Volumetric Pulp Changes after Orthodontic Treatment Determined by Cone-beam Computed Tomography

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Abstract

Introduction: The purpose of this study was to observe and evaluate 3-dimensional pulp cavity changes during orthodontic treatment. **Methods:** Eighty-seven patients formed the study sample and were divided into an experimental group (48 patients) and a control group (39 patients). Cone-beam computed tomographic (CBCT) records were obtained before the start of the treatment (T0) and after space closure for the experimental group, whereas for the control group CBCT images were obtained approximately 17–18 months (T1) after obtaining the first image (T0). CBCT data were reconstructed with surface and volume rendering software (Mimics; Materialise, Leuven, Belgium), and the volumetric images were modified to display the teeth from various orientations. Six anterior teeth were segmented and their pulps isolated. Paired *t* test was used to check for statistical significance. **Results:** The difference in the pulp volume was statistically significant at $P < .05$ for all the anterior teeth in the experimental group and at $P < .05$ for the right canine, $P < .05$ for the right and left lateral incisors, and $P < .05$ for the left central in the control group. **Conclusions:** Orthodontic treatment in the experimental group produced a significant decrease in the size of the pulp, which was statistically significant. *(J Endod 2014;40:1758–1763)*

Key Words

Cone-beam computed tomography, mimics, pulp cavity, tertiary dentin

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An injury to the teeth might affect the pulp or the periodontium. If the injury is not severe, the pulp recovers from it by tertiary dentin deposition, whereas if the periodontium is injured, it results in surface resorption (1, 2). Orthodontic therapy involves the application of forces on teeth in order to obtain desired tooth movement. Forces within the physiologic limits bring about a physiologic response in the teeth and the periodontium, but orthodontic treatment can cause adverse tissue reactions as well. One of the consequences of such adverse reactions is external apical root resorption (EARR). The causes for EARR can be multifactorial, such as genetic and systemic factors, orthodontic force magnitude, tooth movement type, sex, duration, and type of force (3, 4), but most of the literature is focused on the effect of orthodontic force and tooth movement on EARR (5–9).

Orthodontic force, which is considered a so-called controlled trauma (10), could produce an injury to the pulp because a lack of collateral circulation in the pulp makes it one of the most sensitive tissues in the body. Histologic studies evaluating the changes in the pulp after orthodontic tooth movement suggest the etiology to be disruption of the odontoblastic layer, compromise of pulpal blood flow, formation of secondary dentin, and vacuolization of pulpal tissue (11–15). Recent studies suggest an increase in angiogenic growth factors in the pulp of orthodontically moved teeth (16). Studies using radiorespirometric techniques suggest depression of the respiration rate of the pulp in the tooth subjected to orthodontic forces (17, 18). Popp et al (10) compared the pulp size radiographically of individuals who had undergone orthodontic treatment with untreated individuals and found a decrease in pulp cavity size in both groups. These studies implicate that orthodontic treatment might have iatrogenic effects on the long-term vitality of teeth.

Traditionally, pulp changes have been detected through periapical radiographs, pulp vitality tests, histologic sections, and scanning electron microscopy (SEM). However, magnification errors and inaccurate reiterative abilities have made the usage of these aforementioned modalities questionable. Also, the area of pulp cavity measured on conventional radiographs gives the size in 2 dimensions, which is not reliable because the pulp cavity is a 3-dimensional (3D) structure. Although histologic studies have shown accuracy in determining the orthodontically induced changes in the pulp, routine clinical application of the histologic evaluation requires extraction of the tooth, and, hence, its clinical application during and after orthodontic treatment is ambiguous. In recent years, cone-beam computed tomographic (CBCT) imaging has revolutionized the way diagnosis and treatment planning is made in orthodontics (19–22). CBCT imaging has also been used for the detection of EARR in all 3 planes. Recently, various studies have been performed to evaluate the change in root volume caused by EARR after orthodontic treatment (23, 24). Until now, no prospective long-term studies have appeared in the literature reporting on the effect of orthodontic treatment on the volume of pulpal tissues. Therefore, the aim of this study was to quantitatively evaluate the volumetric change of pulp tissue during orthodontic therapy using CBCT imaging.

Materials and Methods

CBCT images of 48 patients (21 males and 27 females, mean age = 18.1 years) who were undergoing orthodontic treatment (experimental group) were selected from the database of the Department of Orthodontics and Dentofacial Orthopedics (after getting approval from the institutional review board and ethical committee and informed consent from patients or parents for minor patients). The test subjects had proclination with mild to moderate crowding in the anterior teeth. The control subjects consisting of 39 patients (23 females and 16 males, mean age = 17.5 years) were compared with the experimental group and were selected from the institutional database records from the Department of Oral Medicine and Radiology and an adjacent diagnostic facility. The records were matched according to age and malocclusion type. Patients in the experimental group were treated with a preadjusted edgewise appliance with McLaughlin Bennett Trevisi (MBT) prescription (0.022-in. Gemini Series Bracket; 3M Unitek, Monrovia, CA). The experimental group was treated by extraction therapy, which required the extraction of all first premolars. Leveling and alignment were completed with 0.016/0.018-in. superelastic nickel-titanium or stainless steel wires. Space closure was performed using 0.019 × 0.025-in. stainless steel archwire with sliding mechanics. A controlled force of 150 g was applied using NiTi coil springs for en masse retraction of the anterior teeth. Patients with a previous history of orthodontic treatment, traumatic injuries, or restorations were excluded from both the experimental and control groups.

