Original Article

Ultrasonographic Thickness of the Masseter Muscle in Growing Individuals with Unilateral Crossbite

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ABSTRACT

Objective: To study the bilateral differences in the thickness of the masseter muscles in untreated individuals with lateral crossbite, as well as in subjects with successfully treated functional lateral crossbite, at least three years after the end of treatment.

Materials and Methods: Three groups of growing individuals were studied: (1) untreated group: 38 individuals with unilateral crossbite, (2) control group: 224 subjects without transversal malocclusions, and (3) treated group: 18 individuals with functional lateral crossbite, treated with a quad helix, and at least three years out of retention with all permanent teeth erupted. The thickness of the masseter muscle was measured bilaterally with ultrasonography, using a real time scanner with a 7.5 MHz linear array transducer.

Results: In the untreated group, the thickness of the masseter muscle on the crossbite side was statistically significantly thinner than the one on the normal side ($P = .025$). No statistically significant differences were found in the thickness of the masseter muscle between the left and the right side in the control group. In the treated group, no statistically significant differences were found in the thickness of the masseter muscle between the former crossbite side and the normal one.

Conclusion: The masseter muscle in untreated individuals with unilateral crossbite is thinner in the crossbite side when compared to the non-crossbite side possibly due to asymmetric activity of the masticatory muscles. Such an asymmetry in thickness of the masseter muscle could not be detected some years after the successful correction of the crossbite.

KEY WORDS: Crossbite; Masseter muscle; Ultrasonography

INTRODUCTION

Intensive use of any skeletal muscle may cause changes in the muscle fiber size and composition, which in turn will increase the strength of the muscle and the resistance to fatigue.[1–3] This is also true of the masticatory muscles.[4] Prolonged high activity of these muscles resulted in increased ultrasonographic thickness of the masseter muscle[5] and increased maximal bite force values.[6]

A different level of bilateral activity of the masticatory muscles was recorded in children with unilateral crossbite or lateral forced bite,[7–11] possibly a functional adaptation of the masticatory system to avoid cuspal interferences. Thus, it could be expected that this prolonged bilateral difference in the activity level of the masticatory muscles may work as an asymmetric training stimulation, resulting in differences in the thickness of these muscles.

However, the masticatory muscles are also involved in functions that are not necessarily related only to mastication, and thus it is unknown if the previously observed bilateral differences in the activity level of the masticatory muscles are enough to create detectable changes in the muscle thickness. Besides, it would be interesting to know if the possible differences in the thickness of the masticatory muscles are reversible after orthodontic treatment, when the functional lateral crossbite has been eliminated. Ideally, a longitudinal study following cases

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with functional unilateral crossbite and recording their masticatory muscles before and after the treatment, as well as after a certain posttreatment period, would provide support for these hypotheses. However, before embarking on such an undertaking, an attempt could be made on a cross-sectional basis.

This study was aimed at detecting whether there are bilateral differences in the thickness of the masseter muscles in untreated individuals with lateral crossbite, as well as in subjects with successfully treated functional lateral crossbite, at least three years after the end of treatment.

MATERIALS AND METHODS

Untreated group

This group consisted of 38 growing individuals (17 male and 21 female) with unilateral crossbite, with a mean age of 11.9 years (range: 8.1–17.8 years). These subjects belong to a group of 329 persons participating in a comprehensive investigation previously described by Raadsheer et al.[12] This was an epidemiologic study that took place in collaboration with the UMCA camp in Chalkidiki, Greece. The subjects and their parents were informed in advance by the camp administrator and gave their approval. All subjects were healthy, and none showed any growth disorder or facial malformation. Two hundred eighty-two subjects of this group were growing individuals (age range: 7.0–18.2 years). Among them, 42 persons had unilateral crossbite, 16 bilateral crossbite, and the 224 showed no sign of transversal malocclusion. Four of the 42 subjects with unilateral crossbite were not included in the present study because they were under orthodontic treatment. Approval of the Medical Ethical Committee of the Academic Medical Center of the University of Amsterdam was obtained prior to the study.

Treated group

This group consisted of 18 subjects (9 male and 9 female), with a mean age of 16.3 years (range: 12.0–22.0 years).

