Long-term follow-up of enamel color changes after treatment with fixed orthodontic appliances

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Introduction: The aim of this study was the long-term follow-up of enamel color changes observed in the middle third of buccal tooth surfaces after treatment with fixed orthodontic appliances. **Methods:** The study included 120 maxillary central and lateral incisors and canines of 20 subjects who had fixed orthodontic treatment. The Spectro Shade Micro device (MHT, Verona, Italy) was used to evaluate the color changes of the teeth. Measurements were made from the middle third of the buccal surfaces of the teeth after fixed orthodontic treatment and in month 3, month 6, and year 1 of the retention phase. The Commission Internationale de l'Echairage L* a* b* system that expresses the color coordinates in L*, a*, and b* symbols was used to determine the tooth color, and ΔE values between the time periods were calculated. Repeated measurement analysis of variance was used in evaluating the color changes. **Results:** The increases in ΔL values at 3 months, 6 months, and 1 year after treatment were statistically significant, whereas they were not statistically significant from months 3 to 6, month 3 to year 1, or month 6 to year 1. The decrease in Δa and the increase in Δb values were not statistically significant. ΔE values at all time periods were statistically significant within themselves, and the greatest change was observed 1 year after treatment. ΔE values were 1.52 to 3.57, and a visible but clinically acceptable color change occurred. **Conclusions:** In the first 3 months, there was a significant increase in the lightness of the tooth color. (Am J Orthod Dentofacial Orthop 2018;154:213-20)

Since the introduction of the acid-etching technique, orthodontic brackets have been directly bonded to the enamel surfaces.[1] The adhesion between the enamel surface and adhesive must resist the orthodontic forces applied during treatment[1,2] and cause a minimum of enamel loss so that it can return to its original state after the treatment.[3]

Enamel loss due to bonding and debonding procedures may result from acid etching, debonding forces, and mechanical removal of residual adhesives by rotary instruments.[4] Debonding and cleaning procedures may also cause enamel microcracks, scratches, abrasions, and inhibition of remineralization leading to decalcification and caries.[5] In addition to these structural and surface defects, enamel color changes may stem from irreversible penetration of resin tags to the enamel surface up to 50 μm.[3,6] These color changes are caused by absorption of coloring agents in foods and corrosion products from orthodontic brackets to resin tags that cannot be resolved by debonding and cleaning procedures.[6] The long-term penetration of these resin residues into enamel tags in the middle third of the buccal surfaces of teeth makes the color change in this material critical for the teeth.[5]

Two common methods—visual determination and instrumental measurement—are used to determine in-vivo tooth color.[7,8] Although visual determination, by comparison of a tooth with tooth shade guides, is a subjective method, it is the most applied method in dentistry. However, external light conditions, age, experience, fatigue of the eyes, and natural limitations of the tooth shade guides influence the consistency of the color selection.[7,9] Along with the rapid progress in optical electronic sensors and

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computer technology, the general demand for objective color evaluation made the instrumental measurement a supplementary adjunct to visual determination.[7,8] Today tristimulus colorimeters, spectroradiometers, digital color analyzers, and spectrophotometers are used in objective color evaluation.[7,9]

The aim of this study was a long-term follow-up of color changes observed in the enamel surface due to fixed orthodontic treatment, with the Spectro Shade Micro device (MHT International, Verona, Italy). The null hypothesis was that these enamel color changes in the middle third of the buccal surfaces of the teeth, where the brackets are placed, may also increase after orthodontic treatment from the coloring agents in foods.

MATERIAL AND METHODS

The study included 20 subjects who had fixed orthodontic treatment with the straight wire technique using 0.018-in slot Roth brackets at the Department of Orthodontics, Faculty of Dentistry, Yüzüncü Yıl University, Van, Turkey. The inclusion criteria were good oral hygiene, no plaque accumulation and gingival inflammation, no decay and decalcification in teeth caused by fixed orthodontic treatment, not drinking more than 3 cups of coffee or tea a day, and no cigarette or alcohol use. Subjects who had functional orthopedic treatment and would not continue during the retention phase were not included in this study.

