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EVALUATION OF ENAMEL SURFACE USING EDI AND ESRS INDEX AFTER REMOVAL OF THE FIXED ORTHODONTIC APPLIANCE

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Abstract: Introduction**:** After completion of therapy with fixed orthodontic appliances, it is necessary to remove the brackets and the remaining adhesive. The process of removing the brackets and adhesive can lead to iatrogenic damage to the enamel surface. The aim of this research was to make a visual assessment of the enamel surface after application of the Enamel Surface Rating System and Enamel Damage Index after application of the green stone for the removal of the adhesive remnants, after completion of therapy with fixed orthodontic appliances.
Material and Method: Within the research, 40 human premolars, extracted for orthodontic purposes, were collected. The back surface of all premolars was treated with 37% orthophosphoric acid and then the metal brackets were placed on 20 premolars. After the removal of the brackets, the residual adhesive was removed with a green stone. A visual assessment of the damage to the enamel was performed by the application of the Enamel Surface Rating System and the Enamel Damage Index.
Results: The most commonly estimated score with EDI at the overall level was 1 (52.5%), while the most commonly estimated score by ESRS was 4 (35%). A statistically significant difference was observed between the examined groups.
Conclusion: Using the ESRS index and the EDI index, significant enamel damage was determined after the application of green pebbles to remove the remaining adhesive after the completion of therapy with fixed orthodontic appliances. As part of the protocol for removing the rest of the adhesive after removing the fixed orthodontic appliance, it is recommended that the green stone be used at the very beginning of the removal of the adhesive, while the instrument is away from the viewing surface.

Keywords: fixed orthodontic appliances; green stone; adhesive removal.

1. INTRODUCTION

Therapy with fixed orthodontic appliances has a wide application in modern orthodontics. The treatment of orthodontic malocclusions with fixed orthodontic appliances requires the preparation of each tooth for placement of attachments (brackets) on the labial or lingual surface, usually with appropriate light-curing or chemically-curing composite material. The bracket placement requires etching of the enamel surface to achieve a micromechanical bond with the composite material. The preparation of the tooth for the placement of the fixed orthodontic appliance leads to the dissolution of the enamel hydroxyapatite crystals and the formation of a porosity area so that there is already a lack of enamel in relation to the untreated part of the tooth surface [1-3]. After the therapy, it is necessary to remove the remaining resin from each tooth using one of the methods. It is the process of removing

brackets and resin that can cause iatrogenic damage to enamel [4-7]. Resin is usually removed from the tooth surface with rotating instruments, and often with stones (grindstones). There are various methods to remove the composite resin from the tooth surface, such as the use of a tungsten carbide drill, Sof-Lex disc, ultrasonic instrument, adhesive removal pliers, Er: YAG or CO2 laser, composite bur, stone, etc. Many authors have studied these methods to determine the procedure by which the adhesive resin can be removed in a minimum operating time with maximum enamel preservation. It is important that these damages are minimal and do not endanger the vitality of the teeth. Stones are rotating instruments which are composed of the base and abrasive particles (carborundum, quartz and diamond) [8-11]. They are most often used for finishing ceramic prosthetic works, and they can also be used for finishing aesthetic fillings on enamel, depending on the size of abrasive particles. Some studies have shown that their use for adhesive removal from the tooth surface has led to significantly greater damage compared to the use of fissure tungsten-carbide burs, abrasive discs and even an ultrasonic instrument for the same purpose [12-15].

Methods for assessment of enamel damage caused by adhesive removal after completed orthodontic therapy can be divided into quantitative and qualitative. Quantitative methods can accurately show the surface roughness and the average depth of enamel damage caused by bracket debonding and adhesive removal from the tooth surface, using three-dimensional scanning. Considering the quantitative methods, contact profilometry is most often used for this purpose [16]. Semi quantitative methods involve the application of appropriate indices such as the Adhesive remnant index (ARI) and the Composite remnant index (CRI) which can be used to estimate the area of residual composite material, after applying some of the methods for its removal after removal of orthodontic brackets [17, 18]. Qualitative methods involve subjective observation of the enamel surface after brackets debonding, during which stereomicroscopy or electron microscopy can be used. The obtained micrographs most often perform a visual assessment of the enamel surface, using indices made by some authors for this purpose, such as the Enamel Damage Index (EDI) and the Enamel Surface Rating System (ESRS) [19,20].

