Preliminary Study on the Tensile Strength of Some Adhesive Materials Used to Luting Brackets

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In our study we compared in vitro the tensile strength of 4 types of adhesive systems used for brackets, two using bonding and two self-etching. The detachment test were made by the Instron® 8801 universal mechanical testing machine, from the Mechanical Testing Laboratory of the Materials Resistance Department, the Faculty of Engineering and Management of Technological Systems, the Polytechnic University of Bucharest. From the experimental results we find that the used adhesives offer good shear resistance. Vertise Flow adhesive used for sample 2, which has the highest shear stress at break (τ_{max} ~ 25 MPa), is clearly highlighted. Vertise Flow is follow by the Orthocem adhesive used for sample 1 with τ_{max} ~ 14 MPa, then the Neobond adhesive used in sample 4 with τ_{max} ~ 13 MPa, and the weakest of the adhesives is Grandio Flow used for sample 3 (τ_{max} ~ 12 MPa). We believe it is necessary to carry out further studies on larger batches of samples to obtain results that can be validated by statistical analysis.

Keywords: bracket, tensile strength, adhesion, dental materials

Among the requirements for acceptable dental material is the biocompatibility. Multiple studies present the benefits of biomaterial properties, as well as the need to reduce their use failures and the need to optimize their biomechanical performance [1]. For this reason, used dental materials must ensure the resistance [2].

The adhesive system of brackets has to present high enough bond strength to resist the forces that are applied during daily activities, but low enough in order to allow for a debonding at the end of the treatment in a way that leaves the surface of the enamel intact. [3]

At present time, there are adhesive systems with and without bonding for fixing brackets. Studies [4,5] have shown that self-etching adhesive systems exhibit traction resistance similar to conventional bonding systems.

During mastication, the developed forces vary widely, requiring different dento-periodontal units asymmetric [6], which can lead to the detachment of the brackets. The retention of the bracket on the tooth is influenced by bracket morphology [7-9], as well as the particularities of the adhesive system used [10].

Experimental part

In our study we compared in vitro the tensile strength of 4 types of adhesive systems used for brackets, two using bonding and two self-etching.

The four dental materials tested were: Orthocem, produced by FGM, applied on sample 1; Vertise Flow, manufactured by Kerr, applied on sample 2; Grandio Flow, produced by VOCO, applied on sample 3; Neobond, manufactured by Densply, applied on sample 4.

We selected four teeth extracted in orthodontic purpose, two lower incisors and two lower premolars, and on each we fixed a metal bracket with the adhesive materials above.

From the time of extraction to the application of the brackets, the teeth were kept in the physiological serum to avoid desiccation of the dental hard tissues.

In order to apply composite materials, the teeth were initially demineralized with 37% Orthophosphoric Blue Etch, for a period of 15 s , after which they were flushed and air-jetted from the dental unit.

After demineralization, washing and drying, for Neobond and Grandio Flow we applied universal bonding from 3M, with light-curing for 20 s.

We applied on each bracket one of the adhesive material, we placed the brackets on the teeth, and started light-curing of adhesives.

The light-curing was performed for each tooth in 3 directions, for the time period recommended by the manufacturers for each dental adhesive.

After applying the brackets to the detachment test, the samples were kept in a humid atmosphere, so that there was no excess of liquid but no completely anhydrous medium that could compromise the adhesion of the composites to the dental tissues (fig. 1).

Fig. 1. Keep samples in a wet environment

For the experiments, the samples were embedded in a resin (fig. 2).

The detachment test were made by the Instron® 8801 universal mechanical testing machine, from the Mechanical Testing Laboratory of the Materials Resistance

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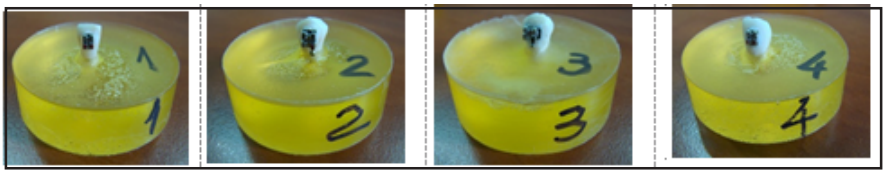

Fig. 2. The 4 samples are prepared for the detachment test

Department, the Faculty of Engineering and Management of Technological Systems, the Polytechnic University of Bucharest (fig. 3).

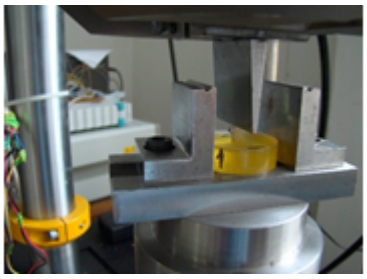

Fig. 3. Sample 1 in the starting position of the detachment test

The Instron® 8801 universal mechanical testing machine is a compact fatigue-testing servo-hydraulic system that meets the requirements for various static and dynamic tests. The system provides complete testing solutions to meet the requirements of advanced materials and component testing and is ideal for fatigue and mechanical fracture testing.

