Case Report

Three-Dimensional Magnetic Resonance Image of the Mandible and Masticatory Muscles in a Case of Juvenile Chronic Arthritis Treated With the Herbst Appliance

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Abstract: The present report documents, in a case of juvenile chronic arthritis (JCA) with mandibular retrognathia, three-dimensional (3D) changes in the mandible and the relationship between the mandible and the masticatory muscles resulting from treatment with the Herbst appliance after cessation of growth. Magnetic resonance scanning of the whole head was carried out before and after treatment. The mandible, the masseter, and the medial and lateral pterygoid muscles were segmented bilaterally and reconstructed in 3D for both stages. Superimposition of the datasets was carried out according to anatomical structures in the brain (cranial base). Mandibular superimposition was performed according to the mandibular symphysis and the lower mandibular border. The mandible moved forward and downward relative to the anterior cranial base. In addition, bone apposition was observed at the superior and posterior surfaces of both mandibular condyles and at the roof of the glenoid fossa. The masticatory muscles remained relatively stable in position in relation to the anterior cranial base. To our knowledge, such information in JCA patients has not previously been published in the literature. Using magnetic resonance imaging (MRI), it was possible to gain improved insight into the 3D morphology including soft tissues without the overlap of the surrounding tissues observed in the conventional radiographs. Accordingly, it is suggested that 3D magnetic resonance analysis is a more useful method for the follow-up of the JCA patients than radiographic techniques. (*Angle Orthod* 2002;72:81–87.)

Key Words: Juvenile chronic arthritis; Herbst appliance; Magnetic resonance image

INTRODUCTION

High frequencies of temporomandibular joint (TMJ) involvement have repeatedly been reported in children with juvenile chronic arthritis (JCA),[1–7] and numerous studies have documented that the TMJ involvement leads to dysplastic mandibular growth[8–15] and malocclusion.[3,4,6,10,16–18] Mandibular growth in JCA is characterized by a backward growth rotation, leading to mandibular retrognathia, distal molar occlusion, an increased overjet, and in some cases, frontal open bite.[13,14] In addition, many studies have shown that children with JCA and TMJ involvement frequently have impaired oral function,[1,2,4,5,13,18–22] eg, reduced mandibular movements, reduced strength of masticatory muscles, and pain. Various methods of treating malocclusion and mandibular retrognathia in individuals with JCA and TMJ involvement have been attempted, including functional ap-

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pliances,[2,15,23,24] fixed orthodontic appliances,[15,23] and combined orthodontic and surgical treatment.[13,23,25] Several authors have stressed the importance of early treatment in JCA to obtain good occlusal stability and thereby good working conditions for the musculature throughout the growth period.[2,13–15,24]

Proffit[25] stated that functional appliances are not recommended in children with JCA and TMJ involvement since stimulating increased bone turnover in the joint area may cause a net loss of skeletal tissue at the condyle rather than the desired net gain. Kjellberg et al[15] reported that JCA children treated with an activator often showed a change from distal to normal molar occlusion primarily due to dento-alveolar adaptation, whereas a significant skeletal improvement could not be verified. However, no cases showed loss of skeletal tissue in the condyles during treatment. Therefore, it is conjectured that functional appliances can be applied to patients with JCA if the condition of the TMJ is monitored carefully.

Distal occlusion, large overjet, and mandibular retrognathia in normal children have been treated successfully with the Herbst appliance, and several reports have documented forward positioning of the mandible and increased sagittal condylar growth.[26–34] The malocclusion was, in these reports, corrected partly through forward shift of the mandible and partly through dento-alveolar adaptation.[29–31] Such an effect would also be desirable in JCA patients with mandibular retrognathia. However, there are no reports available in the literature where the Herbst appliance has been applied to JCA patients.

The purposes of this study were to examine (1) the three-dimensional (3D) morphology and position of the mandible, including the TMJ and the masticatory muscles, before and after treatment with the Herbst appliance and (2) to evaluate the effect of the Herbst appliance on these structures in a case of JCA.