Subjects were selected from the files of patients treated between 1987 and 1993 for functional lateral crossbite in the Department of Orthodontics, Göteborg University, Sweden. The following selection criteria were used:

- Child or adolescent with unilateral functional crossbite, without any other major malocclusion.
- Treatment of the crossbite using a quad helix, which also served as a retention appliance with no other orthodontic treatment performed thereafter.
- At least a three-year postretention period and at the age when all the permanent teeth except the third molars had erupted.

Twenty-nine subjects fulfilled the above criteria. Efforts were made to invite them to participate in the study. All individuals were contacted and 18 accepted the invitation. The remaining subjects did not participate for the following reasons: three had moved out of the city, two declined the invitation, and six individuals did not respond despite repeated invitations.

Control group

The control group consisted of 224 growing individuals (112 male and 112 female), without transversal malocclusions, originating from the group of the 282 growing individuals. The mean age of the group was 12.0 years (range: 7.2–18.2 years). This group was used as a control to the untreated group.

In order to form a control group that meets the demands of the older treated crossbite group, age adjustment of the control group was performed excluding younger subjects. Thus, a separate control group of 28 individuals (age-adjusted control group) was created with the same mean age as the treated group (mean: 16.1 years, range: 15.2–18.2 years).

Method

The thickness of the masseter muscle was measured bilaterally, as described by Kiliaridis and Kälebo.[13] All the subjects were examined by the same operator, using a real time scanner (Pie Medical Scanner 480, Maastricht, The Netherlands), with a 7.5 MHz linear array transducer. The participants were seated in an upright position with their heads in a natural position. To avoid tissue compression, a generous amount of gel was used under the probe. The transducer was oriented perpendicularly to the ramus. Scanning the masseter obliquely would increase the thickness of the muscle. In order to avoid this source of error, the angle of the transducer was altered until the best echo of the mandibular ramus was achieved. The site of measurement was in the thickest part of the masseter close to the level of the occlusal plane, halfway between the zygomatic arch and gonial angle, approximately in the middle of the mediolateral distance of the ramus.

The imaging and the measurements of the masseter were performed bilaterally, under contracted conditions, by asking the participants to clench maximally in the intercuspal position. The imaging and the measurements were performed twice. An interval of at least five minutes was taken between the two readings. The final thickness was obtained from the mean of the two measurements. The measurements were made directly from the image at the time of scanning

Table 1. Characteristics of the Studied Groups as Related to Group Size (N), Age, and Thickness of the Masseter Muscle in Contraction (mm)*

		Age, y		Thickness on Crossbite side		Thickness on Normal Side		
Group	N	Mean	Range	Mean	SD	Mean	SD	Significance
Untreated unilateral crossbite	38	11.9	8.1–17.8	11.7	1.6	12.0	1.7	$P < .025$
Treated unilateral crossbite	18	16.3	12.0–22.0	14.0	1.8	14.0	2.0	NS

* SD indicates standard deviation; Significance, significance of differences between crossbite and normal side; NS, not significant.

Table 2. Characteristics of the Control Groups as Related to Group Size (N), Age, and Thickness of the Masseter Muscle in Contraction (mm)*

		Age, y		Thickness on Right Side		Thickness on Left Side		
Group	N	Mean	Range	Mean	SD	Mean	SD	Significance
Control	224	12.0	7.2–18.2	12.1	1.9	12.1	2.0	NS
Age-adjusted control	28	16.1	15.2–18.2	14.0	2.2	14.1	2.3	NS

* SD indicates standard deviation; Significance, significance of differences between right and left side; NS, not significant.

with a readout to the nearest 0.1 mm. The real-time scans were then printed on film paper by a videocopy printer (Mitsubishi, model P66E, Tokyo, Japan).

Statistical methods

A paired *t*-test was used to evaluate possible differences in thickness of the masseter muscle between the crossbite side and the normal side, in both the untreated and the treated groups. The same test was used to evaluate possible differences in the thickness of the left and right masseter muscles in the control group.

Error of the method

The error of the method (Se) in the ultrasonographic thickness of the masseter muscle was calculated by the means of the two measurements of the 20 double recordings of imaging and measurements of the thickness of this muscle on two separate occasions using Dahlberg's formula ($Se = \sqrt{\Sigma d^2/2n}$, where d = the difference between the means of two recording occasions of the individual and n = 20, which is the number of individuals with recordings at two different occasions).[14] The error of the thickness of the masseter was found to be small, not exceeding 0.3 mm.

