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Evaluation of Volume Width and Thickness of Masseter Muscle in Different Facial Patterns Using Magnetic Resonance Imaging: A Comparative Study

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ABSTRACT:
Aim: The present study attempts to assess morphologic variations of the masseter muscle in different facial patterns using Magnetic Resonance Imaging (MRI).
Methodology: A total of 30 young, healthy subjects in the age group of 20-28 years were selected and divided into 3 groups of 10 each as vertical, average and horizontal growers using lateral cephalograms. In these subjects, various anatomic dimensions of masseter muscle were measured using MRI, in sagittal, axial and coronal views.
Results: The results showed a statistically significant difference between the vertical and horizontal growth patterns ($p<0.05$), with respect to Masseter muscle volume, thickness, width at area of insertion.
Conclusion: It was concluded that volume, thickness as well as width of masseter muscle was more in horizontal growth pattern from muscle's origin point as compared to vertical growth pattern.
Keywords Masseter muscle, Growth patterns, MRI.

INTRODUCTION

Craniofacial morphology is the result of a complex interaction between genetic and environmental factors. The role of all these factors was widely evaluated and several authors studied the influence of function on craniofacial form and showed a correlation between the morphology of craniofacial skeleton and the function and morphology of masticatory muscles.[1,2] This relationship was investigated in both experimental animal and human clinical studies.[3,4] Many factors such as size, fiber content, metabolism and biomechanics of masticatory muscles seem involved in the development of the craniofacial complex but their role is not completely clarified.[5]Among the masticatory muscles, the masseter was mainly investigated exploring the relationship between size and the vertical and transversal skeletal pattern. Masseter size measurements were performed using several techniques, including computed tomography (CT)[6], magnetic resonance (MR)[7] and ultrasonography (US)[8]. In most

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studies, masseter size was found to be significantly related to the vertical and transversal skeletal dimensions.[9] The association between masseter size and face height seemed to be negative, while the relationship between size and facial width seemed to be positive. Scientific evidence showed that masseter muscle thickness might be considered as one of the factors influencing the maxillary dental arch width.[10]Increases in lower anterior face height are reported to be independent of other skeletal units but dependent on neuromuscular factors.[11] Furthermore, high palatal vaults have been observed in children with lip incompetence.[12] As the muscles primarily responsible for elevating the upper lip are the levator labii superioris and the zygomaticus major,[13,14] it can be hypothesized that there might be a relationship between vertical facial morphology and the muscles of facial expression.The effects of muscle thickness on bone morphology can be explained by a theory which is recognized in the field of biodynamics as Wolff's law.[15] This law points out that the internal structure and the shape of the bone is closely related to function, and defines a relationship between bone shape and muscle function.[16] In order to describe facial morphology, the structure of the facial muscles should be investigated thoroughly to determine the pattern of interaction of the skeleton and muscles. The association between masseter muscle thickness and vertical craniofacial morphology seems to be a negative relationship but, in contrast, the association between masseter muscle thickness and craniofacial width appears to be positive.[17]CT was used by Weijs and Hillen to measure masticatory muscle thickness in adults.[18] The imaging tecnique used in that study produced reliable data but, for ethical reasons, radiographic exposure for experimental purposes is now restricted. Hannam and Wood published results on masseter thickness of adults, as measured by MRI, a technique which was also found to be accurate.[19]

AIM OF THE PRESENT STUDY

To study the anatomical variations of masseter muscle in subjects with different facial patterns using MRI as well as assessing the correlation between them.

METHODOLOGY

Thirty subjects willing to undergo orthodontic treatment at the Department of Orthodontics and Dentofacial Orthopedics, GITAM Dental College & Hospital, Visakhapatnam, A.P, India were included in this study. A written consent was obtained from all the participants prior to conducting the study. They were all post-adolescent with a mean age group of 20-28 years and were included in three different groups with 10 samples each. Lateral cephalograms were taken for all the selected subjects. People with systemic diseases, as well as with any orthognathic surgical history were excluded from the present study.

Group 1-Vertical growth pattern
Group 2-Average growth pattern
Group 3- Horizontal growth pattern

Tracing of the cephalogram was done on an acetate paper and analysis of four angular and one proportional variable to define the growth pattern of the subject was done.

The following measurements were made on image produced by MRI scan.

1. Volume of the muscle
2. Thickness of the muscle
3. Width of the muscle at area of origin, mid-belly and insertion

a. Volume of the muscle: This was calculated 3- dimensionally. The length, width and thickness of the muscle were calculated and substituted in the formula given by American Heart Association used to measure cardiac muscle volume.

Volume = (L×B×H) / 0.58

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b. Thickness: This is the bucco-lingual width of the muscle measured as the largest measurement obtained in axial view.
c. Width: This is the mesio-distal width of the muscle fibres obtained at the areas of origin, mid-belly region and insertion.
All the obtained values were tabulated and statistically analysed. The measurements of the different parameters were calculated as the mean and Standard Deviation using ANOVA one way test to find the significant value within the groups. Post Hoc Tukey HSD test was performed to find the significant values ($p<0.05$) between the groups.

