CASE REPORTS

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Undesirable dental hard tissue effects hypothetically linked to orthodontics – a microscopic study

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Abstract

Like any other medical intervention, the orthodontic treatment may have, besides the positive effects, also unwanted secondary consequences. The aim of this study was to evaluate the changes present in dental hard tissue associated with orthodontic treatment. The stereo-microscopic *ex vivo* analysis was performed on two sets of maxillary first premolars undergoing orthodontic treatment for a long period of time (12 and 23 months); five teeth with other clinical situations were used as controls. By analyzing the teeth undergoing orthodontics, enamel color alterations were mainly found adjacent to the bracket, more pronounced in the gingival area, suggesting the need for a correct oral hygiene around it. Roughness was higher on the enamel surface corresponding to the bracket's base, aspect linked to the resign impregnation during bonding procedures. At the apical part, changes regarding contour, appearance and surface roughness were noticed. These modifications were suggestive for the presence of apical root resorption. The severity of root resorption was not correlated with the duration of treatment. In conclusion, through microscopic analysis changes that may be associated with orthodontic treatment have been observed in both crown and apical level.

Keywords: orthodontic treatment, discoloration, root resorption, microscope.

Introduction

Orthodontic treatment aims to improve the oral health, functionality and aesthetics, with positive consequences on quality of life [1]. Besides the expected improvements, like in any other medical intervention, some unwanted side effects may occur [2, 3]. Local conditions, hypothetically linked to orthodontics, include mainly dental and periodontal changes. Enamel involvement may appear due to poor oral hygiene and during bonding and debonding procedures [4, 5]. Complications such as tooth discolorations, decalcifications, caries and enamel fractures may appear. Also, in less than 5% of the patients with a history of orthodontic treatment, severe root resorption with shortening greater than a quarter of original tooth length can be found [6]. The presence of these unwanted changes can interfere with the time prognosis of the teeth and quality of treatment [3, 7, 8].

Most studies, which analyze the changes in hard dental tissue associated to orthodontic treatment, using the microscope as mean of investigation, are performed on teeth with short-term history of orthodontic treatment, usually less than two months [9–13]. Protocol will require, often, the selection of cases in which extraction is indicated and prior to tooth ablation, the orthodontic device will be applied. The new element in this series of cases is that the microscopic analysis, which is high sensitive, was performed on extracted teeth with a history of orthodontic treatment carried out over a long period of time (12 and 23 months). Also, the microscopic investigation was performed during treatment, right after the impact of specific oral factors and orthodontic forces, and not after a period of time after removing the orthodontic device, when would have been possible for the human body's own repair mechanisms to act. Using these teeth during the study was possible by identifying in the Department of Orthodontics and Dento-Facial Orthopedics of the Faculty of Dentistry, "Carol Davila" University of Medicine and Pharmacy, Bucharest, within one year, of two cases that presented fixed orthodontic devices, on which was necessary to review and change the treatment plan, with the assessment of the need to extract, on orthodontic purpose, the upper first premolars.

The aim of this case series study was to evaluate the changes present in dental hard tissue associated with orthodontic treatment. We chose to analyze tooth surface from two significant areas: crown (due to the

direct relation of the buccal surface with the bracket) and the apical part of the root (where root resorption, as an indirect effect, can occur).

