

Comparative Assessment of Adhesion to Dental Enamel and Friction Forces of Bracers

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Abstract – The study is devoted to comparative analysis of some technical aspects of braces. According to some reports, the prevalence of dentofacial anomalies in the Republic of North Ossetia-Alania reaches nearly 40 %, which is slightly higher than the level across the Russian Federation in general. Undue detection and treatment of dentofacial anomalies subsequently leads to various complications. The purpose of the study was to conduct a comparative analysis of technical characteristics of braces of various price range made of various materials. The friction force of orthodontic arches in braces and adhesion of various braces to dental enamel was studied. The study covered metal braces Yoka Ortho, Ortodent-T, DamonClear. The comparison was carried out with ceramic braces – Empower (American Orthodontics), ClarityAdvanced, InspireICE where orthodontic arches were fixed and the friction force was measured at a test bench. Besides, the braces of the specified firms were fixed on teeth extracted for orthodontic indications thus measuring the adhesion force. **Results.** The study made it possible to conclude that Empower braces (American Orthodontics) have preferable characteristics in comparison with other ceramic samples. It was also found out that ceramic braces have higher adhesion to dental enamel in comparison with metal systems. It was established that out of all studies braces the InspireIce braces have the highest adhesion.

Key words – dental enamel, orthodontics, bracers, friction

I. INTRODUCTION

In the modern world the society is ever more focusing on appearance, in particular healthy and beautiful smile. A beautiful smile is a brand identity of each person. In this regard, the popularity of orthodontic treatment constantly increases, including among middle-aged patients [1].

Continuous development of methods and means of orthodontic treatment defines the need for regular study of properties of braces offered by manufacturers, comparative assessment of biomechanical characteristics, features of biomechanics and the influence on oral cavity hygiene, degree of convenience and comfort for a patient [2, 3].

Scientific publications on orthodontics refer to studies defining the dependence of the friction force between a groove and an arch on the number of factors, including the material and section.

Today the market of braces is becoming broader. It is possible to reduce the time on treatment due to changes in composition and structure of products. Modern companies are strongly trying to satisfy esthetic needs of patients thus maintaining the functional importance of a design. New materials and alloys appear, which properties are insufficiently studied these days [4, 5].

According to different epidemiological data conducted in our country and abroad, the prevalence of dentition and occlusion anomalies in some population groups varies and reaches 30–55 % in the general population and 40 % at children under 18 years old [6, 7].

Dentition anomalies are the consequence of not only congenital pathology and imbalance of bone formation and resorption with change of density and strength of osseous tissue, but are also caused by bad health habits, way of life and physical activity. The treatment of abnormality of occlusion is the most relevant problem of stomatology. However, there were not enough studies on this matter in the Republic of North Ossetia-Alania [8, 9].

Considering that people having this pathology make a socially important group, it is necessary to know the features of various orthodontic systems, including the most advanced ones, to render more efficient dental help.

II. PROBLEM STATEMENT

The purpose of the study is to compare the friction force between braces and orthodontic arch when using samples of various producers and to conduct a comparative analysis of adhesion to dental enamel of braces made of different materials.

III. MATERIALS AND METHODS

The study was carried out by the Department of Stomatology No. 1 of the North Ossetian State Medical Academy of the Ministry of Health of the Russian Federation and the Department of Physics of the North Ossetian State University named after Kosta Levanovich Khetagurov.

The mathematical model of the experiment [10], which served the basis for a test bench to measure the friction force of an orthodontic arch in grooves of braces, was developed. The stand represented an acrylic structure with platforms to fix extracted teeth and to ensure controlled activity of the orthodontic arch. The loading was carried out by hanging a capacity to an arch and gradually poured the distilled water into it. When the arch was removed, according to the Newton’s Law, the friction force equaled the force of gravity. Loading was measured via dynamometer [11]. Loading was measured in a dry state and with imitation of a biological medium representing a model medium, i.e. the solution of artificial saliva made according to T. Fusayama (1975). The pH value in the model medium equaled 7.0.

