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Volume and shape changes of mandibular condyles in growing patients treated with fixed Class II appliances using CBCT

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***Abstract*---**Objective: Evaluate the changes in the mandibular condyle volume and shape in growing Class II malocclusion patients, following the use of fixed functional Class II appliances (Forsus and Advacsync II). CBCT images were used to help understand which appliance might cause more changes. Methods: Twenty growing adolescent patients were randomly allocated to Two groups (Forsus and Advancesync II). A total of fourty CBCT images were taken pre- and posttreatment. The pre- and posttreatment CBCT images were segmented using a newly developed and validated semiautomatic condylar segmentation technique. and the quantitative assessment of the mean distance differences of the condyle surfaces was de using Iterative Closest Point technique. Results: A statistically significant increase in condylar volume was observed in both groups (Forsus and Advancesync II) and

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no significant differences in the magnitude of condylar volumes between both groups were found. There were no statistically significant changes in the mean distance differences of the condyles shape in both groups.Both groups (Forsus and Advancesync II) expressed different patterns of shape changes with no clear pattern associated with the treatment groups. Conclusions: The use of fixed Class II functional appliances (Forsus and Advancesync II) in Class II growing patients was not associated with any statistically significant changes in mean condyle volume and shape. Both groups in this study showed similar increases in condylar volume and no clear patterns of condylar shape changes, suggesting that any changes seen in the condyle volume and shape might be part of overall normal condylar growth.

***Keywords*---**condyle volume, fixed functional, forsus, advancesync II.

Introduction

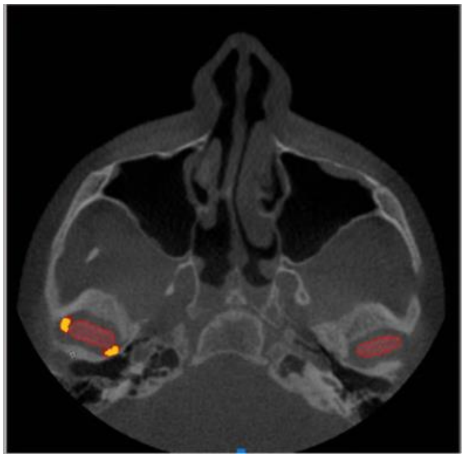
Class II malocclusion is frequently related with mandibular retrognathism, anterior displacement of the maxilla, greater posterior maxillary vertical dimension, mandibular fossa in the posterior position, maxillary constriction, or a combination of these characteristics. In general, maxillary and mandibular incisors are well-positioned, unlike maxillary incisors, which have a tendency to stand out. In class II skeletal malocclusions, it appears that mandibular retrognathism is a key contributing component.1 Kingsley (1879) was the first to employ the forward mandible position in orthodontic therapy. The detachable device produced by the author consists of a continuous labial wire, a posteriorly increasing biting region, and molar clasps, and is regarded as a prototype of oral myofunctional equipment. According to his description, the goal was not to protrude out the mandibular teeth, but to modify or jump bites in cases of extreme mandibular retrusion.2

Since the 1930s, myofunctional oral treatment equipment has been widely employed throughout Europe. This equipment, whether fixed or removable, is used to improve class II malocclusion while improving the shape and function of the upper and lower jaw, stimulating natural growth by transducing muscle strength to basal bone and dentoalveolar processes, which influence neuromuscular complexes, and treating mandible deficiency. Myofunctional oral treatment is believed to rectify sagittal discrepancies by expanding the maxilla, allowing the mandible to be put forward, because the development of the jaw forward is sometimes restricted by a small maxillary arch..3. The use of functional appliances to move the mandible forward appears to modify the stress status of TMJ tissues. The application of finite element analysis allows for a deeper comprehension of the influence of structural stress. This study seeks to investigate the condylar volume and shape changes related with the usage of Forsus and Advamcesync II fixed functional Class II appliances using CBCT imaging as a data source.

Material and Methods

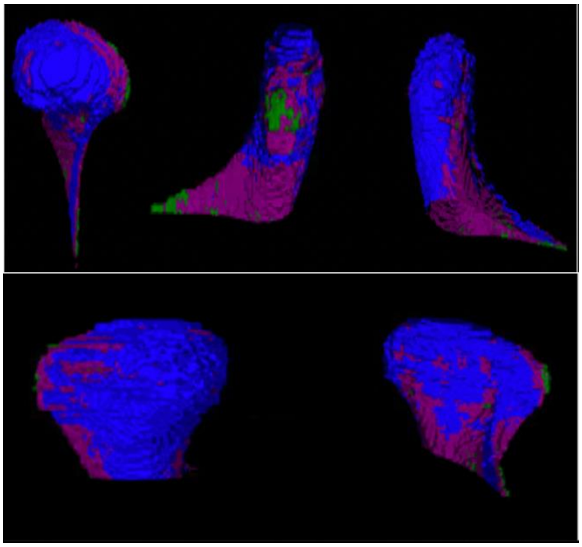
The data for this retrospective research project was collected from a randomized clinical trial that was approved by the scientific committee of orthodontic department of faculty of dental medicine Al-Azhar university, Assiut branch. The study sample was composed of growing Class II patients who were treated orthodontically at the outpatient clinic of orthodontic department. Treatment was performed by a single clinician. True blinding during clinical treatment was not possible as the study was performed by a single clinician who could easily differentiate between the appliances used in this study. To ensure equal group sampling, a block randomization method was done by a third-party statistician. The assignments were concealed in a numbered sealed envelope to ensure randomization was correctly done. The sample consisted of twenty healthy growing adolescent patients that were randomly assigned to one of two different groups (Forsus and Advancesync II) with no class II mechanics during the considered time period.