Materials and Methods

In order to achieve the proposed objectives, nine extracted teeth were analyzed: four first upper premolars with a history of orthodontic treatment (representing the study group) and five teeth with other clinical situations (representing the control group). The four premolars with a history of orthodontic treatment were collected from two patients undergoing treatment with fixed orthodontic appliances, at the Department of Orthodontics and Dento-Facial Orthopedics, Faculty of Dentistry, "Carol Davila" University of Medicine and Pharmacy. On both cases, after reviewing the treatment plan, the decision to extract the upper first premolars was taken. The first case is represented by a female patient, aged 13 years, from Bucharest, diagnosed with Angle Class II Division 1 malocclusion. The cephalometric values indicate a skeletal Class I (ANB = 4), normodivergent (FMA angle = 27) pattern. The treatment started in February 2008, with the application on the vestibular surface of the roots of the metallic brackets, slot size 0.022×0.028 inch. As bonding material, a self-curing composite resin was used. The arch-wire sequence before teeth extraction was: 0.014-inch nickel titanium, 0.016×0.022 inch stainless steel, 0.017×0.022 inch stainless steel. During treatment, the patient did not present to appointments according to the treatment schedules, having an uncooperative attitude. Oral hygiene status was assessed as being unsatisfactory, and all the training efforts to improve it have been without positive results. In February 2009, after revaluation of the treatment plan was decided to extract the upper first premolars. The second case is represented also by a female patient, aged 12 years, from Bucharest, diagnosed with Angle Class II Division 1 malocclusion, with severe overjet. The cephalometric analysis showed that she had a Class I skeletal relationship (ANB = 4) and a normodivergent pattern (FMA angle = 23). The fixed appliance (slot size 0.022×0.028 inch, Roth prescription, from metallic materials) was applied in February 2007. A self-cured bonding method was used. The arch-wire sequence before teeth extraction was the same as in the first patient. The inconsistent attitude regarding the treatment and the poor oral hygiene were similar to the first case, which required in January 2009 the revaluation of the case and treatment plan, which led to the decision of extraction the first upper premolars. The presented cases show similar issues regarding the age, gender, demographic region, malocclusion, skeletal pattern, features of the orthodontic treatment, the patients' uncooperative behavior, missing the control appointments and poor oral hygiene status. In order to identify the conditions hypothetically linked to orthodontic treatment, cases with different clinical situations were recruited for a control group. Five extracted teeth were included: one included wisdom tooth, two newly erupted upper first premolars and two premolars with dental wear.

Prior to extraction, in all cases, explanations were brought to patients and their legal guardians and informed consent was obtained. In the study group, anterior to the surgical phase, the brackets were debonded, in order not to increase the difficulty of this therapeutic act. Teeth extraction was done conventionally, with elevators and forceps. For decontamination and removal of organic unmineralized components, the extracted teeth were cleaned, introduced in sodium hypochlorite solution 5.25% and prepared by autoclaving at 134^0C for 40 minutes. To remove the residual bonding material remained on the teeth with a history of orthodontic treatment, a tungsten carbide bur was used. Then all teeth were polished, the methodology being similar to that applied in clinical practice.

The microscopic analysis was performed by using the high precision stereomicroscope (Stemi 2000, Carl Zeiss, Germany). The specific areas of interest of the teeth were analyzed using magnifications up to 5×, lower ones being used to identify the changes and higher ones to obtain more information about the present alteration.

In order to assess enamel changes, possibly associated with the orthodontic treatment, the buccal surface, where the orthodontic bracket was applied, was analyzed in comparison with the lingual surface, which was used as control. We performed a qualitative assessment of the enamel surface, in order to identify any changes that might be suggestive for tooth discolorations, decalcifications and caries. The main aspect taken into account was the surface uniformity, aiming to asses if there were differences between areas in relation to the region where the orthodontic bracket was bonded. We wanted to detect both the color and the surface roughness changes. In order to assess the modifications present in the apical part of the root, the teeth with a history of orthodontic treatment were analyzed in comparison with the teeth from the control group. The main aspects taken into account were: the aspect of root surface, the apical contour and surface roughness. We wanted to identify changes that may be suggestive for external root resorption.

Results

By analyzing the buccal surface of the maxillary premolars with a history of orthodontic treatment, in all four teeth, there were identified changes in terms of color and roughness. In terms of color, there was found an irregular aspect of the buccal surface of the crown (Figure 1), with clear identification of the area where the bracket was applied. The enamel area corresponding to the bracket's base presented a uniform, white aspect. The enamel area corresponding to the margins of the bracket, was assessed as having an irregular aspect, with color changes (lighter and darker shades), allowing the clear identification of the area where the orthodontic bracket was bonded. The marginal changes adjacent to

the bracket base were more severe on the gingival region compared to the occlusal one. The enamel lingual area (considered as control) presented an aspect considered as being uniform (Figure 2). Regarding the surface roughness, the enamel area correspondent to the orthodontic bracket base was assessed as having a surface roughness higher than the adjacent buccal and lingual surfaces.

