Three-dimensional assessment of musculoskeletal features in Class II and Class III patients

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SUMMARY

Objective: To evaluate and compare dimensional morphology of masseter and medial pterygoid muscles and mandibular skeletal parameters between subjects with skeletal Class II and Class III

Materials and Methods: The sample consisted of 13 patients with skeletal Class II and 10 patients with skeletal Class III prior to the start of combined orthodontic treatment and orthognathic surgery with correspondence to definite inclusion and exclusion criteria. Magnetic resonance imaging was performed for mandibular muscles and following 2D and 3D measurements were done: cross-sectional area (CSA), thickness, width, longitudinal dimension and volume. 3D multislice computed tomography investigation was performed for the assessment of skeletal mandibular parameters and following measurements were done: height of mandibular ramus, length of mandibular corpus, overall mandibular length, intergonial width. All the measurements were done bilaterally. Data were analyzed using descriptive statistics, t-test, and correlation coefficients.

Results: it was found that values of all mandibular and medial pterygoid measurements were higher in Class III subjects with statistical significance (p<0.05). There was a tendency of all masseter variables to be higher in Class III patients. Positive correlations were found between muscles' volume and CSA in both groups, muscles' volume and all mandibular parameters in Class II group, CSAs and all mandibular variables except intergonial width in Class II group.

Overall symmetry was observed between left and right sides in all muscular and mandibular measurements in both groups.

Conclusions: The data were acquired using two different imaging techniques – MRI and MSCT that can be mentioned as a novelty in this field of research. Remarkable differences were observed between study groups for both skeletal and muscular measurements.

Key words: masseter, medial pterygoid muscle, mandible, magnetic resonance, multi-slice computed tomography.

INTRODUCTION

The performance of masticatory muscles can be associated with several significant aspects from orthodontic view. As being a part of biomechanical environment creators in craniofacial area, they can affect growth and development of dentofacial complex and thus influence aetiology process of dentofacial deformities [1,2,3,4,5]. The role of muscles in response to treatment is critical. Successful treatment outcome and stability of treatment results require reorganization and adaptation of muscle fibres [6]. From all mandibular muscles a particular importance is allocated to masseter and medial pterygoid muscles on the subject of their anatomical location and function [6]. The creation of tendinous sling between them allows the medial pterygoid and masseter to be powerful elevators of the jaw.

Relation between mandibular muscles and craniofacial morphology has been studied widely with different methods and from several aspects. Most of studies have been directed to facial growth pattern assess-
ment with the main conclusion that subjects with strong mandibular muscles have wider and shorter facial dimensions [7,8,9,14,15]. The recent advent of modern imaging techniques enables more precise assessment of different muscular size parameters.

Mandibular muscles can be investigated using different imagining techniques: ultrasonography [7,8], computed tomography (CT) [14-19] and magnetic resonance (MRI) [9-13].

MRI as a non-invasive imaging technique has high resolution quality in superficial and in profound soft tissues as well. It allows 2D and 3D image acquisition that enable accurate assessment of masticatory muscle dimensional morphology.

Acquiring of multiplanar images, high resolution in hard tissues and a full size truly volumetric 3D description in real anatomical (1:1) size are the advantages of CT imaging method [21], thus this could be a method of choice for the assessment of skeletal structures.

There are no studies in literature with the aim of particular and integrated investigation of dimensional morphology of skeletal and muscular parameters in such severe deformities as skeletal Class II and Class III.

The aim of the present study was to evaluate and compare dimensional morphology of masseter and medial pterygoid muscles and mandibular skeletal parameters between subjects with skeletal Class II and Class III.

MATERIAL AND METHODS

The sample consisted of 13 patients with skeletal Class II (mean age 18.4) and 10 patients with skeletal Class III (mean age 19.2) prior to the start of combined orthodontic treatment and orthognathic surgery with correspondence to subsequent inclusion and exclusion criteria. The inclusion criteria for Class II patients were: overjet ≥6 mm, angle ANB ≥4 degrees, Wits appraisal ≥4 mm; for Class III patients: overjet ≤0 mm, angle ANB ≤0 degrees, Wits appraisal ≤-4 mm. The exclusion criteria were: clinically evident facial asymmetry, functional mandibular deviations, symptoms of temporomandibular disorders, previous orthodontic treatment. All patients had indication for combined orthodontic treatment and orthognathic surgery.

Magnetic resonance imaging (MRI)

Before starting preorthognathic orthodontic treatment MRI was performed in all patients using GE “Si- gnus Advantage” 1.0 MR System. The position of patients was standardized: supine position with Frankfurt horizontal plane oriented vertically and in habitual occlusion. Scan protocol included: T1 SE in sagittal plane, T2 FSE in axial plane, STIR T2 sequence images in coronal plane and 3D SPGR T1 with following 2 D and 3 D image reconstructions for the assessment of muscular size parameters.

