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Research Article

Effect of Antimicrobial Agent-Applied Brackets and Resins on Plaque Accumulation: An In Vivo Study

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Abstract

Objective: In order to prevent plaque formation during fixed orthodontic treatment, bracket and band surfaces have been coated with a selenium-containing antimicrobial agent, and the same agent has been incorporated into adhesive resin materials. The aim of this study is to evaluate and compare the clinical performance, in terms of plaque accumulation, of the combination of selenium-coated brackets and selenium-enhanced adhesive resin (research group) versus the combination of conventional brackets and light-cured adhesive resin (control group) during fixed orthodontic treatments.

Materials and Methods: Seventeen female subjects with skeletal Class I malocclusion were included in this study. A total of 142 selenium-coated brackets and 145 conventional brackets were bonded by the same researcher using a split-mouth design. Selenium-enhanced adhesive resin was used with the selenium-coated brackets, while a conventional adhesive resin was used with the conventional brackets. In all patients, the incidence of plaque accumulation was determined using a computerized image analysis system based on monthly photographic records during the first three months of fixed orthodontic treatment.

Results: After three months, the average plaque percentage in the selenium-coated bracket group was not significantly lower" veya "did not differ significantly compared to the conventional bracket group. In intra-group comparisons, time and jaw had a statistically significant effect ($p < 0.05$), while no statistically significant difference was found between the groups for the bonded teeth" veya "between the test and control teeth ($p > 0.05$).

Conclusion: No statistically significant difference in plaque accumulation was found between the selenium-coated and conventional bracket combinations.

Keywords: Adhesive resin, Conventional bracket, Plaque accumulation, Selenium-coated bracket.

Introduction

It is difficult for patients undergoing fixed orthodontic treatment to effectively remove plaque from their teeth through brushing and maintain good oral hygiene (1,2). The placement of fixed orthodontic appliances in the oral cavity leads to changes in the oral environment and causes both quantitative and qualitative alterations in dental plaque (3,4). The fixed orthodontic appliances used create retentive surfaces, which increase the amount of plaque (5) and the number of microorganisms in the plaque6, alter the microbial composition (4), and due to the inability to remove plaque, lead to demineralization (7). As a result of demineralization, persistent white discolorations (white spot lesions), which are initial carious lesions, appear around the brackets on the enamel (7). Fixed appliances facilitate the continuous accumulation and retention of bacterial plaque, which creates a risk for the development of white spot lesions during orthodontic treatment (6,7). Typically, this permanent whitish discoloration is caused by decalcification of the enamel surrounding the brackets (3).

Among the microorganisms in plaque, Streptococcus mutans is particularly significant, as it cannot adhere to soft tissues in the oral cavity (8) and instead attaches to hard surfaces like teeth and prostheses (9). In patients undergoing fixed orthodontic treatment, the increase in hard surfaces within the mouth enhances the adhesion and proliferation of microorganisms such as Streptococcus sanguis and Streptococcus mutans (4,8,9). Even though patients are given oral hygiene instructions prior to treatment, it has been found that microbial levels increase following the placement of fixed orthodontic appliances (10). Especially in areas where bands are placed and in locations where adhesive resin overflows near the gingival margin and bracket surroundings, the amount of plaque increases, making these regions most susceptible to demineralization (10,11). Streptococcus mutans plays the most significant role in the initiation of carious lesions. Additionally, while the number of Lactobacillus also increases, it tends to appear in the later stages of lesion progression (10).

Various orthodontic materials and agents have been developed to achieve successful orthodontic treatment by maintaining good oral hygiene. In an effort to prevent caries, fluoride-releasing varnishes, fluoride-containing solutions and gels, cements, adhesives, and brackets and bands coated with agents that inhibit the proliferation of cariogenic microorganisms have been used. Studies have shown that topical fluoride agents used in fixed orthodontic treatments reduce caries formation (12,13). However, since the effectiveness of topical fluoride

application depends on patient cooperation, it cannot always be used as the clinician intends (13). Furthermore, when used, it may negatively affect the bonding strength of orthodontic brackets (12-15). To eliminate patient compliance issues and protect the facial surfaces of teeth bonded with brackets, enamel varnishes were developed, but these have shown limited success in preventing caries during long treatment periods (16,17).

