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DOES CIGARETTE SMOKING AFFECT THE BOND STRENGTH OF ORTHODONTIC BRACKETS? AN IN VITRO STUDY.

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ABSTRACT

Introduction: In orthodontic treatment, the attachment of the bracket to the tooth is influenced by a variety of external factors, including nutrition and smoking. We assessed the variation in shear

bond strength of different varieties of orthodontic brackets utilized by smokers as part of our research. One hundred teeth were separated into two equal groups: ceramic and metal. Subsequently, each group was divided into an equal number of subgroups, one each, with and without smoking exposure. The brackets were fastened utilizing the traditional approach, and the tensile strength was evaluated by means of a "universal testing machine" (UTM). To simulate smoke exposure to the resin-mounted teeth, the "British American Tobacco's Exposure Chamber" was utilized. A comparison was conducted between the groups utilizing suitable statistical tools, with significance set at $p<0.05$.We observed that the maximum strength was exhibited by the nonsmoker ceramic bracket. The least was seen in the metal brackets of the smokers. All the observations were statistically significant. The physical properties of the orthodontic brackets specifically the shear strength is affected by cigarette smoking. The ceramic brackets performed better than the metallic, when compared.

Key words: Bond Strength, Brackets, Smoking, Orthodontics.

INTRODUCTION

The application of force that induces tooth displacement in fixed orthodontic treatments is facilitated by the brackets. Numerous factors influence the efficacy of the treatments, including the attachment source of the brackets to the tooth, the material utilized for the brackets, and the positioning thereof. One of the most frequent issues encountered by orthodontists is the debonded bracket. Debonding of the retainer from the tooth could have been caused by the ineffectiveness of the bonding agent or patient-related factors. The subsequent element could potentially arise from the tooth enamel strength, the inadequate choice of bonding agents, or the improper technique employed during embedding of bracket [1–3].

In addition to the torsional force, shear and tensile forces are particularly significant among the numerous forces to which a bracket is subjected. Constantly acting upon the bracket is a combination of these forces, which may have an effect on its durability. Additionally, the tooth enamel that braces the bracket must endure these forces [4,5]. Therefore, dental enamel quality must also be taken into account before bracket is fixed [6, 7].

These forces can be measured in a lab setting using the “universal testing machine" (UTM). The orthodontic brackets that are commercially supplied are subjected to many quality checks before being marketed.

Prior to being introduced to the market, commercially available orthodontic brackets are subjected to a rigorous quality control process. Bracket assortments of the most recent design were created to withstand these diverse forces. For orthodontic brackets, a minimum average tensile bond strength of six to eight mega Pascals is required. A reduction in bond strength to below 50% may occur when patient-related factors, such as intraoral conditions including mucous and blood,

encircle the bracket. As a result, it is advised that the tensile bond strength of the bracket average between 15 and 20 MPa [8–10]. However, the enamel of the teeth may be impacted if a bond strength of greater magnitude is utilized. Therefore, 18 MPa is the strongest shear bond strength that is optimally recommended. The adhesive material between the bracket and the molar is the most critical component in securing the two [11–13]. Commonly employed substances for the purpose of bonding are resins. The cement endures numerous degradations caused by intraoral fluids, food, and patient habits. Cigarette smoke is one of these well-established behaviors that alters the composition of resin cements [14–16]. The properties of the cement may be modified by the numerous compounds present in cigarette smoke and oral fluids, including saliva, which come into contact with the bracket [17–19]. Therefore, we assessed the variation in shear bond strength among the different varieties of brackets utilized in orthodontics as part of our research.

MATERIAL AND METHODS

An in vitro pilot study was conducted to determine the effect of cigarette smoke on the bracket dental interface. Two varieties of brackets were chosen for the research: ceramic polycrystalline and metal. One hundred extracted human teeth that were sound enough to receive the bracket and devoid of any enamel pathologies were included in the study. All teeth that exhibited hypomineralization, restoration, caries, or fractured enamel surfaces were omitted from the study. Ethics approval was obtained for the research due to the involvement of human tissue. The survey was conducted in August 2023.

In order to simulate the oral environment, research was devised. After disinfecting the teeth, we preserved them at the proper relative humidity. The artificial saliva 22 was applied to the tooth prior to the bracket's insertion. Based on the material of the bracket and smoke-free status, the included teeth were divided into two batches of fifty each: Group 1 contained metal brackets made of "Werdenta Unique mini stainless steel," while Group 2 contained ceramic brackets made of "Novo Ortho Elegen, alumina ceramic." Two subdivisions were subsequently formed from these groups: Group 1a (consisting of 25 metals) and Group 2a (comprising 25 ceramics). The ultimate sample size for each group and subgroup was therefore 25. The brackets were affixed to the enamel surfaces of the teeth subsequent to their cleaning and preparation with the "3 M Unitek" composite resin. Every protocol was rigorously adhered to. Following this, the teeth were affixed with resin and preserved in cold water to prevent any structural changes.