RESULTS

Untreated unilateral crossbite group

Bilateral asymmetry of the thickness of the masseter muscle was found in the untreated unilateral crossbite group (Table 1). It was found that the thickness of the masseter on the crossbite side was statistically significantly thinner than the one on the normal side ($P = .025$).

No statistically significant differences were found in the thickness of the masseter muscle between the left and the right side in the control group (Table 2).

Treated unilateral crossbite group

No statistically significant differences were found in the thickness of the masseter muscle between the former crossbite side and the normal side in the treated crossbite group (Table 1).

No statistically significant differences were found in the thickness of the masseter muscle between the left and the right side in the age-adjusted control group (Table 2).

DISCUSSION

The present study has shown that the masseter muscle in untreated growing individuals with lateral crossbite is thinner on the crossbite side when compared with the contralateral normal one. This was not the case for the individuals some years after successful treatment of lateral crossbite, who showed no differences between the two sides, that is, the previous crossbite side and the normal one.

A possible explanation is that the difference that existed in the thickness of the masticatory muscles was reversible after orthodontic treatment, when the lateral crossbite and possible asymmetric muscle activity had been eliminated.

Our findings are possibly the physiologic result of the different level of bilateral activity of the masticatory muscles in children with unilateral crossbite or lateral forced bite,[7–11] possibly a functional adaptation of the masticatory system to avoid cuspal interference. Thus, the prolonged bilateral difference in the activity level of the masticatory muscles may have worked as an asymmetric training stimulation, resulting in differenc-

es in the thickness of these muscles in the untreated group. The reduced thickness of the masseter at the crossbite side could be explained by the findings of a recent study, which showed that active occlusal interference can cause reduction in the number of electromyographic activity periods of the masseter muscle per hour and their mean amplitude.[15] It has been shown that reduced activity of the masseter muscle results in thin muscle fibers.[4,16]

The successful treatment of the unilateral crossbite seems to have eliminated the underlying reasons for the different level of bilateral activity of the masticatory muscles, and thus the asymmetric stimulation of the masseter muscle. Therefore, no bilateral differences in the thickness of the masseter muscles were detectable among the individuals with successfully treated lateral crossbite. This is in accordance with the results of a previous study by Tsarapatsani et al,[17] who found no differences in the maximal bite force level of the corresponding sides of previously treated patients with lateral crossbite. The normalization of the thickness of the masseter muscle on the crossbite side some years after treatment can be explained by the previous knowledge in work physiology that physiologic use of any skeletal muscle may cause increase in the muscle size, which in turn will improve the strength of the muscle.[1,3] Similarly, in the masticatory system, the adaptation of the masseter muscle in bilateral prolonged functional demands, due to systematic chewing-gum training, resulted after a four-week period in increased ultrasonographic thickness of the masseter muscle and higher maximal bite force values.[5,6]

Despite the significant positive correlation between masseter muscle size (thickness, cross-section) and maximum bite force,[18–20] Sonnesen et al[21] reported no difference in maximum bite force between crossbite and non-crossbite side before treatment. This was attributed by the authors of the latter study to the fact that bite force registration as a method is not sensitive enough to detect left-right differences in functional capacity of the masticatory muscles, since the bite force level on the two sides is not independent. To support this explanation, they reported unpublished data where patients with complete unilateral paralysis of the jaw elevator muscles can still obtain low levels of bite force on the paralyzed side.[21]

The results of cross-sectional studies should be interpreted with caution. Ideally, a longitudinal study, following patients with functional unilateral crossbite and recording their masticatory muscles before and after the treatment, as well as after a certain posttreatment period should provide a sufficient answer to this question. The present study gives support for undertaking such an effort, the only suitable one to elucidate in detail the changes that may take place in the functional system of these individuals.

CONCLUSION

- The masseter muscle in untreated individuals with unilateral crossbite is thinner in the crossbite side than in the contralateral normal side.
- This was not the case for the individuals some years after successful treatment of this malocclusion, possibly due to elimination of the asymmetric bilateral activity of the masticatory muscles after the crossbite correction.

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