The study aimed to use the ESRS index and EDI index to perform a visual assessment of the enamel surface after the application of green stone to remove composite material, and after completion of therapy with fixed orthodontic appliances.

2. MATERIAL AND METHOD

As part of the research, 40 human premolars extracted for orthodontic purposes were collected, which were kept in saline until the beginning of the research. The saline was changed once a week to slow down the growth of bacteria. Before storage, the teeth were thoroughly cleaned with fluoride-free toothpaste and a soft brush to avoid further damage to the enamel surface. The middle third of the labial surface of all 40 premolars was treated with 37% orthophosphoric acid for 20 seconds, according to the manufacturer's instructions. After rinsing the acid with a water-air jet, the tooth surface was dried for another 10 seconds. GC Ortho Connect paste (GC Orthodontics, USA) was applied to the base of the metal Forestadent Mini Sprint brackets (Pforzheim, Germany), which were placed on the middle third of the surface of 20 teeth (Figure 1). The brackets were placed using counter-tweezers, and the excess material around the base of the bracket was removed using a probe. Polymerization was performed for 40 seconds, according to the manufacturer's instructions. The middle third of twenty premolars were treated with only 37% orthophosphoric acid, so they served as a control group. The sample was left in Biotene gel for 48 hours. After this period, the brackets were separated from the tooth surface with pliers for bracket removal [21]. The rest of the adhesive was removed from the tooth surface using green stone, with abrasive particles of carborundum (Kerr Dental, USA) (Figure 2). The adhesive was removed under the light of a dental chair reflector, as long as there was no more visible resin on the tooth surface.

Figure 1. *GC Ortho Connect paste*

Figure 2*. Green stone*

The samples were then prepared for scanning electron microscopy (SEM), and the buccal surface of the tooth was separated from the rest of the crown by a diamond disk. Four micrographs were taken for each sample: 15x, 50x, 100x and 200x magnifications (Figure 3).