CBCT images were taken of the 6 maxillary anterior teeth before the start of treatment (T0) and after completion of space closure (T1) for the experimental group, whereas for the control group CBCT images were obtained approximately 17–18 months (T1 [in order to match the average time duration taken for space closure in the experimental group]) after obtaining the first image (T0). All the CBCT images were generated using the Kodak 9000 3D (Kodak Carestream Health, Trophy, France). Specifications for rendering images were as follows: exposure at 70 kVp, 10 milliamperage, and exposure time of 10.8 seconds. The DICOM files were imported into computed tomographic and CBCT diagnosis and treatment planning software (Mimics Version 14 on Windows; Materialise, Leuven, Belgium), which allows soft and hard tissue volume calculations. Separation and segmentation of the involved teeth were automatically performed by setting a grayscale threshold referring to the grayscale of the different tooth and surrounding tissue components and was manually checked and corrected whenever necessary. The detailed procedure is as follows.

To segment the selected tooth, a mask is created, and an optimal separating grayscale threshold is chosen on axial images showing the tooth in bone. Threshold values were set individually for each patient. The same Hounsfield Units (HU) was used for the segmentation of each patient's before and after records (Fig. 1). The mask is cropped in 3 axes to limit it to the closest region of the selected tooth, and a 3D image (3D) is calculated. A 3D calculation of the mask assembling

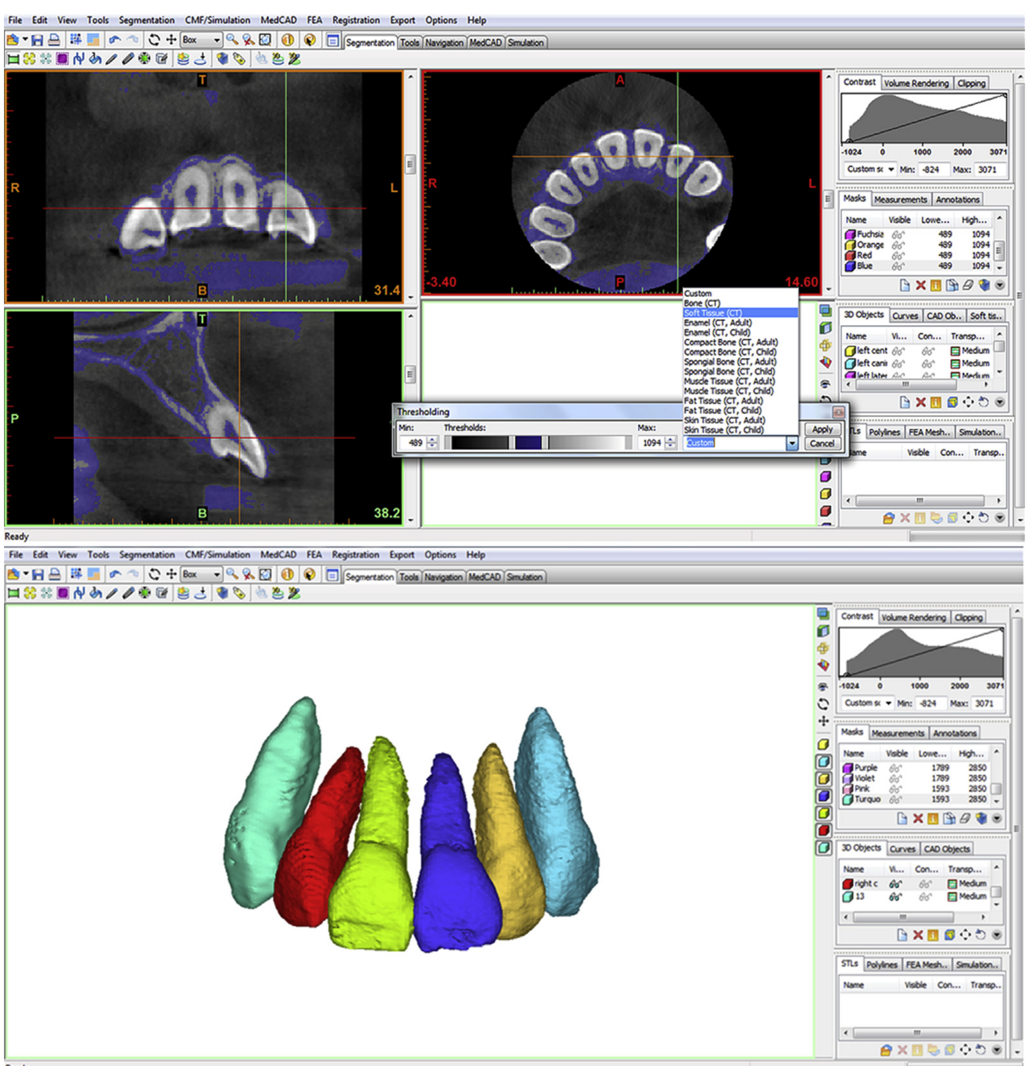

Figure 1. Thresholding of tissues according to the predefined density values (Hounsfield units) and segmentation of 6 anterior teeth on Mimics software.