The detachment test was carried out by applying the forces progressively, using a speed rate of the upper crosspiece of 0.5mm / min. This speed rate has been used to accurately detect the moment when the bracket is detached and, in particular, the exact amount of detachment force.

Results and discussions

The test results of the 4 samples were automatically recorded by the Instron 8801 universal machine software. These can be seen in figure 4. On each curve is marked by a triangle the force at which the bracket was detached.

From the experimental results, we find that the used adhesives offer good and very good shear resistance.

However, the comparative analysis of the results allows us to clearly highlight the adhesive used for sample 2, Vertise Flow, which has the highest shear stress (τ_{max} ~ 25 MPa).

Follow the adhesive used for sample 1 (Orthocem) with τ_{max} ~ 14 MPa, which provides adhesion with approx. 79% lower, then the adhesive used in sample 4 (Neobond) with τ_{max} ~ 13 MPa and thus with less adhesion of approx. 92%, and the weakest of the adhesives is used for sample 3 (Grandio Flow) with τ_{max} ~ 12 MPa and thus with a lower adhesion of approx. 108%.

Also, after the test we analyzed the macroscopic aspect of each sample. There were differences in the detachment mode determined by the type of bracket and implicitly the roughness of the contact surface with the tooth.

It can also be noted that the thickness of the adhesive layer differs from the sample to the sample, which is normal since the bracket is glued manually. Different thicknesses of adhesive are obviously important in achieving good adhesion, but the type of adhesive is decisive in achieving good adhesion.

Materials used in orthodontics are constantly changing and improving [11]. The success of any fixed-appliance orthodontic treatment depends on multiple factors, most important of which being correct bracket placement and bonding together with the longevity of these accessories on the teeth [12].

Bracket failure at the bracket-adhesive interface is advantageous as it leaves the enamel surface relatively intact [13].

Achieving a good adhesion between the brackets and the tooth surface is essential [14]. In many papers were

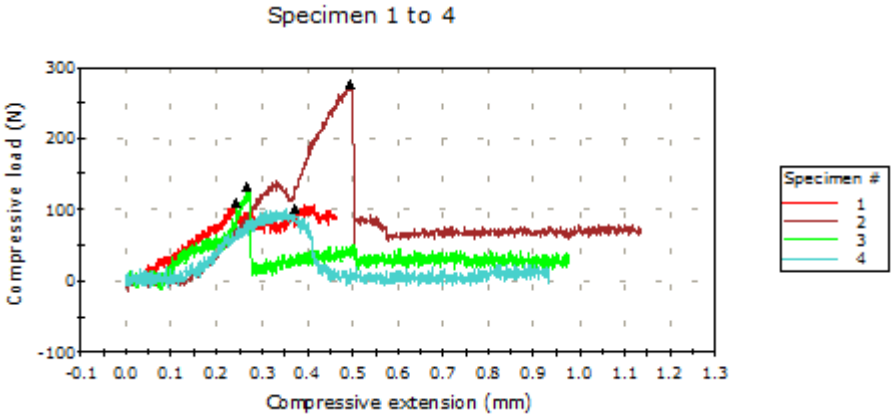

Fig. 4.The force variance diagrams for the 4 analyzed samples

Sample	The force at which the detachment occured (N)	Contact surface (mm^2)	The shear stress at which detachment occurred (MPa)
1	111.37128	7.82	14.24
2	275.26021	11.02	24.98
3	133.26406	11.02	12.09
4	100.69013	7.82	12.88

Table 1
RESULTS OBTAINED FROM TESTING

Fig. 5.Appearance of samples after testing

studied some aspects related to the orthodontic implants aligners and treatment [15-19].

Conclusions

From the macroscopic appearance of the samples after the test, we can also notice that for samples 1 and 4, where the adhesive layer was thinner and the surface of the bracket has less pronounced striations, the bracket has been detached leaving the adhesive on the tooth. For samples 2 and 3, in which a different type of bracket was used with the striking strips, the detachment occurred with the adhesive layer.

From the experimental results we find that the used adhesives offer good shear resistance. Vertise Flow adhesive used for sample 2, which has the highest shear stress at break (τ_{max} ~ 25 MPa), is clearly highlighted. Vertise Flow is follow by the Orthocem adhesive used for sample 1 with τ_{max} ~ 14 MPa, then the Neobond adhesive used in sample 4 with τ_{max} ~ 13 MPa, and the weakest of the adhesives is Grandio Flow used for sample 3 (τ_{max} ~ 12 MPa).

We believe it is necessary to carry out further studies on larger batches of samples to obtain results that can be validated by statistical analysis.

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