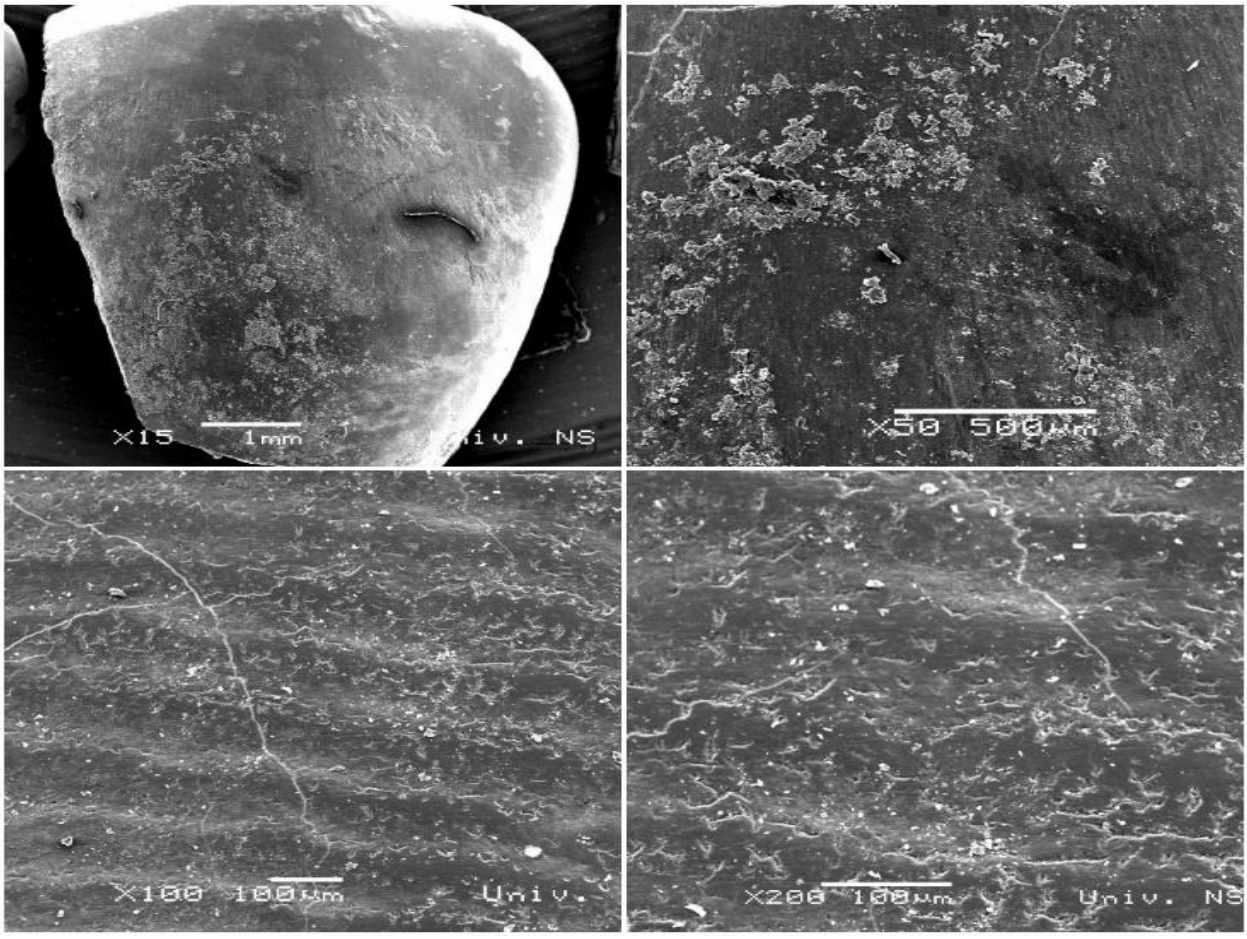

Figure 3. *Micrographs of the enamel surface after removal of the residual adhesive with green stone magnified 15x, 50x, 100x and 200x.*

Micrographs were used to assess enamel damage using the ESRS index and the EDI index.

The ESRS index (Enamel Surface Rating System) was assessed using the following 6 ratings:

− grade 1 – large defects/roughness of the entire enamel surface,

− grade 2 – large defects/roughness of certain parts of the enamel surface,

− grade 3 – individual parts of enamel with defects/roughness of individual parts of the enamel surface,

− grade 4 – minimal enamel roughness without visible defects,

− grade 5 – smooth enamel surface with minimal defects and

− grade 6 – smooth enamel surface without damage [19].

The EDI index was performed using grades from 0 to 3:

− grade 0 – the smooth surface of enamel without damage,

− grade 1 – the acceptable appearance of the enamel surface with a few scratches,

− grade 2 – enamel surface with numerous scratches and small indentations and

− grade 3 – enamel surface with wide indentations and enamel damage visible to the naked eye [20].

The assessment was performed on micrographs by one researcher, and the mean value from the three assessments was taken as relevant.

3. STATISTICAL ANALYSIS

EDI and ESRS index scores are presented through the number of occurrences and the percentage. The parametric Student's t-test was used to compare the mean values of the EDI index and the ESRS index. Values with $p < 0.05$ were taken as statistically significant.

4. RESEARCH RESULTS

The percentage of EDI index scores is shown in Table 1. For teeth treated with only 37% orthophosphoric acid, only grades 0 (9 teeth, 45%) and 1 (11 teeth, 55%) were assigned, while for teeth with grades 2 (2 teeth, 10%) and 3 (4 teeth, 20%) were also determined with green stones. In 4 teeth, a grade of 0 (20%) was assigned, and the largest number of teeth from this group (50%) received a grade of 1. Statistically significant differences were found in the average values of EDI index between the two examined groups of teeth ($t(38) = 2.91$, $p < .01$) (Table 2).