MATERIALS AND METHODS

Subject

The patient was a female who had suffered from polyarticular JCA from the age of 6 years 8 months. She was referred to the Department of Pediatric Dentistry, University of Copenhagen, at the age of 9 years 6 months because of mandibular retrognathia, mild asymmetry of the mandible (the left side of the mandible being shorter than the right side), extreme overjet (8 mm), distal molar occlusion, deviation of the mandibular midline to the left, and involvement of the left TMJ with flattening of the condyle.

Orthodontic treatment was attempted with an activator. This treatment was, however, not successful and therefore was discontinued after 1 1/2 years. After growth had ceased, the patient had an overjet of 9 mm and a frontal open bite (−1 mm) (Figure 1A) and still presented with deviation of the mandibular midline to the left side. During

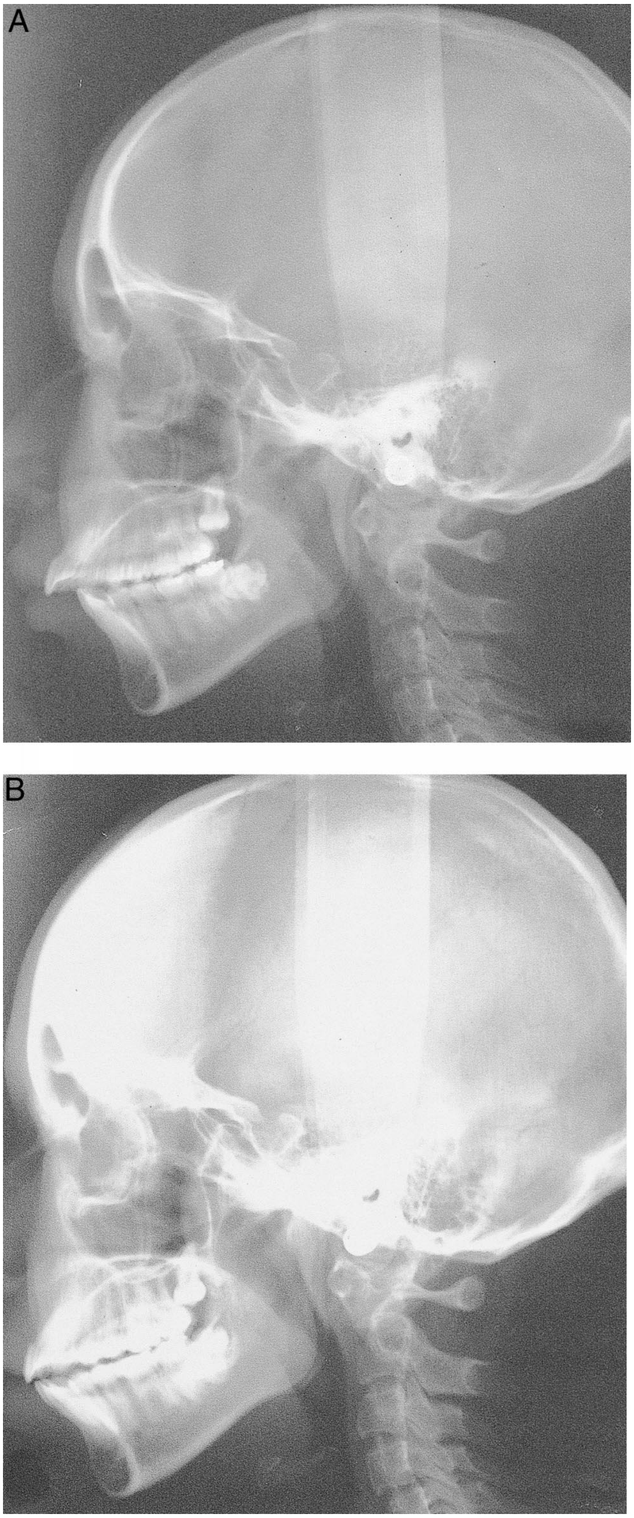

FIGURE 1. Lateral cephalometric radiographs. (A) Pretreatment (17 years 7 months). (B) Posttreatment (20 years). The chin appeared small and retrusive at the pretreatment but improved at the posttreatment examination. The overjet was corrected.

