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COMPARATIVE EVALUATION OF MANDIBULAR CONDYLAR TRABECULAR BONE CHANGES

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ABSTRACT

This study aimed to compare changes in mandibular condylar trabecular bone structure in growing patients treated with a maxillary expansion appliance or a Twin Block–Monoblock appliance, using fractal analysis of panoramic radiographs. This retrospective study was designed to include 20 patients, allocated to two groups according to the appliance used: Group A, maxillary expansion appliance (n = 10), and Group B, Twin Block–Monoblock appliance (n = 10). Panoramic radiographs obtained before treatment (T0) and after treatment (T1) were evaluated. Mandibular condylar trabecular bone structure was assessed using fractal dimension analysis. The decrease in mean fractal dimension in Group A from 1.3261 ± 0.0599 at T0 to 1.2144 ± 0.054 at T1, and in Group B from 1.2567 ± 0.1314 at T0 to 1.218 ± 0.1972 at T1. The statistically significant pre- to post-treatment differences ($p < 0.05$). The mandibular condylar trabecular patterns change during treatment with both maxillary expansion and Twin Block–Monoblock appliances.

Keywords: Fractal Analysis; Mandibular Condyle; Maxillary Expansion; Twin Block Appliance; Monoblock Appliance; Orthodontic Treatment.

1 INTRODUCTION

Functional orthodontic appliances may be classified as removable or fixed according to whether they can be inserted and removed by the patient [1,2]. Removable appliances are widely used in orthodontic practice because they are relatively easy to use, facilitate oral hygiene, and are generally less costly than some fixed alternatives [3,4]. However, their bulk may interfere with speech and swallowing by reducing available tongue space, and their use may limit the simultaneous application of certain fixed orthodontic mechanics [4].

Functional jaw orthopedics seeks to promote adaptive responses in the craniofacial complex through changes in the functional environment. The relevant stimuli are generated by the orofacial musculature, including the masticatory,

facial, and tongue muscles, and may be transmitted to skeletal structures through muscle attachments and the periodontal ligament [5,6]. According to Wolff's law, bone adapts its internal architecture in response to changes in its mechanical environment [7]. Accordingly, alterations in loading associated with orthodontic and orthopedic treatment may be accompanied by remodeling of trabecular bone.

Maxillary expansion is used to correct transverse maxillary deficiency and may influence the spatial and functional relationship between the maxilla and mandible. Maxillary transverse constriction has been discussed as a factor that may affect mandibular positioning, while expansion may contribute to changes in the interarch relationship in selected patients [9–11]. Twin Block appliances, and related Monoblock designs, are used to modify mandibular posture in patients with sagittal discrepancies. The two-piece Twin Block design permits functional mandibular advancement and may also be combined with maxillary expansion when clinically indicated [12,13].

Previous studies have described dentoskeletal changes associated with functional appliance therapy, including changes in mandibular rotation, facial height, maxillary growth, and condylar adaptation [14–19]. However, the response of mandibular condylar trabecular architecture to different removable appliance protocols remains an area of interest. Fractal analysis provides a quantitative approach to describing the complexity of trabecular patterns on radiographic images.

The aim of the present study was to compare mandibular condylar trabecular bone changes following treatment with a maxillary expansion appliance and a Twin Block–Monoblock appliance by evaluating pre-treatment and post-treatment panoramic radiographs using fractal analysis.

2 MATERIALS AND METHODS

2.1 Study design and sample

This retrospective study evaluated panoramic radiographs obtained before (T0) and after (T1) orthodontic treatment in patients treated with removable orthodontic appliances. The sample was specified as 20 patients, with 10 patients in each group:

- Group A: Maxillary expansion appliance (n = 10).
- Group B: Twin Block–Monoblock appliance (n = 10).

2.2 Eligibility criteria

2.2.1 The inclusion criteria were:

Availability of diagnostically acceptable panoramic radiographs obtained at the beginning (T0) and at the completion (T1) of treatment.