Table 1. *EDI index scores/percentage*

EDI grades

	0	1	2	3	Total
Green stone	4 (20%)	10 (50%)	2 (10%)	4 (20%)	20 (100%)
Control	9 (45%)	11 (55%)	0 (0%)	0 (0%)	20 (100%)

Table 2. *Average EDI index values in the examined groups*

	N	M	SD	t	df	p
Green stone	20	1.30	1.03	2.91	38	.006
Control	20	.55	.51			

The percentage of ESRS index scores is shown in Table 3. Teeth treated with only 37% orthophosphoric acid were assigned scores of 4 (20%) and 5 (40%) and 6 (40%). For teeth in which the rest of the adhesive was removed with green stones, grades from 2 to 5 were determined. Grade 2 was given to 2 teeth (10%), grade 3 to 4 teeth (20%), grade 4 - 8 teeth (40%) and grade 5-6 teeth (30%). None of the teeth from both examined groups received a grade of 0. Statistically significant differences were found in the average values of the ESRS index between the examined groups ($t(38) = -4.71$, $p < .01$) (Table 4).

Table 3. *ESRS index scores/percentage*

ESRS grades

	1	2	3	4	5	6	Total
Green stone	0 (0%)	2 (10%)	4 (20%)	8 (40%)	6 (30%)	0 (0%)	20 (100%)
Control	0 (0%)	0 (0%)	0 (0%)	4 (20%)	8 (40%)	8 (40%)	20 (100%)

Table 4. *Average values of the ESRS index depending on the method*

	N	M	SD	t	df	p
Green stone	20	3.90	.97	- 4.71	38	.001
Control	20	5.20	.77			

5. DISCUSSION

The results of this study showed that the damage caused by the use of green stones to remove residual adhesive after completion of therapy with fixed orthodontic appliances led to enamel damage that was significantly higher than the minimal demineralization caused by 37% orthophosphoric acid. The application of the ESRS and EDI index for visual assessment of the enamel surface indicated that the green stone nevertheless led to significant damage to the enamel surface.

Using scanning electron microscopy, Gwinnett and Gorelick examined the effect of different methods of removing the residual adhesive on the enamel surface after brackets debonding. On the obtained micrographs, they compared the appearance of the tooth enamel surface from which the adhesive was removed using five different procedures: adhesive removing pliers, ligature and wire cutting pliers, green and white stones, abrasive discs, green rubber and burs (tungsten carbide bur, fissure bur and acrylic bur), with the application of polishing paste after all applied methods. They found that the appearance of the enamel surface differed after the application of different adhesive removal methods. Minor enamel damage in the form of scratches was noticed after removing the adhesive with white and green abrasive stones. This result is in line with the result of this research. They also pointed out that it is necessary to take into account the number of rotations per minute used when using rotating instruments to avoid major damage to tooth enamel [22].

Albuquerque at all conducted research on 60 human premolars from which, after debonding brackets, they removed adhesive residues using a fissure tungsten-carbide bur with 32 blades at lower and higher micromotor speed, then with white stone at lower and higher micromotor rotations per minute and using adhesive removal pliers. The Tungsten carbide drill bit caused the least damage to the enamel surface, then the pliers to remove the adhesive, and the stones caused the heaviest damage to the enamel. Since the comparison of the application of stones with another method was not performed in this study, but a comparison concerning the enamel treated with orthophosphoric acid, a significant difference and damage caused by their application was observed. Damage to the green stone can also be explained by the size of the abrasive particles present [23].

In their study of 75 human premolars extracted for orthodontic purposes, Ryf et al. examined, among other things, the amount of adhesive residue after applying five methods for removing adhesives: tungsten carbide bur with eight blades, tungsten carbide bur with eight blades and stones Brownie and Shofu Greenie), tungsten carbide bur with eight blades and Astropol polishing system, tungsten carbide bur with eight blades and Reniew system, and tungsten carbide bur with eight blades, stones and PoGo polisher. In all methods, a certain amount of residual adhesive was observed on the micro-

graphs, with a mean surface area of 200.2 μm and a mean volume value of 2.48 mm3. The residual adhesive was observed on micrographs obtained after the application of stone in this study as well, which also suggests that the method itself is not fully effective [24].

Hong and Lew researched 50 premolars extracted for orthodontic purposes, from the labial surface of which they removed the rest of the adhesive bracket debonding using five methods: tungsten-carbide bur at a higher speed, tungsten-carbide bur at a lower speed, adhesive removal pliers, ultra-fine diamond bur and white stone. They concluded that the tooth surface was best preserved when they applied a combined procedure which first removes the adhesive with pliers, and then completely removes the adhesive from the enamel surface, first with a tungsten carbide bur at a higher speed, then with the same bur at a lower micromotor speed [18].