puberty, the patient developed mild involvement of the right TMJ with slight flattening of the condyle (Figure 2A) and the malocclusion became somewhat more pronounced. Orthognathic surgery was recommended at this time, but both the patient and the parents refused to accept a surgical procedure. As an alternative, the girl was offered treatment with the Herbst appliance, providing that the family would accept that the outcome of treatment could not be expected to be optimal and that careful monitoring of the TMJs during treatment was recommended. The family accepted these conditions, and the girl was, accordingly, treated with a Herbst appliance from 17 years 7 months to 18 years 6 months of age. Before treatment was initiated, magnetic resonance (MR) scanning of the TMJs was carried out, and no signs of activity of the JCA were found in the TMJ. During treatment, the JCA was still active in some other joints but not in the TMJ, and there was no pain from the TMJ at any stage of the treatment. MR scanning of the TMJs was repeated following the Herbst treatment.

Magnetic resonance imaging

MR scanning of the whole head was carried out at 17 years 3 months of age, just before treatment with the Herbst appliance was initiated, and again 1 1/2 years after the appliance was removed (20 years of age). Images were obtained by means of an MR scanner (Siemens, Erlangen, Germany) with head coil in a T1 weighted image of TR = 9.7 milliseconds and TE = 4.0 milliseconds. The field of view was 25 cm by 25 cm with a matrix size of 256 by 256 picture elements. The patient was placed in the supine position on the scanner table with the soft tissue Frankfort horizontal plane (tragus to soft tissue orbitale) positioned perpendicular to the floor. The patient was asked to maintain slight intercuspal contact between upper and lower teeth during the magnetic resonance imaging (MRI) examination without force exertion. A total of 143 slices of sagittal image were recorded before treatment and 64 slices of sagittal image after treatment. Each slice had a 1.0-mm thickness at the first examination and a 2.5-mm thickness at the second examination. Later, the second dataset was reformatted to a 1.0-mm slice thickness dataset so that it corresponded to the data obtained at the first examination before data analysis.

Data analyses

All MRI data were transferred to a graphic workstation (Silicon Graphics, Inc, Mountainview, Calif) using the software package Magic View™ (Siemens, Erlangen, Germany). The following 3D image analysis was implemented by use of the image analyzing software package Mvox™ (Anamedic, www.anamedic.com): The mandible, the masseter, and the medial and lateral pterygoid muscles were segmented bilaterally and reconstructed in 3D from the coronal slices. The condylar heads and glenoid fossae were segmented and reconstructed in 3D from the sagittal slices. The 3D objects reconstructed from the coronal and sagittal slices were fused, and the fused 3D objects were used for the following analyses.

Superimposition of the datasets was carried out according to anatomical structures in the brain by use of rigid landmark registration. The anterior and posterior horns of the lateral ventricle were selected bilaterally as the landmarks used for registration. The landmarks on the right side are shown in Figure 3.

In addition, mandibular superimposition was performed according to the mandibular symphysis and the lower mandibular border by use of the 3D software packages SceneViewer™ and Gview™ (Silicon Graphics, Inc).

RESULTS

Changes of profile and condyles

The profile was improved and no backward rotation of the mandible was observed as a result of treatment (Figure 1B). Loss of skeletal tissue in the condyles was not observed from pretreatment to posttreatment (Figure 2B).

Changes of mandible including the TMJ

Figure 4 provides the superimposition of the 3D mandibles registered according to the anatomical landmarks of the brain. The mandible was displaced forward and downward in relation to the anterior cranial base (the brain) as a result of the orthodontic treatment, and the overjet was corrected (Figure 1B). A small amount of bone apposition was observed at the roof of the left glenoid fossa, whereas the right glenoid fossa showed no changes during the treatment period.

Superimposition of the 3D mandibles, registered according to the mandibular symphysis and the lower mandibular border, is illustrated in Figure 5. Apposition of bone at both mandibular condyles, superiorly and posteriorly, was observed. The bone apposition was most marked on the left side.

