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Relationship between orthodontic treatment and bone density

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Abstract

The aim of this study is to examine the change in bone density around the apex of mandibular anterior teeth in groups formed based on malocclusion types after orthodontic treatment. A total of 18 individuals were included in the study, grouped according to malocclusion types (Class I, Class II, and Class III). This retrospective study analyzed the bone density around the apex of mandibular anterior teeth using fractal analysis on panoramic images. Bone density increased around the apex of mandibular anterior teeth in individuals with Class I, Class II, and Class III malocclusions after orthodontic treatment. Statistically significant differences were found in the change of bone density before and after orthodontic treatment among the malocclusion groups. The greatest change in bone density was observed in the Class III group, while the least change was in the Class I group. The fractal analysis method is a technique that facilitates the diagnosis of minimal changes occurring in patients undergoing orthodontic treatment. Potential changes in teeth and adjacent tissues should be carefully evaluated, and orthodontic treatments should be planned in accordance with these evaluations.

Keywords: Fractal analysis; Orthodontic treatment; Orthodontic malocclusion; Mandibula; Bone density

1. Introduction

The oral region is a complex structure that includes teeth, bones, nerves, masticatory muscles, or a combination of these structures (Poveda Roda et al., 2007; Okeson, 1995). Orthodontic disorders can affect individuals of all ages (Moyaho-Bernal et al., 2010). Changes in bone due to orthodontic treatment have been found to be associated with factors such as tooth loss, improper orthodontic treatment, occlusal disorders, trauma, psychological stress, masticatory muscle fatigue, dysfunction, or parafunctional habits (Okeson, 1995). The bone quality of the mandibular anterior region depends on several factors, including trabecular continuity, bone geometry, micro-damage in the bone, bone tissue architecture, the amount of mineralization, and defects. In the past years, bone mineral density measurement has frequently been used to analyze bone structure (Çakur et al., 2008). Fractal geometric applications and fractal dimension measurements can be used to describe the complex structure of trabecular bone (Bollen et al., 2001). Since bone tissues are part of the craniofacial complex, orthodontists also examine bone formations constituting joints for diagnosis and planning, and orthodontic treatment can be modified before any existing or potential deformities occur. Based on the literature, the aim of this study is to investigate the effects of orthodontic treatment on mandibular anterior region bone formation according to malocclusion groups.

2. Materials and methods

A total of 18 individuals were included in the study, grouped according to malocclusion types (Class I, Class II, and Class III). The study was conducted retrospectively. The bone density around the apex of mandibular anterior teeth was analyzed using fractal analysis on panoramic images. The patients included in the study were scanned from the archives according to specific inclusion criteria. Inclusion criteria for participants were having a panoramic film at the start of

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treatment, no pathology in the mandibular anterior region, no congenital and/or acquired anomalies (such as cleft lip), and no previous orthodontic treatment. Patients were classified into malocclusion groups based on the bone quality of the mandibular condyle: skeletal Class I malocclusion (6 patients), skeletal Class II malocclusion (6 patients), and skeletal Class III malocclusion (6 patients). The bone quality of the mandibular condyle in panoramic images taken before orthodontic treatment was compared with that in images taken after the completion of treatment.

Panoramic films taken with the same X-ray device at the beginning and after orthodontic treatment were used for all patients. Only images with no problems affecting bone quality (such as magnification, low contrast, or blurriness) and those taken in or close to a natural head position were selected. The quality of the trabecular bone in the mandibular condyle was analyzed using the fractal analysis method, which measures the complexity of repeating geometric patterns through a value called the fractal dimension. The patients' panoramic radiographs were converted into TIFF format, and fractal analysis was performed on the images.

3. Results

The Class I malocclusion group consisted of 3 males and 3 females. The Class II malocclusion group included 3 males and 3 females, while the Class III malocclusion group had 3 males and 3 females. According to the findings, no statistically significant difference was found in the change of bone quality in the mandibular anterior region before and after orthodontic treatment when considering age and gender.