Burapavong et al. conducted a study on 26 human premolars extracted for orthodontic purposes from which the adhesive, after bracket debonding, was removed using a sickle instrument, a green grindstone and an ultrasound instrument. Observing the surface of the enamel with a scanning electron microscope, they noticed that all three methods damaged the enamel, the greatest damage being caused using green abrasive stones [25].

Uma et al. conducted their research on 40 human premolars extracted for orthodontic purposes. After bracket debonding, they removed the adhesive resin using the following four methods: an ultrasonic instrument, a probe, a fissure tungsten-carbide bur with 12 blades and a green stone. All four methods resulted in minimal enamel damage, and adhesive residuals on the tooth surface were visible after the application of scanning electron microscopy. On the micrographs of the teeth, it was observed that the slightest damage to the enamel occurred during the application of the fissure. On tooth micrographs, it was found that the least damage to the enamel occurred when using a fissure tungsten-carbide drill with 12 blades, while the greatest damage was found in the group of teeth from which adhesive residues were removed with green stone [26].

For the adhesive removal from the tooth surface after the completion of the therapy with fixed orthodontic appliances, several rotating instruments with polishers are usually used to minimize the damage to the enamel. The disadvantage of this study is that only one method was used and that no comparison was made with any other method. Also, the application of semiquantitative methods (ARI, CRI index) would be useful for further research to estimate the amount of adhesive remaining after stone application.

6. CONCLUSION

Using the ESRS index and the EDI index, significant enamel damage was found after the application of green stone to remove the remaining adhesive after the completion of therapy with fixed orthodontic appliances. Since appropriate protocols are used to remove the remaining adhesive from the tooth surface after finishing the therapy with fixed orthodontic appliances, which includes the use of several methods to maximize the preservation of the enamel integrity, green stone can be used as part of the protocol in combination with other methods rather than the only method for removing adhesive resin, due to major enamel damage caused when using green stone. As part of the protocol, it is recommended to use it at the very beginning of adhesive resin removal, keeping the instrument distant from the enamel surface.

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ИСПИТИВАЊЕ ПОВРШИНЕ ГЛЕЂИ ПРИМЈЕНОМ EDI И ESRS ИНДЕКСА НАКОН УКЛАЊАЊА ФИКСНОГ ОРТОДОНТСКОГ АПАРАТА

Сажетак: Увод: По завршеној терапији фиксним ортодонтским апаратима, потребно је са сваког зуба уклонити бравице и преостали лијепак. Управо поступак уклањања бравица и лијепка може довести до јатрогених оштећења глеђи. Циљ истраживања је био да се примјеном ESRS индекса и EDI индекса изврши визуелна процјена површине глеђи након примјене зеленог каменчића у сврху уклањања остатка адхезива, по завршеној терапији фиксним ортодонтским апаратима.
Материјал и метод: У склопу истраживања прикупљено је 40 хуманих премолара, екстрахованих у ортодонтске сврхе. Букална површина свих премолара третирана је 37% ортофосфорном киселином, а потом су металне бравице постављене на 20 премолара. Након уклањања бравица, остатак адхезива је уклоњен зеленим каменчићем. Визуелна процјена оштећења глеђи извршена је примјеном Система за оцјењивање површине глеђи и Индекса оштећења глеђи.
Резултати истраживања: Најчешће заступљена оцјена Индекса оштећења глеђи на укупном нивоу била је оцјена 1 (52,5%), док је најчешће заступљена оцјена Система за оцјењивање површине глеђи била оцјена 4 (35%). Између испитиваних група уочена је статистички значајна разлика.
Закључак: Примјеном ESRS индекса и EDI индекса утврђено је значајно оштећење глеђи након примјене зеленог каменчића у циљу уклањања остатка адхезива по завршеној терапији фиксним ортодонтским апаратима. У склопу протокола за уклањање остатка адхезива по уклањању фиксног ортодонтстког апарата, препорука је да се зелени каменчић користи на самом почетку уклањања адхезива, док је инструмент удаљен од глеђне површине.

Кључне ријечи: фиксни ортодонтски апарат, зелени каменчић, уклањање адхезива.

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