Changes of masticatory muscles

Superimposition of the 3D mandibles including the masticatory muscles, registered according to the anatomical landmarks of the brain, is illustrated in Figure 6. Despite the forward shift of the mandible, the masseter and the medial and lateral pterygoid muscles remained in a relatively stable position relative to the anterior cranial base from the first to the second MRI examination. Superimposition of the 3D mandibles, including the masticatory muscles, registered according to the mandibular symphysis and the lower mandibular border, is illustrated in Figure 7. After treatment, the masseter and the medial pterygoid muscles were located more posteriorly relative to the mandible compared with the situation before treatment. After treat-

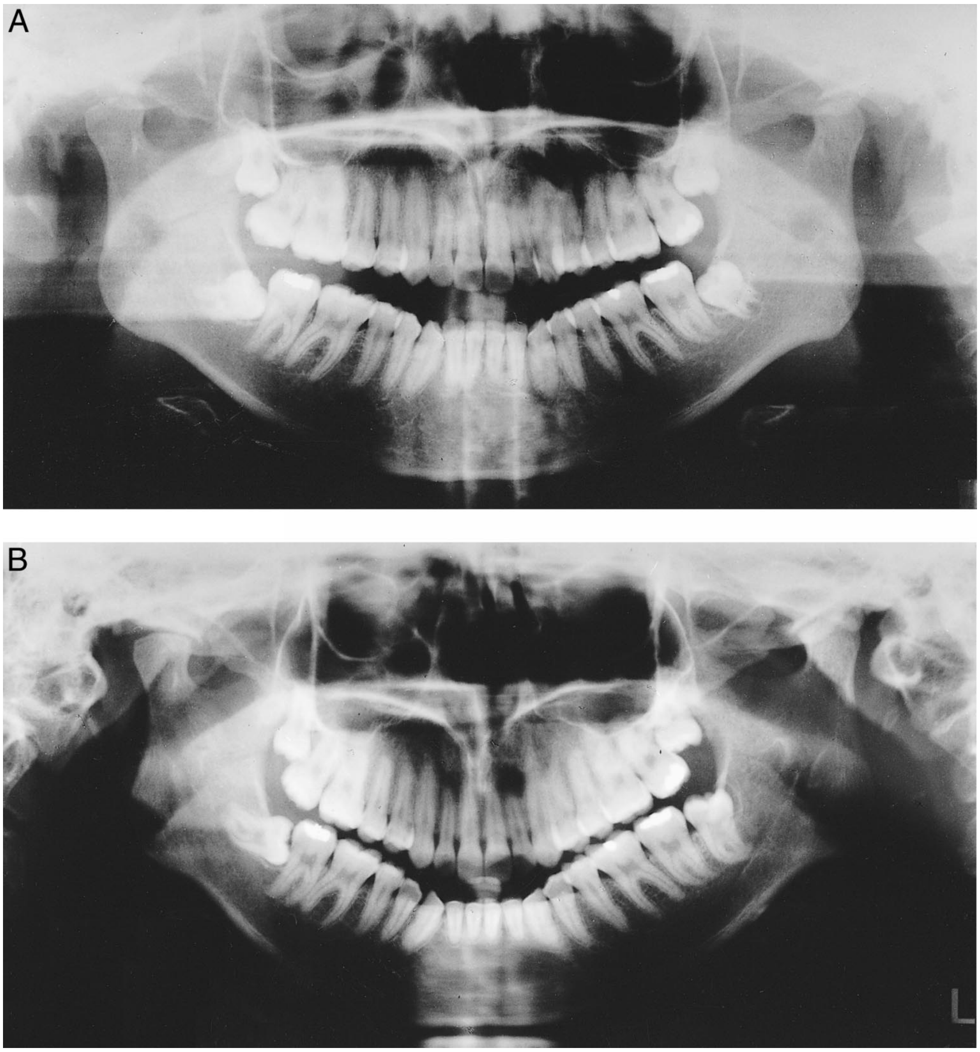

FIGURE 2. Panoramic radiographs. (A) Pretreatment (17 years 7 months). (B) Posttreatment (20 years).

ment, the lateral pterygoid muscle was located more superiorly relative to the mandibular symphysis and the lower mandibular border compared with the situation before treatment.