To prevent caries, fluoride-releasing cements have also been developed. Glass ionomer cements (GICs) and resin-modified glass ionomer cements (RMGICs) have been reported to halt caries progression and remineralize demineralized enamel (16,18). GICs have the ability to release additional fluoride during and after setting, as well as in acidic environments (19). On the other hand, fluoride-releasing adhesive resins used in orthodontic treatments have been reported to release smaller and shorter-term amounts of flüoride (20,21) and are ineffective in preventing caries (22). Although fluoride-releasing adhesives provide less protection against caries compared to cements, they offer stronger bond strengths and lower failure rates for bracket adhesion (22). Moreover, fluoride has been incorporated into various orthodontic agents (23), ligature wires (24), and brackets (25) to prevent demineralization during treatment.

Another orthodontic material developed to improve oral hygiene in orthodontic patients is the SeLECT Defense technology introduced by Class One Orthodontics. This mechanism was developed to prevent bacterial plaque formation around orthodontic brackets due to its antibacterial properties and, thus, to prevent demineralization (white spot formation) around the brackets (26). This technology utilizes selenium for its antibacterial function. It has been reported that the selenium compounds contained in the material are released in small doses during treatment, come into contact with the treated surfaces, and kill bacterial strains such as Streptococcus mutans and Lactobacilli. The SeLECT technology incorporates this antibacterial feature into brackets, bands, archwires, and adhesive resins (26-33). However, there are no existing in vivo studies evaluating the effects of these selenium-enhanced materials on plaque accumulation.

The aim of this study is to investigate, in vivo, the plaque-inhibitory effects of using antibacterial selenium-coated brackets combined with selenium-containing adhesive resin, and to compare these effects with those of a conventional bracket and adhesive resin combination.

Materials and Methods

This prospective in vivo study included individuals undergoing fixed orthodontic treatment at the Department of Orthodontics, Faculty of Dentistry, Ondokuz Mayıs University. Ethical approval for the study was obtained from the Clinical Research Ethics Committee of Ondokuz Mayıs University. Both the individuals and their parents were informed about the study, and informed consent forms were signed.

In determining the sample size, a power analysis was performed using the GPower software (GPower 3.1.9.7; Germany 2020) with $\alpha = 0.05$ and power of 95%, which indicated that each group should consist of at least 11 subjects. A total of 17 individuals with Angle Class I malocclusion, who were next in line for fixed orthodontic treatment at the Orthodontics Department of Ondokuz Mayıs University Faculty of Dentistry, were included in the study. All participants were female patients with a mean chronological age of 14 ± 2 years before treatment. The inclusion criteria were: individuals who had not undergone previous orthodontic treatment, had no missing permanent teeth, had no periodontal disease or attachment loss, maintained good oral hygiene, and had no restorations on the surfaces of the teeth to which brackets would be bonded.

Based on clinical and radiological evaluations, fixed orthodontic treatment was applied as follows: six of the 17 participants underwent upper and lower premolar extractions, six were treated without extractions, and five underwent single-arch premolar extractions. Two patients were excluded from the study — one due to relocation to a distant city and the other because treatment was performed only in the upper jaw. For fixed orthodontic treatment, selenium-coated (S) orthodontic metal brackets (SeLECT Defense, ClassOne Orthodontics, USA) and conventional metal brackets (K) (Freedom, ClassOne Orthodontics, USA) were used. Both bracket systems were produced by the same manufacturer and had identical morphological features, designs, and base characteristics. A total of 142 S brackets and 145 K brackets were bonded by the same researcher using the split-mouth technique. To avoid variation in bond failure rates due to unilateral chewing habits, S brackets were bonded to the upper right and lower left quadrants of half the patients, while K brackets were bonded to these quadrants in the other half. S brackets were bonded using selenium-enhanced adhesive resin (SeLECT Defense, ClassOne Orthodontics, USA), while K brackets were bonded with Transbond XT adhesive resin (3M Dental Products, St. Paul, Minnesota, USA).