Following measurements of masseter muscle were performed: 2D cross-sectional area (mm$^2$) (Picture 1), thickness (mm) in antero-posterior dimension (Picture 2), width (mm) in medio-lateral dimension (Picture 3), longitudinal dimension or length (mm) (Picture 4), and 3D volume (cm$^3$). For medial pterygoid muscle: 2D cross-sectional area (mm$^2$) (Picture 5), thickness (mm) at the level of tuberositas pterygoidea mandibulae and 3D volume (cm$^3$). All the measurements were done bilaterally.
Multi slice computed tomography (MSCT) examination

Before starting preorthognathic orthodontic treatment, a 3D MSCT investigation was performed using GE Medical Systems Light Speed Pro 16CT99_Oc0 system. The position of the patient was lying on the back, head positioned in the middle of orbitomeatal plane, closed mouth position – direct touch of molar teeth in habitual occlusion. Axial scanning was done from soft tissue point Glabella down to upper margin of C6. CT scan protocol – helical full 1.0 s, slice thickness 0.625 mm, pitch 0.625 mm, reconstruction – bone and soft tissue using IAC Review and Transparent Bone programs.

Following measurements were done: height of mandibular ramus – linear distance between condylus and gonion, length of mandibular corpus – linear distance between gonion and gnathion, overall mandibular length – linear distance between condylus and gnathion, intergonial width – linear distance between left and right gonion. All the measurements were done bilaterally.

All the measurements were done by one operator three times with a time interval 2 weeks.

Statistical analyses

Descriptive statistics were calculated for all the measurements of muscular and mandibular structures and the difference of mean values were tested using t-test. The differences were considered significant at P<0.05.

For evaluation of relation between muscular and mandibular skeletal variables, correlation coefficients were calculated.

RESULTS

The means, standard deviations and differences between Class II and Class III study groups of masseter variables are listed in Table 1. Calculation was performed separately for the left and right sides, but there were no statistically significant differences in volume, thickness, length, width and cross-sections between both sides neither in Class II nor Class III study group. Although there was a tendency of all the measurement values to be higher in Class III study group, the differences were not with the statistical significance.

The means, standard deviations and differences between Class II and Class III study groups of medial pterygoid variables are listed in Table 2. Calculation was performed bilaterally, but there were no statistically significant differences in volume, thickness and cross-sections between the left and right muscles neither in Class II nor Class III study group.

There were significant differences between study groups in volumetric measurements (p=0.001) and thickness (p=0.004) between Class II and Class III study groups. Cross-sectional areas values tend to be higher in patients with Class III deformity, but with no statistical significance.

The means, standard deviations and differences between Class II and Class III study groups of mandibular skeletal variables are listed in Table 3. Calculation was performed bilaterally, but there were no statistically significant differences between left and right sides in neither Class II nor Class III study group.
As showed in Table 3, patients with Class III deformity have larger mandibles comparing with Class II patients. There were observed significant differences in mandibular length (p<0.0001), mandibular ramus height (p=0.04) and mandibular body length (p<0.001) between both groups.

Relationship between muscular and skeletal variables in Class II patients are shown in Table 4 and Table 5. There were several significantly positive correlations between: masseter volume and mandibular length, masseter volume and mandibular body length, masseter volume and ramus height of mandible, masseter CSA and all the mandibular parameters except intergonial width. Positive weaker correlations were observed between other masseter and mandibular variables.

Medial pterygoid muscles’ volume and CSA showed positive correlations with mandibular length, body length and ramus height.

Relationship between muscular and skeletal variables in Class III patients are shown in Table 6 and Table 7. Mainly no significantly positive correlations between muscular and skeletal parameters were found in this study group except mandibular body length and muscles’ volume and CSA.

**DISCUSSION**

The data were acquired using two different imaging techniques – 3D MRI and MSCT that can be mentioned as a novelty in this field of orthodontic research.

This report documents: (1) the association of dimensional morphology of masseter and medial pterygoid muscles with mandibular skeletal parameters separately in skeletal Class II and Class III patients; (2) the comparison of masseter and medial pterygoid muscles between Class II and Class III study groups.

Some authors have found no difference in measurements on both sides of the face [10,11,17,18] and similarly overall symmetry was observed between left
and right sides in all muscular and mandibular measurements in both groups in our study. Class III patient group had larger mandibles in all dimensions that is explicable with subjacent aetiopathology of definite deformity. There was a tendency of all the muscular variables to be higher in Class III patient group. There was a tendency of all the muscular and mandibular measurements.