DISCUSSION

The present report documents, in a case of JCA, 3D changes in the mandible, the TMJ, and the relationship between the mandible and the anterior cranial base and the masticatory muscles resulting from treatment with the Herbst appliance after cessation of growth. To our knowledge, such information has not previously been published in the literature. The mandibular changes included both changes in the position and the size of the jaw. The mandible showed a forward and downward displacement relative to the anterior cranial base concomitant with apposition of bone at both condyles superiorly and posteriorly, most pronounced on the left side. In addition, a small amount of bone apposition was observed at the roof of the glenoid fossa on the left side. These findings are in accordance with the 2-dimensional observations made in normal Class II individuals treated with the Herbst appliance in late puberty or in the adolescent or adult period.[27,29,31,33,34] The fact that normal growth had ceased in the present case would seem to indicate that the bone apposition observed is an adaptive remodeling caused by the mechanical forces delivered by the appliance.[31,35] The finding of a more pronounced bone apposition at the left condyle combined with bone apposition in the left glenoid fossa can probably be related to the initial asymmetry of the mandible, with a shorter length of the left side. Paulsen[31] previously reported a similar finding.

Although we believe that an orthognathic surgical procedure would probably have led to a more satisfactory result in terms of facial morphology, the Herbst treatment corrected the malocclusion, and no clockwise rotation of the mandible and no adverse effects in the TMJ morphology were observed.

The reaction of the TMJ to the Herbst treatment is in

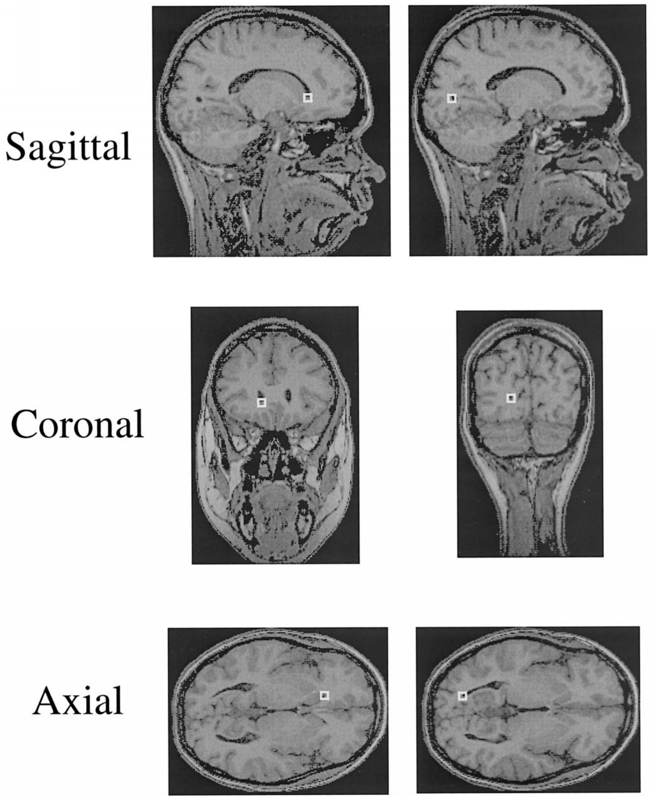

FIGURE 3. Anatomical landmarks on the right side used for registration on the brain (left, anterior horn of lateral ventricle; right, posterior horn of the lateral ventricle of the brain).