All teeth with a history of orthodontic treatment presented at the apical root part a highly irregular contour, with interruption of the continuity of the hard dental structures (Figures 3 and 4). Multiple lacunas with different depths were identified, the general appearance being integrated to the presence of apical root resorption. In the set of premolars belonging to the first case, the changes' gravity was assessed as being higher than the one of the second case. The aspect of the root surface of the teeth from the control group was very different from those in the study group. In the case of impacted tooth, the root surface was assessed as uniform, with a linear apical shape, not being identified resorption gaps (Figure 5). Concerning the erupting teeth, the root surface was also appreciated as uniform, with a linear apical contour. In these particular cases, a normal appearance of the forming root, with a wide-open apex, was identified (Figure 6). Teeth with dental wear presented a linear contour at the apical root level. Unlike previous cases belonging to the control group, the surface roughness was assessed as being more pronounced, but overall it showed a uniform aspect (Figure 7). Altogether, the teeth with a history of orthodontic treatment appeared with morphological changes of their apical root surface. Conversely, the controls presented uniform aspects of their apical thirds.

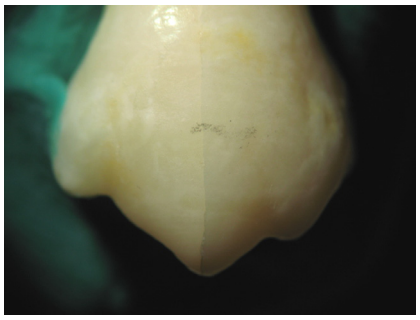

Figure 1 – ***Tooth discoloration on a maxillary first premolar after treatment with a fixed orthodontic appliance (magnification 1.25×).***

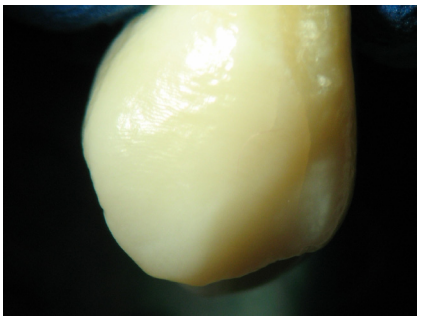

Figure 2 – ***Normal appearance of enamel on lingual surface of a tooth with a history of orthodontic treatment (magnification 2.5×).***

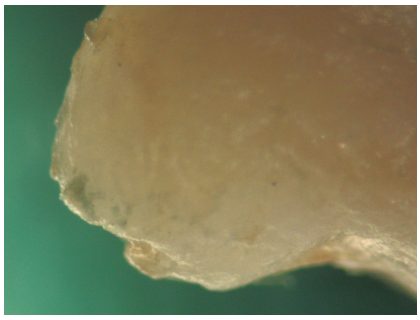

Figure 3 – ***Microscopic image of the apical part of the root of an upper first premolar after treatment with an orthodontic device (magnification 2.5×). The irregular contour and the aspect of root surface are suggestive for the presence of apical root resorption.***

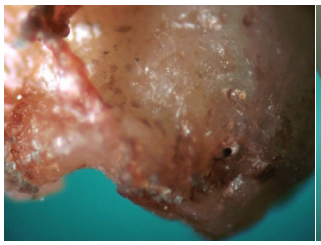

Figure 4 – ***Microscopic image of the apical part of the root of a teeth with a history of orthodontic treatment (magnification 5×).***

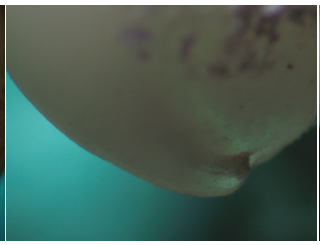

Figure 5 – ***Aspect of the apical third of the root of the included wisdom tooth (magnification 4×).***