We prepared 18 teeth of various functional groups (incisors, canines, molars) extracted according to orthodontic indications. Each tooth was previously studied on enamel damage and if such was detected the samples were excluded from the study. All samples were washed with water and soaked in 0.9 % NaCl solution until their use.

Two groups of braces were chosen for comparison: group A – metal braces by 1) Yoka Ortho; 2) Ortodent-T; 3) DamonClear (Ormco). Group B included ceramic braces by 1) Empower (Americanorthodontics); 2) ClarityAdvanced; 3) InspireICE. The braces of each brand were fixed on 3 teeth – one per an incisor, a canine and a molar. Orthodontic arches were selected by the size of 0.016*0.022 and 0.018*0.022

NiTi. The arches in braces were fixed by elastic ligature rings (ORMCO, USA).

During the study the surface of teeth was etched with 37 % solution of orthophosphoric acid Diamondbrite (Confi-Dental, USA) within 60 seconds, then washed and dried. Dental adhesive Adper Single Bond 2 (3M) was applied on a vestibular surface of teeth, then braces were fixed on the surface of teeth via orthodontic glue Enlight (ORMCO, USA). Excessive amount of glue was removed from a peripheral part, which followed by polymerization within 40 seconds (10 seconds from each side of braces). After that the teeth with fixed braces were placed in clips on the test bench. An arch was fixed in a groove of braces, shells were placed on a special support, small weights were hang on the arch edge and the friction moment was fixed. During the study the angulation did not change, the arch was fully contacting with a braces groove.

The second part studied the adhesion of braces to dental enamel, thus the teeth were placed in the clips of the test unit, and the ligature wire was attached to braces. The effort was applied to the wire by means of the test machine (HD-B611-S Universal Test Machine) until the braces were separated from enamel. The peel force for each type of braces was recorded, the adhesion of braces to teeth of various functional groups was compared.

Statistical data was processed using Statgraf software.

IV. RESULTS AND DISCUSSION

The samples of group A showed different results through the study of the friction force. At the same time the friction force considerably changed when arches of different section were used (Table 1).

TABLE I. FRICTION FORCE OF METAL BRACES IN DEHYDRATED MEDIUM (GRAMS)

Arch size	Yoka Ortho	Ortodent-T	DamonClear
0.016*0.022	69	77	82
0.018*0.022	98	105	127

The table shows that with the increase of the arch section the friction force also increases, which is quite logical. The difference of indicators between the maximum and the minimum value was more than 60 %.

Similar results were obtained in moist medium; at the same time the friction force was much lower than in the dehydrated medium (Table 2).

TABLE II. FRICTION FORCE OF METAL BRACES IN MOIST MEDIUM (GRAMS)

Arch size	Yoka Ortho	Ortodent-T	DamonClear
0.016*0.022	40	49	52
0.018*0.022	53	63	71

As we see, the study was conducted in all cases irrespective of moist or dehydrated medium, and the lowest friction force was typical for Yoka Ortho braces, and the highest – for DamonClear.

In group B the braces of ClarityAdvanced and InspireICE had high friction force in comparison with Empower. This

difference allows concluding on the ability of braces to move teeth in required direction (Table 3).

TABLE III. FRICTION FORCE OF CERAMIC BRACES IN DEHYDRATED MEDIUM (GRAMS)

Arch size	Empower	Clarity	Inspire ICE
0.016*0.022	77	97	152
0.018*0.022	112	122	197

In moist medium the received results for ceramic braces were similar to metal braces. On average almost double decrease of the friction force is observed in moist medium (Table 4).

TABLE IV. FRICTION FORCE OF CERAMIC BRACES IN MOIST MEDIUM (GRAMS)

Arch size	Empower	Clarity	Inspire ICE
0.016*0.022	35	56	77
0.018*0.022	66	71	99

The study of adhesion of braces to enamel clearly demonstrates that the adhesion of ceramic braces is significantly higher than that of metal braces.