When patients were examined according to malocclusion groups, the average chronological age of the 6 patients in the Class I group was 182.50 ± 41.09 months. The trabecular structure of the mandibular anterior region in Class I orthodontic patients was 1.331 ± 0.086 before treatment and 1.372 ± 0.077 after treatment. The change in the trabecular structure of the mandibular anterior region in Class I malocclusion patients was statistically significant between pre- and post-treatment ($p < 0.05$).

For the Class II group, the average chronological age was 172.85 ± 34.09 months. The trabecular structure in Class II patients was 1.336 ± 0.074 before treatment and 1.316 ± 0.128 after treatment. No statistically significant difference was found in the trabecular structure of the mandibular anterior region in Class II patients between pre- and post-treatment ($p > 0.05$).

For the Class III group, the average chronological age was 195.56 ± 18.36 months. The trabecular structure in Class III patients was 1.309 ± 0.044 before treatment and 1.347 ± 0.084 after treatment. No statistically significant difference was found in the trabecular structure of the mandibular anterior region in Class III patients between pre- and post-treatment.
After orthodontic treatment, bone density around the apex of mandibular anterior teeth increased in individuals with Class I, Class II, and Class III malocclusions. The change in bone density around the apex of mandibular anterior teeth before and after orthodontic treatment differed significantly among the malocclusion groups, with the greatest change observed in the Class III group and the least change in the Class I group.

4. Discussion

The fractal analysis method facilitates the diagnosis of minimal changes occurring in patients undergoing orthodontic treatment. Changes in teeth and adjacent tissues after orthodontic treatment should be carefully evaluated, and orthodontic treatments should be planned accordingly. In some patients who have undergone orthodontic treatment, changes in bone quality in the mandibular anterior region, as well as temporomandibular disorders, may occur. Based on this information, this study investigated the change in bone quality in the mandibular anterior region following orthodontic treatment in different patient groups.

Bone tissue is a key element of the musculoskeletal system that enables movement and supports various functions. Bone tissue consists of trabecular and compact compartments, with trabecular bone being more metabolically active despite comprising only 20% of total bone mass (Southard et al., 1996). Various studies have indicated that diseases affecting bone tissue show earlier signs in trabecular bone (White SC and Rudolph, 1996). Fractal analysis has become a popular tool for early diagnosis of trabecular bone microstructure, especially with technological advancements and the increasing use of computers in research. This method, which uses a mathematical image analysis algorithm, has been shown to be beneficial in biological image analysis (Law et al., 1996). In this study, fractal analysis was used to examine the trabecular structure of the mandibular condyle bone.

Research examining the relationship between orthodontic treatments and mandibular bone quality has yielded mixed results. Sadowsky and BeGole compared the records of 75 orthodontic patients 10 years after treatment with those who had not undergone orthodontic treatment and found no difference in mandibular bone quality between the two groups (Sadowsky and BeGole, 1980). Similarly, Sadowsky and Polson reported no association between fixed orthodontic treatments and mandibular bone quality (Sadowsky and Polson, 1984). Dibbets and Van der Weele studied the relationship between orthodontic treatments and mandibular bone quality in malocclusion groups and found that orthodontic treatment did not cause mandibular bone deformities (Dibbets and Van der Weele, 1991). Since the bone structure of patients undergoing orthodontic treatment tends to become more spongy, the fractal dimension of trabecular bone may decrease after treatment. Bone quality is influenced by several factors, including trabecular continuity, bone geometry, micro-damage in the bone, mineralization defects, and bone tissue architecture. Fractal analysis is a technique that facilitates the diagnosis of minimal changes in radiographs of orthodontic patients and helps assess the progression of disease. A relationship was found between orthodontic treatment in different malocclusion groups and mandibular bone quality. Therefore, when evaluating orthodontic treatments, mandibular bone quality should be taken into consideration.

5. Conclusion

A relationship was found between orthodontic treatment applied to different malocclusion groups and mandibular anterior bone formation. When evaluating orthodontic treatments, mandibular anterior bone formation should be taken into consideration.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of ethical approval

This study was conducted by getting permission from Izmir Katip Celebi University Human Ethics Research Committee.

Statement of informed consent

The approval from the Ethics Committee of Izmir Katip Çelebi University was granted in accordance with the principles of Declaration of Helsinki and informed consent was obtained prior to sample collection.

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