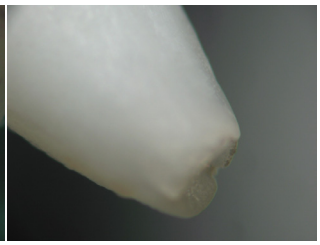

Figure 6 – ***Aspect of the apical third of the root of the newly erupted tooth (magnification 4×).***

Figure 7 – ***Aspect of the apical third of the root of a tooth with dental wear (magnification 4×).***

Discussion

The aim of this study was to evaluate the changes present in the hard dental tissues associated with fixed orthodontic treatment. The microscopic analysis revealed the presence of changes both in the buccal surface of the crown, where the bracket was bonded, and in the apical part of the root, as an indirect effect of the tooth movement.

The enamel color alterations identified as lighter and darker shades were more pronounced in the area adjacent to the bracket's base, where brushing is more difficult. These changes probably appeared during the process of demineralization and remineralization, leading to a common complication of orthodontic treatment, which is tooth discoloration [14, 15]. On the dental surface that corresponded to the bracket's base, it was found a uniform appearance, but showing a more pronounced roughness. This suggests that, at that level there is not a greater risk of decay appearance, the roughness being probably associated with the bonding technique with composite materials, due to the resign impregnation in the enamel structure [3]. Following the bracket removal there's a difference in the surface roughness, some authors considering, regardless the

cleaning procedures, it is very difficult to obtain a situation close to the original one [16]. Our observations suggest the fact that the enamel area adjacent to the orthodontic bracket shows a higher risk of decay damage compared to the surface underneath the bracket's base and the oral one. But it should not be neglected the fact that in both cases the patients' oral hygiene was assessed as unsatisfactory and that they had an uncooperative attitude, skipping the regular-checks, these being the main risk factors for the appearance of the mentioned enamel side effects. Under these circumstances, the elastic modules used could have contributed to the plaque retention and thereby enhance the risk to appear enamel decalcification. These aspects are especially important when the orthodontic bracket is removed, considering that the teeth with white spots present a greater risk of defects occurrence, evidenced by the lack of substance in the enamel level, in comparison with the unaffected teeth [17].

Within the root level, at all teeth with a history of orthodontic treatment, the dental surface showed an irregular aspect, very different from those from the control group. Other studies that used the microscopic method revealed that various clinical situations are associated with different aspects of root surface [7]. Our study observations are very suggestive for the presence of external root resorption, a complication that is commonly known as being linked to the orthodontic treatment [18]. The onset of this undesirable side effect is characterized by the presence of resorption lacunae. The aspects observed by us suggest a more severe impairment. The gravity of this process was generally linked to some orthodontic factors such as increased treatment period, intrusion, force magnitude, etc. [8, 9, 19]. The two cases investigated by us presented similarities regarding age, gender, malocclusion, features of the orthodontic treatment and the patient's behavior. Despite this, the severity of root resorption was assessed as being higher in the case undergoing shorter treatment (12 months), compared to the second case, where treatment time was almost double (23 months). Our findings suggest that treatment time is not correlated with root resorption severity, probably individual susceptibility being the most important predictor.

The main limitation of this study is the limited number of analyzed teeth, therefore not allowing generalization. Despite this fact, our results are relevant not only because of the particular features investigated and similarity of effects, but also presence of different clinical condition for a long period of time.

Conclusions

Thus, the teeth that were undergoing orthodontic treatment showed changes in both crown and apical root level. The microscopic examination highlighted enamel changes probably resulted due to both patients' unsatisfactory oral hygiene and direct relation with the elements from the orthodontic devices. Apical root alteration most probably occurred as an indirect effect of tooth movement. Enamel color alterations were mainly found adjacent to the bracket, suggesting the need for a correct oral hygiene around them, especially in the gingival area. The contour and appearance changes, as well as surface roughness of the radicular apical third suggest the presence of resorption at this level. The stereo-microscopic analysis proved to be high sensitivity tool for *ex vivo* evaluation of consecutive undesirable effects of the medical interventions.

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