We utilized the "British American Tobacco's Exposure Chamber, manufactured by Curbridge Engineering (Hampshire, UK)" to simulate smoking for the research. This was chosen because it simulates the "whole smoke" to which a person's teeth are actually exposed while smoking. A month was spent exposing the tooth bracket assembly to "1 pack per day smoked for 2 minutes per cigarette" [20–26]. The teeth that were exposed to the smoke were maintained submerged in the synthetic saliva during the entire procedure, both inside and outside the chamber. The teeth

were subsequently tested under the conditions of the "universal testing machine" (UTM). The shear bond strength of the bracket was evaluated by applying the load parallel to the enamel surface (Image 1). The load values were documented until the bracket experienced failure, at which point the shear bond strength was computed.

Statistical analysis was performed with SPSS v.25 software (Statistical Package of Social Sciences, SPSS Inc., Chicago, IL, USA). Data normality was verified with Shapiro-Wilk test. Evaluation of color and roughness variables before and after exposure to smoke was performed with paired t-tests. Comparisons between control group (not exposed) and experimental group (exposed to cigarette smoke) of shear bond strength variable was carried out with independent t-tests. Intergroup comparisons of color, roughness and shear bond strength variables were performed with ANOVA/Tukey test. We calculated the significance, keeping $p<0.05$ as significant.

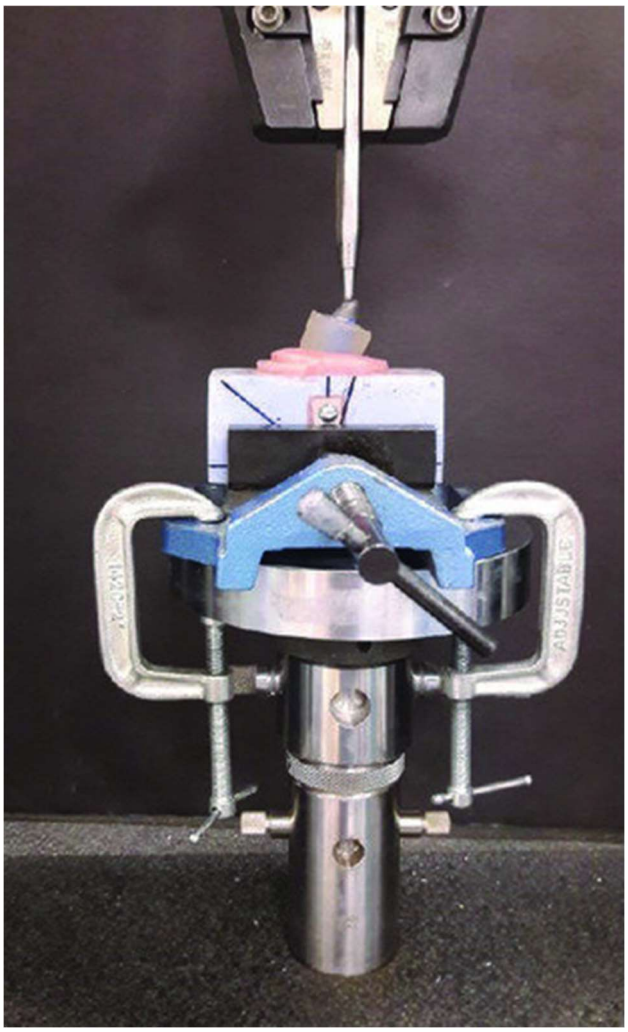

Image 1-Tooth in position for testing using Universal testing machine

RESULTS

Descriptive statistics of before and after exposure to smoke results and intergroup comparisons and their conversions to NBS scale parameters are presented in Table 1. Metallic brackets presented a significant difference between control and experimental groups, as higher SBS values were observed in the group exposed to cigarette smoke. Composite brackets presented significant decreased SBS values compared to control groups of ceramic brackets and experimental groups of ceramic and metal brackets. Despite the Fisher's exact test demonstrated that there was no association of ARI scores between control and experimental groups for all types of brackets (GCE: $x2 = 5.850$; $p = 0.121$/ GCO: $x2 = 6.929$; $p = 0.051$ / GPS: $x2 = 2.220$; $p = 0.370$), it can be observed that the highest rate of ARI score 3 values was presented by the ceramic experimental group.