Table 4. Correlation coefficients (r) of masseter and mandibular variables in Class II patients

<table>
<thead>
<tr>
<th>Variables</th>
<th>Md length</th>
<th>Md ramus</th>
<th>Md body length</th>
<th>Go-Go distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mas volume</td>
<td>0.7</td>
<td>0.7</td>
<td>0.8</td>
<td>0.3</td>
</tr>
<tr>
<td>Mas CSA</td>
<td>0.6</td>
<td>0.6</td>
<td>0.7</td>
<td>-0.4</td>
</tr>
<tr>
<td>Mas thickness</td>
<td>0.7</td>
<td>0.4</td>
<td>0.8</td>
<td>0.1</td>
</tr>
<tr>
<td>Mas length</td>
<td>0.4</td>
<td>0.2</td>
<td>0.3</td>
<td>0.7</td>
</tr>
<tr>
<td>Mas width</td>
<td>0.6</td>
<td>0.1</td>
<td>0.5</td>
<td>-0.4</td>
</tr>
</tbody>
</table>

Mas – masseter muscle; CSA – cross-sectional area; Md – mandibular; Go- gonion

Table 5. Correlation coefficients of medial pterygoid muscles’ and mandibular variables in Class II patients

<table>
<thead>
<tr>
<th>Variables</th>
<th>Md length</th>
<th>Md ramus</th>
<th>Md body length</th>
<th>Go-Go distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pt volume</td>
<td>0.8</td>
<td>0.8</td>
<td>0.9</td>
<td>0.1</td>
</tr>
<tr>
<td>Pt CSA</td>
<td>0.6</td>
<td>0.6</td>
<td>0.5</td>
<td>0.2</td>
</tr>
<tr>
<td>Pt thickness</td>
<td>0.3</td>
<td>0.3</td>
<td>0.01</td>
<td>-0.1</td>
</tr>
</tbody>
</table>

Pt – medial pterygoid muscle; CSA – cross-sectional area; Md – mandibular; Go – gonion

Table 6. Correlation coefficients of masseter muscles’ and mandibular variables in Class III patients

<table>
<thead>
<tr>
<th>Variables</th>
<th>Md length</th>
<th>Md ramus</th>
<th>Md body length</th>
<th>Go-Go distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mas volume</td>
<td>0.4</td>
<td>-0.3</td>
<td>0.6</td>
<td>0.1</td>
</tr>
<tr>
<td>Mas CSA</td>
<td>0.4</td>
<td>-0.3</td>
<td>0.6</td>
<td>0.3</td>
</tr>
<tr>
<td>Mas thickness</td>
<td>0.4</td>
<td>-0.6</td>
<td>0.7</td>
<td>0.3</td>
</tr>
<tr>
<td>Mas length</td>
<td>0.3</td>
<td>0.02</td>
<td>0.4</td>
<td>0.05</td>
</tr>
<tr>
<td>Mas width</td>
<td>0.3</td>
<td>0.1</td>
<td>0.4</td>
<td>0.04</td>
</tr>
</tbody>
</table>

Mas – masseter muscle; CSA – cross-sectional area; Md – mandibular; Go- gonion

Table 7. Correlation coefficients of medial pterygoid muscles’ and mandibular variables in Class III patient

<table>
<thead>
<tr>
<th>Variables</th>
<th>Md length</th>
<th>Md ramus</th>
<th>Md body length</th>
<th>Go-Go distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pt volume</td>
<td>0.2</td>
<td>0.02</td>
<td>0.6</td>
<td>0.01</td>
</tr>
<tr>
<td>Pt CSA</td>
<td>0.4</td>
<td>-0.4</td>
<td>0.5</td>
<td>0.01</td>
</tr>
<tr>
<td>Pt thickness</td>
<td>0.1</td>
<td>-0.1</td>
<td>0.2</td>
<td>-0.02</td>
</tr>
</tbody>
</table>

Pt – medial pterygoid muscle; CSA – cross-sectional area; Md – mandibular; Go – gonion

and Class III skeletal patients, larger mandibular muscles have a tendency toward wider transverse facial dimensions [9, 10], but it was not observed in our study. No correlations were found between intergonial width and any of muscular measurements.

CONCLUSIONS

1. Remarkable differences were observed between skeletal Class II and Class III study groups for both skeletal and muscular measurements.

2. More significant association between skeletal and muscular structures were observed in subjects with skeletal Class II malocclusion.

3. Profound examination (MRI and MSCT) of craniofacial structures in severe skeletal malocclusions might be relevant in planning orthodontic treatment and orthognathic surgery.

REFERENCES


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