Besides, metal braces of group A differ among themselves by the adhesion force. The same is observed for braces of group B where ceramic braces considerably differ by their adhesion to enamel. According to three measurements on the separation of braces from an incisor, a canine and a molar, the Yokaortho braces sustained the average loading of 1036 grams. The Ortodont-T and Damon braces showed approximately similar results – 3950 and 4030 grams. We believe that this is caused by better adaptation of the surface of braces to the anatomic surface of teeth. The adhesion of Empower and Clarity ceramic braces made 9736 and 5780 grams. The InspireIce braces sustained the loading of 12360 grams, then in one case the ligature wire broke under the applied pressure and the brace remained on place, and in the other case the brace separated with part of enamel (Figure 1).

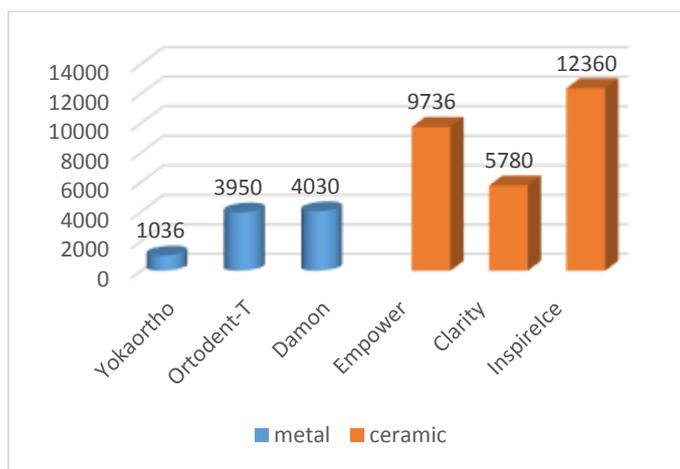


Fig. 1. Adhesion of braced to dental enamel (in grams)

Highlighting high adhesion of ceramic braces to dental enamel of teeth we shall keep in mind that excessively high adhesion can also have a negative effect. In certain cases, upon completion of the treatment it can be difficult to remove

ceramic braces. Having high strength, they can be fragile since they are difficult to bend unlike metal braces, which plastic deformation facilitates this procedure.

The obtained data do not consider some important clinical factors, which influence the friction force of an orthodontic arch in a brace groove. For example, we used a rubber ligature ring to fix an arch, and in the clinic the metal ligature can be used, and in this case the friction force can vary from very low to very high depending on how tight the metal ligature is. Besides, the provision of a brace on a tooth and arch angulation play an important role. Considering the variety of material for orthodontic arches and their different sizes and profile sections it is difficult to calculate all options of the friction forces distribution.

The purpose of the study was to assess the adhesion of ceramic and metal braces to enamel and to compare the resulting friction forces for further application in clinical practice. Besides, there is a need to consider that the structure of ceramic braces is more diverse than metal since they can be both monocrystalline and polycrystalline.

V. CONCLUSION

The obtained results show that there is no ideal system for all braces. Each system has its features of clinical application, advantages and disadvantages. Each clinical case shall be individual taking into account the needs of a patient, complexity of a situation and the accompanying pathology.

During this study we came to a conclusion that to date the Empower braces (AmericanOrthodontics) have more preferable characteristics in comparison with other ceramic samples studied by us. Both regarding the friction force of an orthodontic arch and adhesion this system is approximately in the middle of a ranking scale.

Besides, during the study we found that ceramic braces have much higher adhesion to dental enamel in comparison with metal systems. At the same time the InspireIce braces showed the highest adhesion. Such high adhesion to dental enamel can lead to certain difficulties during debonding. Additional efforts and tools may be needed to remove the braces, which is not always justified.

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