RESULTS

The mean volume of masseter muscle measured in vertical, horizontal and average growth patterns were 10.30±2.79 cm^3, 18.70±2.50 cm^3& 17.60±0.97 cm^3 respectively. (Table 1) A Post Hoc Tukey HSD (Honest Significant Difference) test for multiple comparisons among the three study groups for the volume of the masseter muscle showed statistically significant difference between the vertical group and the horizontal group ($p<0.05$) as well as between the vertical group and the average group. However, no significant difference was found when the horizontal group was compared with the average group. Thickness was measured as the maximum bucco-lingual width of the muscle in an axial view. (Table 2) The mean thickness of the muscle measured in vertical, horizontal and average growth patterns were 12.10±1.10 mm, 17.70±0.95 mm & 15.60±1.07 mm respectively. In Post Hoc test, the thickness of the muscle as the dependent variable showed statistically significant difference when the vertical group was compared to horizontal and average groups. Also, the horizontal group also showed a statistically significant difference when compared with the average group.Width of masseter muscle (Table 3) was measured as maximum antero-posterior measurement of the muscle fibres obtained at three different levels i.e at the areas of origin, mid-belly region and at the area of insertion. The mean width of the muscle at the level of origin in the vertical, horizontal and average groups were 32.40±1.71mm, 33.80±0.43mm and 32.50±1.43mm respectively. At 95% confidence level, a Post Hoc Tukey test for multiple comparison among the three study groups for the width of the masseter muscle (origin) showed that, there was a statistically significant difference when the vertical group is compared with average and horizontal group.

Table 1- Statistical measurements assessing the volume of masseter muscle in three groups using Mean, Standard deviation and Post Hoc Tukey test

Volume(cm^3)	Mean	S.D.	P - value
Vertical group	10.30	2.79	0.000
Horizontal group	18.70	2.50	0.000
Average group	17.60	0.97	0.521

Statistically significant if P<0.05

Table 2- Statistical measurements assessing the thickness of masseter muscle in three groups using Mean, Standard deviation and Post Hoc Tukey test

Thickness	Mean	S.D.	P - value
Vertical group	12.10	1.10	0.000
Horizontal group	17.70	0.95	0.000
Average group	15.60	1.07	0.000

Statistically significant if P<0.05

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Table 3- Statistical measurements assessing the width of masseter muscle in three groups using Mean, Standard deviation and Post Hoc Tukey test

Width	Mean	S.D.	P - value
Vertical group	32.40	1.71	0.985
Horizontal group	33.80	0.79	0.075
Average group	32.50	1.43	0.103

Statistically significant if P<0.05

DISCUSSION

Various studies have investigated the association between masseter muscle thickness and vertical craniofacial pattern. The facial morphology of subjects participating in those studies was defined by several variables measured either on lateral cephalograms or standardized facial photographs.[20] Previous studies which have shown that the masseter muscle is especially thick in short face individuals.[21] Inter-individual differences in the cross-section of the masseter muscle may be due to a variable number of muscle fibres, variation in fibre size, or both.[8]Pereira et al. and van Spronsen who reported that individuals with increase (deep) overbite tend to have thicker masseter muscle.[22,23] Rasheed et al. in their study of electromyographic and ultrasonographic evaluation of the circum-oral musculature also found that deep-bite subjects demonstrated greater thickness of masseter muscle compared with normal and open bite subjects.[24] Satiroglu et al showed that the masseter muscle is thicker in individuals with short face who tend to have deep overbite, and thinner in those with long face who tend to have reduced overbite or an anterior open bite.[25]Tabe et alinvestigated the influence of an activator appliance and a spring active appliance on masticatory muscle activity by means of electromyography on twelve adult males. Three functional appliances were used in each subject and long-period EMG recording were done during daytime and while sleeping and short-time EMG recording was used during voluntary biting. The findings obtained were as follows: (1) The activity of all muscles was greater during biting than during daytime and sleep, (2) the muscle activities tended to increase in the digastric muscle and to decrease in the temporal muscle with activators under all conditions, and (3) the temporalis-masseter ratios became lower with the biting use of appliances. This study suggests that functional appliances should be used during sleep and during the day in combination withvoluntary biting to achieve adaptation and development of the masticatory muscles.[26]When studies done to measure the mean volume of the masseter muscle using different imaging techniques were compared, the results of the present study using MRI were lesser than the measurements obtained using computed tomography in the studies done by Matsushima et al. (34.0cm^3) and Gionhaku and Lowe (30.4cm^3). All the studies showed the influence of the volume of the muscle in different growth patterns. The increased mean masseter muscle volume indicates a powerful musculature (more bite force) in horizontal growth pattern and brachycephalic facial form. Thus, the morphology of the masseter exerts its influence both directly (anatomical variations) and indirectly (influence on the bite-force) on the craniofacial growth of the individual.[27,28]The results in the present study show that the masseter muscle thickness is the highest in horizontal group followed by average group and it is the least in the vertical group. This finding supports the positive correlation between masseter thickness and the cephalometric parameters considered in this study. The results of the width of the masseter muscle at the level of mid-belly region show that it is greater in horizontal group when compared with the vertical and average groups. This implies that the greater width of the muscle in horizontal group exerts more bite force and thus influences the growth pattern of the cranio-mandibular apparatus. This muscle mass exerts its influence on the lower border of the mandible causing the growth rotation to be in forward direction.

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CONCLUSION

It was concluded that volume, thickness as well as width of masseter muscle was more in horizontal growth pattern from muscle's origin point as compared to vertical growth pattern.

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