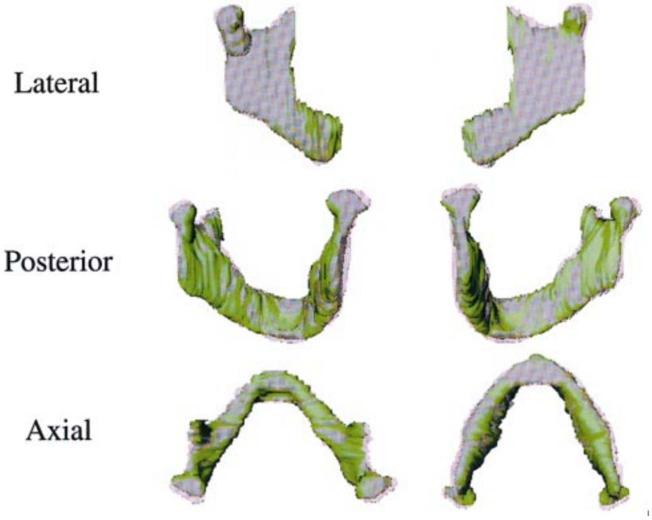

FIGURE 5. Superimposition of the 3D mandibles before and after treatment, registered according to the mandibular symphysis and the lower mandibular border (green, the 3D mandible before treatment; pink, the 3D mandible after treatment; top left, right side view; top right, left side view; middle left, right posterior view; middle right, left posterior view; bottom left, upper view; bottom right, lower view).

disagreement with the suggestion by Proffit[25] that use of a functional appliance in JCA may cause net loss of skeletal tissue at the condyle rather than the desired net gain. This statement may hold true if the arthritis of the TMJ is active but probably not if the arthritis is in remission. Furthermore, Kjellberg et al[15] found no loss of skeletal tissue in the condyles of JCA patients during activator treatment for Class II malocclusion.

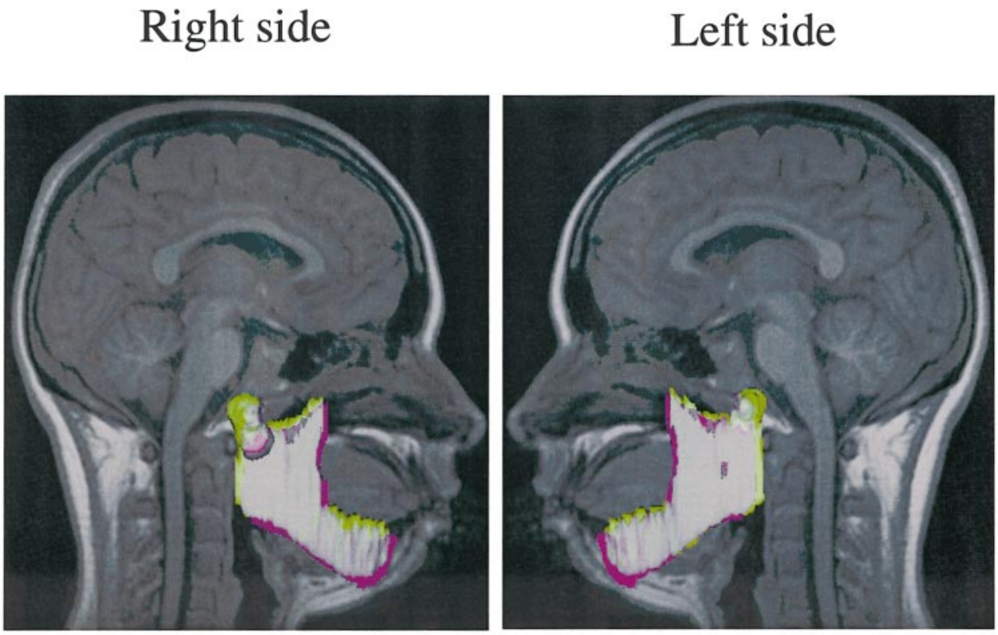

FIGURE 4. Lateral views of superimposition of the 3D mandibles before and after treatment, registered according to the anatomical landmarks of the brain (green, the 3D mandible before treatment; pink, the 3D mandible after treatment).