The tensile bond strength was found to be greatest in ceramic brackets that were shielded from smoke exposure. The metal brackets of the smoke group exhibited the lowest value. The observed shear strengths were as detailed below: (MPa): Group-1 7.1±2.3, Group-14.5±9.9, Group 1a-2.7±0.4, Group 2a-9.3±3.1**.**

TABLE 1: The mean shear strength noted for the teeth and the subgroups.

Groups and subgroups	Mean shear strength
Group 1	7.1±2.3
Group 2	14.5±9.9
Group 1a	2.7±0.4
Group 2a	9.3±3.1

Comparing the smoking and nonsmoking groups, we discovered that the smoking group exhibited the weakest bond strength, whereas the nonsmoking group displayed the strongest. Statistically, the difference between the categories was substantial (p0.001). In comparison to their metal counterparts, ceramic brackets exhibited superior tensile bond strength. No significant difference existed between the categories 2 and 1a. **Table 2**

TABLE 2: Comparison of the significance for the shear strength between group and the subgroups.

Groups and subgroups	**P**			
	Group 1	Group 2	Group 1a	Group 2a
Group 1		0.001	0.001	0.086
Group 2	0.001		0.001	0.001
Group 1a	0.02	0.001		0.042
Group 2a	0.001	0.001	0.001	

DISCUSSION

The strength of the bond between the bracket and the tooth is critical to the efficacy of fixed orthodontic treatment [21–25]. In an in vitro investigation, we compared the effect of smoke on the shear strength of ceramic and metal brackets. The maximum shear bond strength was demonstrated by the ceramic brackets that were shielded from the fumes, according to the results of our investigation. The metal brackets of the smoke group exhibited the lowest value. Almeida et al. [25] compared the tensile strength of the resin cement at the tooth interface and discovered comparable results. The shear strengths exhibited by the metal brackets were the least acceptable [15]. In their investigation, Omar et al. utilized sixty extracted premolar teeth to assess the effects of smoking on ceramic and metallic brackets. It was determined that occupational exposure to cigarette smoke significantly impacts the shear bond strength of orthodontic brackets. The groups that were exposed to smoke demonstrated significantly diminished levels of absolute bond strength. The metallic brackets that were affixed to the sample that was exposed to cigarette smoke demonstrated the least amount of shear bond strength. When comparing metallic and ceramic brackets, it was observed that ceramic brackets demonstrated greater shear bond strength in an environment contaminated with cigarette smoke. It is possible to draw the conclusion that smokers favor ceramic receptacles as a result of this discovery. The ceramic brackets should be recommended subsequent to a comprehensive assessment of the patient's circumstances, including financial situation, form of malocclusion, enamel quality, and overbite [20, 22].

Upon comparing the smoking and nonsmoking groups, it was determined that the smoking group exhibited the weakest bonds, whereas the nonsmoking group displayed the strongest bonds. Statistically, the difference between the categories was substantial. In comparison to their metal counterparts, ceramic brackets exhibited superior shear bond strength [26, 27]. Our research is comparable to that of Eslamian et al. [27]. This research was conducted in vitro to simulate buccal conditions. Intraorally, these high bond strengths are rarely desired. Furthermore, the shear force administered in the laboratory may differ from the one observed in clinical settings. The debonding of the bracket may be influenced by both the masticatory forces employed and the routines of the patients [19, 25–27].

While nicotine solutions have been utilized in prior research, they may not produce the same clinical effect as cigarette vapor. Our research focused solely on examining the shear strength of cigarette smoke, given that this substance produces thermal energy in the form of vapor. Beyond nicotine, the smoke contains more than a hundred chemical compounds, such as benzene and others, which have the potential to modify the properties of the resin. Therefore, treatment planning necessitates a comprehensive history of addictive behaviors [16, 20].

Even though the study was done in a lab and might not be applicable to real-life clinical situations for a number of reasons, the results add to what is known about how bonded orthodontic brackets affect smokers' enamel and support the need for more studies with real people as subjects. Presently, a considerable proportion of adult patients under the care of orthodontists are smokers; if additional malocclusion factors allow, ceramic brackets featuring an enhanced SBS may be furnished to these patients. By using this method, the bracket bond might last longer, which could mean fewer times where it comes loose and a longer treatment period. The selection of teeth from both quadrants and the inclusion of both the anterior and premolar teeth despite the possibility that their enamel properties varied limited our study. The intraoral forces experienced during the study may differ from the laboratory forces recorded.

CONCLUSION

Our analysis leads us to the conclusion that the mechanical strength of the orthodontic bond has been adversely affected by the cigarette smoke. The metal brackets exhibited the least shear strength among the smoke groups. In general, ceramic brackets outperformed metal brackets in the smoke groups. Additional clinical research is recommended in order to validate the results of our comprehensive investigation.

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