- No radiographic evidence of a pathological condition affecting the mandibular condylar region.
- No congenital or acquired craniofacial anomaly, including cleft lip or palate, or a history of maxillofacial trauma.
- No history of previous orthodontic treatment.

Radiographs were required to have adequate image quality, including appropriate contrast, no substantial motion artifacts or magnification-related distortion, and sufficiently standardized head positioning.

2.3 Radiographic assessment and fractal analysis

Fractal analysis was used to quantify trabecular pattern complexity by calculating the fractal dimension. Panoramic radiographs were converted to TIFF format for digital image processing. The same anatomical region of interest should be selected in the mandibular condyle on each radiograph, using a standardized region-of-interest size and positioning protocol.

Malocclusion classification

- Class I malocclusion: ANB angle between 0° and 4°.
- Class II malocclusion: Class II molar and canine relationships, a convex facial profile, ANB angle greater than 4°, and a hyperdivergent growth pattern.

2.4 Statistical analysis

Continuous variables are presented as mean ± standard deviation (SD). Normality of data distribution was assessed before statistical testing. Comparisons of pre- and post-treatment mandibular condylar trabecular bone changes within each group were performed using the paired-samples *t*-test. Analyses should be performed using IBM SPSS Statistics (IBM Corp., Armonk, NY, USA), with the significance level set at $p < 0.05$.

3 RESULTS

- Group A (Maxillary expansion appliance): 1.3261 ± 0.0599 at T0 to 1.2144 ± 0.054 at T1.
- Group B (Twin Block–Monoblock appliance): 1.2567 ± 0.1314 at T0 to 1.218 ± 0.1972 at T1.

Statistically significant decreases in fractal dimension of mandibular condylar trabecular bone changes after treatment in both groups ($p < 0.05$).

4 DISCUSSION

Functional appliances are used to modify the dentoskeletal environment through changes in muscle activity, mandibular posture, and the distribution of mechanical forces [5,8]. Maxillary transverse deficiency may influence mandibular positioning and the interarch relationship. McNamara and Brudon [9] discussed the importance of maxillary transverse dimensions in the assessment of mandibular position, while other reports have described improvements in selected Class II relationships following maxillary expansion [10,11]. Such changes should not, however, be attributed exclusively to mandibular advancement or to a single mechanism.

Twin Block appliances are designed to posture the mandible forward through inclined bite blocks. Their two-piece construction distinguishes them from conventional Monoblock appliances and may facilitate functional mandibular advancement; treatment effects nevertheless depend on appliance design, patient growth, adherence, and the initial skeletal and dental characteristics [12,13]. Previous cephalometric studies have reported a range of dentoskeletal responses to Twin Block and other functional appliances, including changes in mandibular rotation, facial height, and maxillary growth [14–19].

Orthodontic loading may be associated with adaptive remodeling in the mandibular condyle. The magnitude and direction of such responses may vary according to the type, duration, and intensity of loading, as well as the patient's growth status. Fractal analysis may help characterize changes in trabecular architecture, but it does not directly measure bone mineral density and should not be interpreted as a direct densitometric assessment.

Several limitations should be considered. First, the retrospective design limits control over treatment protocols and radiographic acquisition. Second, panoramic radiographs are two-dimensional representations of three-dimensional structures and may be affected by positioning and projection-related variation. Third, the revised sample size is small.

5 CONCLUSION

Future prospective studies with larger samples, standardized radiographic protocols, clearly defined regions of interest, and blinded reliability assessments are warranted to clarify the relationship between different functional appliance protocols and mandibular condylar trabecular adaptation. The decrease in mandibular condylar fractal dimension after treatment with both maxillary expansion and Twin Block–Monoblock appliances.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

Availability of supporting data

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Disclosure of conflict of interest

The authors declare that they have no competing interests.

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