The study began after approval from the Yüzüncü Yıl University Faculty of Medicine, research ethics committee (B.30.2.YYU.0.01.00.00/70). The fixed orthodontic treatment of patients and the evaluation of oral hygiene and tooth surfaces after treatment were performed by 1 investigator (Y.K.). After we provided a detailed description of the study, written and informed consent was obtained from all participants.

The Spectro Shade Micro device was used to evaluate the tooth color changes. Spectrophotometers, working with the multi-sensor principle, are equipped with sensors that can measure in many wavelengths and perceive colors that the human eye cannot detect.[10]

The Commission Internationale de l'Eclairage (CIE) L*a*b* system that expresses the color coordinates in L*, a*, and b* symbols was used in determining the tooth color. The coordinate L* is related to lightness, and the coordinates a* and b* refer to the red-green and yellow-blue axes, respectively. Whereas the coordinate L* is located on the vertical axis containing values from 0 (absolute black) to 100 (absolute white), coordinates a* and b* rotate in the axis around L* and take values from −128 to 127. When a* has positive and negative values, the color becomes red and green, respectively, and when b* has positive and negative values, the color becomes yellow and blue, respectively.[11] The spectrophotometric images of tooth taken twice (ΔE) resulting from the color measurement made with the CIE L* a* b* system indicates how much the color can be perceived by the human eye. $\Delta E < 1$, $1 \leq \Delta E \leq 3.7$ and $\Delta E > 1$ express the invisible, visible but clinically acceptable, and visible and clinically unacceptable tooth colors, respectively. ΔE values between the groups were calculated with the following equations: $\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$; $\Delta L^* = L^*\text{second} - L^*\text{first}$; $\Delta a^* = a^*\text{second} - a^*\text{first}$; and $\Delta b^* = b^*\text{second} - b^*\text{first}$.[7,11]

Before debonding, the treatment outcomes were assessed by using the objective grading system of the American Board of Orthodontics Phase III clinical examination.[12] After mechanical removal of the orthodontic appliances with a debonding plier (Dentaurum, Pforzheim, Germany), residual adhesive on the tooth surfaces was cleaned with a 12-bladed tungsten carbide bur (Axis Dental, Irving, Tex) at low speed under water cooling. Then, the tooth surfaces were visually evaluated under the dental operation light for any residual adhesive and polished with fluoride-free pumice (Imıpomza; Imıcryl, Konya, Turkey). The subjects in the study were instructed to brush their teeth regularly with white toothpaste and not to use mouthwashes that cause coloring in teeth such as chlorhexidine. For the retention phase, fixed retainers, which do not hinder oral hygiene, were applied from canine to canine in the maxillary and mandibular dental arches.

Maxillary central lateral incisors and canines were used as the references in determining tooth colors. Thirty minutes before the measurement, all teeth were cleaned with a rubber-polishing pad and white toothpaste with a low-speed hand piece and thoroughly rinsed with water. The Spectro Shade Micro device was calibrated using the white and green ceramic tiles from the manufacturer. The optical hand piece of the device was positioned at 90° to target the view and then correctly positioned to the gingival matrix. The spectrophotometric image of each tooth was recorded twice by positioning, removing, and again positioning the intraoral camera on the labial surfaces of the teeth that were wet with saliva. These images were compared using the synchronized image program. $\Delta E \leq 1$ were used, and the images with $\Delta E > 1$ were removed; new images were captured so as not to cause erroneous measurements. Spectrophotometric evaluation of each tooth was performed from the middle third of the buccal tooth surface that was divided into 3 equal parts in the horizontal direction by the program (Fig). All images were recorded by the same researcher (Y.K.) after fixed orthodontic treatment and in month