All brackets were bonded in accordance with the manufacturer's recommendations. Prior to bonding, teeth were cleaned with pumice. All teeth were etched for 30 seconds using 37% phosphoric acid (3M Scotchbond™ Etchant, 3M Dental Products, St. Paul, Minnesota, USA), rinsed, and dried with an air-water spray until a chalky appearance was observed. The primer of the S adhesive was applied to half of the etched teeth, while the Transbond XT primer was applied to the other half. After the adhesive was applied to the bracket base, the bracket was placed on the tooth. Care was taken to ensure a uniform adhesive thickness. Excess adhesive was removed, and light curing was performed for a total of 20 seconds (5 seconds each on mesial, distal, occlusal, and gingival sides) using a light-curing unit (3M Dental Products, USA). To avoid affecting bond failure rates, care was taken to prevent contact between brackets and opposing teeth. Archwires (16 HANT, 3M Unitek, USA) were placed at least 10 minutes after all brackets were bonded. At the end of the bonding session, patients were informed about dietary guidelines during orthodontic treatment. Each patient was provided with an orthodontic toothbrush, an interdental brush (Pro-Expert, Oral-B, Istanbul, Turkey), and toothpaste (Sensodyne, GlaxoSmithKline, UK) of the same brand, which were demonstrated on a bracketed model and used throughout the study.

Baseline plaque scores were reset for all individuals, oral hygiene instruction was given, and clinical check-ups were conducted every four weeks. At monthly clinical check-ups during the first three months, the teeth of all patients were stained with a plaque disclosing solution (Hager & Werken GmbH and Co. KG, Duisburg, Germany) (Figure 1).

Figure 1. Photograph of teeth stained with plaque disclosing solution.

Following plaque staining, intraoral photographs were taken from a total of 12 different regions, including the central incisor, canine, and premolar areas in both the upper and lower jaws. The total surface area of the observed plaque on these photographs was measured using a specialized computer image analysis program (Figure 2).

For data analysis, the SPSS 21.0 software (IBM SPSS Statistics 21.0, IBM, New York, USA) was used. The Shapiro-Wilk normality test was applied to determine whether the obtained data followed a normal distribution. Since the analysis showed that the data were normally distributed, the Independent Student's t-test was used for intergroup comparisons at a 95% confidence level. For intragroup comparisons, One-Way Analysis of Variance (One-Way ANOVA) was applied, and the Tukey HSD post-hoc test was used to determine which months showed significant differences.

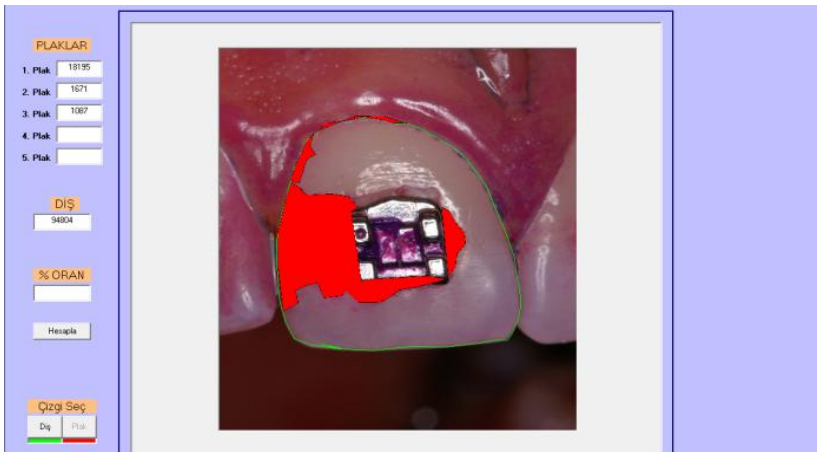

Figure 2. Computer image analysis software and calculation of total plaque surface area.

Results

Descriptive statistical values for the variables measured each month are presented in Table 1. The amount of plaque accumulation was measured at each time point over the 3-month period (T1–T2–T3). In the control group (teeth with K brackets), the mean plaque accumulation was 43.79 mm² in the maxillary teeth and 41.69 mm² in the mandibular teeth. In the research group (teeth with S brackets), plaque accumulation was 49.78 mm² in the maxillary teeth and 40.35 mm² in the mandibular teeth. No statistically significant difference was found between the two groups in terms of plaque accumulation (P > 0.5) (Table 1).

Table 1. Monthly changes and comparisons in plaque scores.

	T1			T2			T3		
	K	S		K	S		K	S	
	Mean(±)	Mean(±)	p	Mean(±)	Mean(±)	p	Mean(±)	Mean(±)	p
Maxilla	42.75(21.6)	48.37(24.4)	.791	48.37(22.1)	54.56(24.3)	.457	40.25(17.8)	46.43(23.3)	.407
Mandible	36.26(25.7)	36.26(16.1)	1.00	46.16(23.5)	43.06(23.6)	.696	42.66(23.7)	41.73(20.7)	.909

In intragroup comparisons, no statistically significant differences were found between the 1st, 2nd, and 3rd months within each group. A slight increase in plaque accumulation was observed in both groups and in both jaws during the second month of treatment. However, this increase was not persistent throughout the entire observation period, and the mean plaque amount was found to decrease in the third month (Figure 3).

