis, the differences among the groups are real. The level of statistical significance was set at $P<0.05$.

RESULTS

For each period (T0 – before the appliance fixation, T1 – at the end of the active phase; T2 –

after six months) the average and the standard deviation of each EMG and EKG index was calculated.

From the data analysis (Table 1), an increase in masticatory muscular activity at T1, both at rest and during exercises, has been found.

Maximum mouth opening was higher after palatal expansion (T0=37.5 mm; T1=40.1 mm).

The muscular activity at rest after TENS showed in T1 values higher than in T0.

Table 2 shows comparisons of EMG activity between T0, T1 and T2. Before RPE muscles appeared to be contracted with altered patterns.

In swallowing, there was no statistically significant difference in the activities of both muscles between the right and left sides. However, the mean values of the right-side activities of both muscles were higher than the left-side activities. The statistically non-significant difference of symmetry in both muscles at swallowing was considered within the limits of physiologic asymmetry.

Both muscles' activities increased gradually after RME at swallowing ($P \leq 0.01$)

DISCUSSION AND CONCLUSIONS

The oral cavity develops from an almost symmetric pattern (14). Alterations of this symmetric arrangement may develop in the dental arches or in the supporting bones, but the effects of such an alteration are likely to involve the apparatus as a whole.

Nevertheless, several compensatory adaptations to the altered anatomical imbalances may be found, and assessment of the patient should be aimed mostly at the functional impairments. Occlusal stability has been found to be related to muscular performance, subjects with a higher occlusal stability showing shorter contraction times and larger electromyographic potentials during chewing than subjects with a lower occlusal stability (15).

The analysis of the masticatory muscle activity in subjects with altered occlusal relationships could, therefore, provide useful data on the functional impact (16) of morphological discrepancies. These activities can be investigated using surface EMG, which allows the monitoring of some of the main masticatory muscles (masseter, temporalis, suprahyoid muscles), with results that do not significantly differ from those obtained with intramuscular recordings (17), and that have been found to have a good standard of reproducibility when performed with properly standardized protocols (18, 19).

If functional crossbites are not treated at an early age, they can acquire a functional character.

In this study, repeated measurements were used at the levels of side (right and left) and time (T0, T1, T2).

Thus, we used a within-subject design so that each subject served as his or her own control. Occlusal forces, muscle fatigue, and pain also affect the performance of the masticatory muscles.

Children with unilateral posterior crossbite can have reduced bite force of muscle function during chewing or clenching. Moreover, there is a significant association between posterior crossbite and equilibrium of the masticatory system. This study showed that orthodontic treatment improved the functional capacity of the masticatory muscles during mastication.

Electromyographic analysis showed that activity of the masseter and temporalis muscles increased significantly after the expansion appliance was removed during rest, dental clenching and habitual chewing. Also maximum mouth opening was higher after therapy.

We can conclude that the palatal expansion does not act directly on the masticatory muscles, but it produces important changes in the muscular tone. However, the positive effect of early interceptive treatment was demonstrated by the results of this study.

Facial musculature is directly and intimately related to the development of malocclusions. Its correct functioning is fundamental in obtaining equilibrium of the masticatory system and planning treatment.

These findings reinforce the advantages of treating children with UPCB and functional shift as early as possible.

Based on the results of this study and the literature review, early orthodontic treatment of unilateral posterior crossbite with mandibular shifts is recommended.

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Received: 21 10 2014
Accepted for publishing: 28 09 2015