The CBCT images were acquired using an i-CAT machine (i-CAT, Imaging Sciences International, Hatfield, Pennsylvania) with the following parameters: 120kVp, 7mAs, 8.9 seconds, 13cm x 16cm FOV, and 0.3mm voxel size. The images were then transformed to Digital Imaging and Communications in Medicine (DICOM) format before being evaluated using the Avizo programme(standard edition version 9.1, Mercury Computer System Inc, Chelmsford, Mass).



Condyles of all the 40 CBCT scans were segmented using a validated semi-automated technique . Once the DICOM file was loaded into Avizo software, the researcher established the Isosurface of the scanned CBCT image. Before starting the segmentation process, the greyscale value of the CBCT slice was adjusted to enhance the difference between the condyle surface and the surrounding structures relying on the density difference between the two adjacent structures. To analyze the condyle shape, all of the segmented CBCT DICOM files were converted to Standard Tessellation Language (STL) files. In order to compare the pre- and posttreatment segmented condyles, the STL file for each segmented condyle, was oriented in a common standard space. The Iterative Closest Point

(ICP) technique was used to align and analyze the shape of the Condyles . Each superimposed condyle was assessed individually in all views (frontal, lateral, medial, superior and inferior) after clipping the inferior and anterior border to the Sigmoid notch, The descriptive analysis was repeated three times by the same researcher two weeks apart from each other.



Results

Table 1
Mean of MAD (mm) of left and Right condyles with 95% confident interval(CI)

Treatment	Right condyle mean (mm) 95%CI	Left condyle mean (mm) 95% CI
Forsus	0.357 [0.283,0.429]	0.365 [0.308,0.421]
Advancesync 2	0.445[0.363, 0.525]	0.409 [0.341,0.478]

Table
Mean increases in condylar volume from T1 to T2 of different treatment groups

Treatment	Mean increase (mm)3	Mean percentage increase
Forsus	45.46	3%
Advancesync 2	72.18	5.59%

Discussion

The effectiveness of fixed Class II functional appliances in correcting the Class II malocclusion has been extensively studied particularly in an attempt to understand the effect of those appliances in remodeling potential of the TMJ. The development of the 3D image using CBCT enabled researchers to better visualize and analyze the TMJ while reducing the image distortion from the superimposition and exposing the patient to a low radiation dose compared to CT image. Segmentation techniques permit clinicians and researchers to construct a 3D model of the condyle to study the volume and shape. Assessing and measuring the condyle volume and shape accurately relies on precisely identifying landmarks and the outline of the region of interest.

The present study demonstrated that using fixed Class II appliances (Forsus and Advacsync II) had no statistically significant effect on the mean condylar volume posttreatment. The results also revealed that there is mean increase of 4.77% in mean condylar volume posttreatment in both groups (Forsus and Advacsync II) regardless of condyle side (left and right). This indicates that remodeling and/or growth of mandibular condyles and its volume increase reflect possible normal growth rather than an orthodontic treatment effect. This result was surprising since the Advancesync II appliance is designed to prevent the condyle from seating in the glenoid fossa and produce continuous displacement force on the condyle which theoretically would be expected to induce more condylar remodeling response than the Forsus.

Regarding the condyle shape, the result from this study showed no statistically significant differences in average condylar surface displacement among both groups. This suggests that the force applied by the fixed Class II appliances did not result in any significant change in the condyle shape. Suggesting that an increase in mandibular condyle volume and the changes in condyle shape following the use of such appliances is likely part of the normal growth, not due to the force load applied to the joint during Class II fixed functional appliance treatment.

Conclusions

Fixed Class II appliances (Herbst and Crossbow) are not associated with any statistically significant change in mean condyle volume in Class II occlusion in growing patients. All the three groups in this study showed comparable increase in condylar volume, suggesting it might be part of overall normal condylar growth.

There was no statistically significant change in condylar shape and no clear pattern of shape changes associated with both treatment groups. No statistical difference in mean condylar volume and the increase in volume in all three groups is likely due to normal growth.

Recommendations

Further evaluation of condyle shape using a 3D regional registration and superimposition to assess a possible change in condyle shape that might not be detected with the used method in the current study. Evaluation of changes in mandibular condyle position in relation to the glenoid fossa following the use of fixed functional appliances.

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