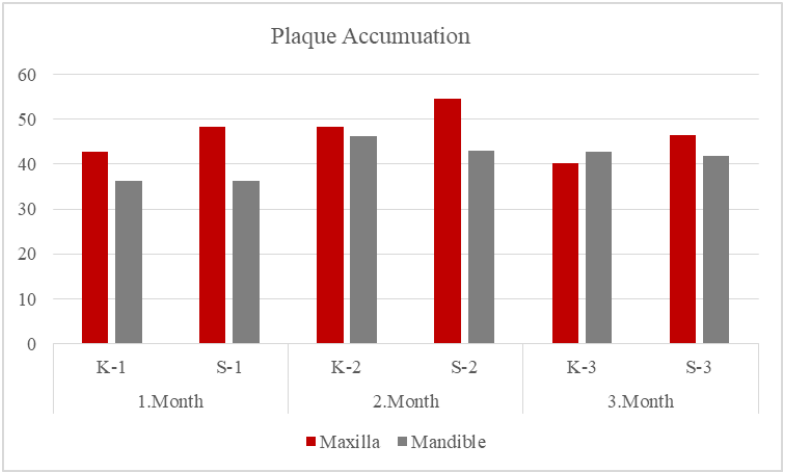

Figure 3. Monthly plaque accumulation in the maxillary and mandibular arches by group.

Discussion

The aim of this study was to determine, using a computerized image analysis system, whether the use of selenium-coated brackets and selenium-infused adhesives is more effective than conventional brackets in preventing dental plaque accumulation. Soder et al. (34) used a similar system to assess dental plaque area. In this study, the computerized image analysis system used by Arici et al. (35) was employed to measure dental plaque. Although not a practical tool in clinical settings, this system is useful for obtaining reproducible quantitative measurements in studies comparing the efficacy of different orthodontic attachments.

In this study, all patients were treated with fixed orthodontic appliances (S and K) using a split-mouth technique. The split-mouth design is commonly used in dentistry (36) and allowed meaningful results to be obtained with fifteen patients in this study.

The manufacturer of the SeLECT® Defense orthodontic system claims that the product inhibits bacterial plaque growth and, due to its antimicrobial properties, prevents demineralization (white spot lesions) around orthodontic brackets (26). It is also claimed that the system utilizes the element selenium to kill Streptococcus mutans and Lactobacillus upon contact with the treated surface (26). However, in this study, the antimicrobial effect claimed by the manufacturer was not observed. After a 3-month in vivo evaluation period, plaque accumulation between the K and S groups was not statistically significantly different ($P > 0.5$). In an in vitro

study, Clark (26) found no significant difference between SeLECT® Defense and three other restorative materials in terms of reducing enamel demineralization. However, Amaechi (37) reported that SeLECT® Defense technology reduced enamel demineralization around orthodontic brackets by 86% when teeth were brushed twice daily, and by 80% in an artificial mouth study where teeth were not brushed.

Only patients whose initial plaque scores were reset and who were given oral hygiene instructions were included in this study. To ensure a standardized and homogeneous study group, identical brushing instructions were provided to all patients. This allowed for a more precise comparison of plaque removal efficacy between the two groups. All patients were given a toothbrush, interdental brush, and toothpaste by the researcher. Patients were instructed to use the same brand of toothbrush, interdental brush, and toothpaste throughout the study to minimize variability between the first three appointments. At each evaluation, toothbrushing was supervised by the same clinician to ensure that patients brushed effectively before photographs were taken. The use of a split-mouth technique in which both bracket and adhesive combinations were applied in the same patient's mouth helps ensure that the results are not significantly influenced by individual variation or other external factors, thereby enhancing the reliability of the findings.

Conclusion

In this study comparing the clinical performance selenium coated and uncoated brackets in terms of plaque accumulation, a slight increase in plaque levels was observed in both groups and both jaws during the second month of treatment. However, this increase was not sustained throughout the observation period, and the average plaque amount decreased by the third month. As a result of the study, no statistically significant difference was found between the two types of brackets and adhesives.

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