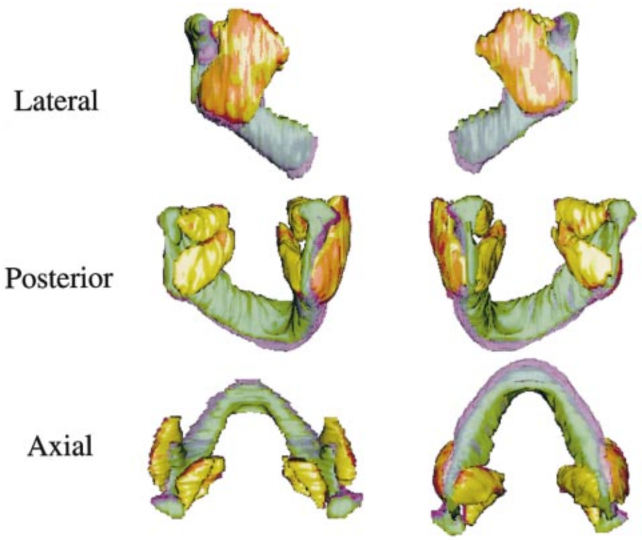

FIGURE 6. Superimposition of the 3D mandibles, including masticatory muscles before and after treatment, registered according to the anatomical landmarks of the brain (green, the mandible before treatment; pink, the mandible after treatment; yellow, the masticatory muscles before treatment; orange, the masticatory muscles after treatment; top left, right side view; top right, left side view; middle left, right posterior view; middle right, left posterior view; bottom left, upper view; bottom right, lower view).

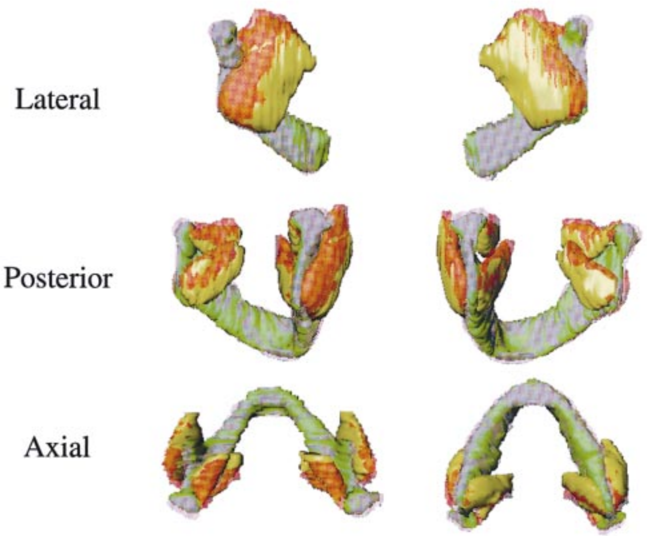

FIGURE 7. Superimposition of the 3D mandibles, including masticatory muscles before and after treatment, registered according to the mandibular symphysis and the lower mandibular border (see Figure 6).

The present study showed that the masseter-pterygoid muscle sling remained relatively stable in relation to the anterior cranial base during treatment with the Herbst treatment, ie, the mandible moved forward and downward relative to the musculature, including the lateral pterygoid muscles. No previous studies have analyzed this relationship. The posttreatment results presented here were those at 1 1/2 years after the appliance was removed. We can say that the treatment results after the removal of the appliance were stable for a short term. However, we should monitor the long-term stability because the finding of the positional relationship between the mandible and masticatory muscles is still not stable.

CONCLUSION

In this patient, the mandible moved forward and downward in relation to the anterior cranial base due to treatment with the Herbst appliance in a JCA patient. In addition, bone apposition was observed at the superior and posterior surfaces of the mandibular condyles and at the roof of the glenoid fossa. Surprisingly, the masticatory muscles did not follow the forward movement of the condyle but remained fairly stable in position relative to the anterior cranial base.

Thus, 3D changes of the mandible, the TMJ, and the relationship between the mandible and the masticatory muscles were documented. Using MRI, it was possible to gain improved insight into the 3D morphology, including the soft tissues without the overlap of the surrounding tissues observed in conventional radiographs. Accordingly, it is suggested that 3D MR analysis is a useful method for diagnosis and follow-up of patients with TMJ problems that, in future studies, may lead to an improved understanding of the reaction of the TMJ and the interrelationship between joints and muscles.

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