An Analysis of Incisive-Bracket Bond Resistance in Orthodontics

I. General approach

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The aim of this study is to determine the bonding resistance of orthodontic brackets in accidental conditions i.e. bites from very hard materials which may occur in a normal activity. Many studies had been developed concerning the integrity of orthodontic systems and the strength of various pairs of brackets and adhesives in controlled conditions. In orthodontics many patients were returning to treatment, especially in the period immediately after the installation of orthodontic system as a result of failure of brackets. This failure is a consequence of patients' natural habits on biting food despite medical recommendations. For this study bovine rib bone were used to simulate the human tooth and a certain pair adhesive-bracket. Pretests were developed in order to identify the behaviour of organic material and the results were satisfying. Unlike other studies in this study the shear resistance of the adhesive was analyzed using an universal testing machine with a load on the bracket. Since the study concerns with accidental detachment of the bracket the experimental parameters were set as close to the natural conditions. The results are encouraging the development of further studies on various pairs adhesive-bracket using bovine bone as human teeth simulator since its results are fitting data reported by other authors following numerical or empirical studies on human teeth. The use of bovine bone ensures the reproduction of the tests without having the care of teeth collection.

Keywords: orthodontics, adhesive, bracket, shear strength.

Orthodontics is the oldest specialty in the dental profession. Orthodontics (Ortho = Straight, Dontic = Teeth), is that branch of dental science concerned with genetic variation and development and growth of facial form. It is also concerned with the manner in which these factors affect the occlusion of the teeth and the function of associated organs. Therefore it is not only concerned with straightening of the teeth, but also the growth, development, and function of the total orofacial complex [1].

Any assessment of quality of orthodontic result must contain an assessment of tooth alignment. In the anterior region, the incisal edges and lingual surfaces of the maxillary anterior teeth and the incisal edges and labialincisal surfaces of the mandibular anterior teeth were chosen as the guide to assess anterior alignment. These are not only the functioning areas of these teeth, but they also influence esthetics if they are not arranged in proper relationship. In the maxillary posterior region, the mesiodistal central groove of the premolars and molars is used to assess adequacy of alignment. In the mandibular arch, the buccal cusps of the premolars and molars are used to assess proper alignment. These areas were chosen since they represent easily identifiable points on the teeth, and represent the functioning areas of the posterior teeth. The results of the four field tests show that the most commonly malaligned teeth were the maxillary and mandibular lateral incisors and second molars, which accounted for nearly 80% of the mistakes [2].

Orthodontics typically involves the use of braces for aligning teeth. Braces consist of brackets that are bonded to the teeth, and arch wires that are threaded through the brackets. The arch wires act as a track and guide each tooth to its proper position. There are several types of orthodontic braces available to consumers, including the more traditional metal braces, ceramic "tooth-colored" braces, and clear plastic or ceramic braces. Braces are used to correct malocclusions such as underbites, overbites, cross bites and open bites, or crooked teeth and various other flaws of teeth and jaws, whether cosmetic or structural. Orthodontic braces are often used in conjunction with other orthodontic appliances to widen the palate or jaws, create spaces between teeth, or otherwise shape the teeth and jaws. Brackets are bonded to the surface of teeth with orthodontic adhesive. Bonding of orthodontic brackets to the tooth enamel has been an important issue since the introduction of direct bonding in orthodontics [3].

The use of braces implies development of complex regimes of mechanical loads both on teeth and brace elements. Since the most used method in orthodontics is to bond the brackets on the teeth and to position and tension the wire to obtain the desired force and torque on each tooth the mechanical analysis of orthodontic systems resumes to study of bond strength of adhesive between tooth and bracket (direct bonding). Many studies concern with the analysis of load (force and torque) developed at the level of tooth-bracket bond [4-8].

The bond strength is generally studied on human teeth and that implies the necessity of their collection. Other studies were performed on bovine enamel as a precaution regarding the tooth integrity during tests. In this study the use of bovine rib bone is purposed and preliminary tests showed that this is fitting the requirements of orthodontic practice. The bond between tooth and bracket has not to affect chemically the structure of dental enamel and in case of debondig it has not to produce cracks on dental surface [9].

Whatever the defect of the dentition would be all the humans are using it to bite various aliments including soft or hard ones. Generally the patient to whom an orthodontic system is mounted is advised not to use the dentition in the habitual way i.e. biting the aliments – especially hard peeled fruits as apples, peaches and prunes or other hard aliments as crackers, croutons and such. Unfortunately

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Fig. 1. Apex MX Opal bracket installed on the tooth surface with wire and silicon ring

Fig. 2. Microscope photos before and after debonding. Almost entire amount of the composite remained on the tooth surface

the natural habits are difficult to inhibit mostly regarding the incisives which represents the most important tool in initial mastication and generally are the most affected by various positioning defects and therefore subject of orthodontics. As human incisives are difficult to procure present study purpose the use of alternate solution in order to analyses the mechanical behaviour of tooth-adhesive-bracket system in laboratory conditions.

More than that it is obvious that many researchers are involved in studies regarding the way in which the quality of tooth-bracket might be improved by changing adhesives, special treatments on the tooth surface and so on [11-14].

Experimental part

Materials

For this study metal brackets Avex MX Opal from Opal Orthodontics by Ultradent had been used and Transbond™ Plus Self Etching Primer and Transbond™ PLUS Colour Change Adhesive from 3M Unitek to ensure the brackets positioning on teeth. Transbond™ PLUS Colour Change Adhesive is a moisture tolerant light cure bonding system with the convenience of delivery on demand. Transbond PLUS adhesive provides excellent bond strength with metal and ceramic brackets along with the special features of colour change and fluoride release [15] it is a photo curable polymer composite allowing a more accurate operation during the bracket installation and its pink colour disappear after the photo cure. Transbond™ Plus Self Etching Primer is the all in one bonding solution. It is one-step primer features unique chemistry and an exclusive delivery system which together allows user to etch, prime and bond enamel in one simple and cost-effective step, in just seconds [16]. Avex MX stainless steel brackets (fig. 1.) offer accuracy and predictable treatment results. They allow for an extremely low-profile design to enhance patient comfort without sacrificing bracket strength. Precise right angles create parallel slots, resulting in more control and reduced wire bending. True torque in the base delivers proper positioning with minimal occlusal interference [17].

Bovine rib bones were human incisive shaped after conditioning and the brackets were installed on them such as the obtained systems can be easily gripped on the universal testing machine. The use of bovine bones allows repeated use of same system including cases of wrong positioning, insufficient etching, various quantities of composite and other difficulties might occur in practice. The presented shape of analyzed system ensures the facile manipulation of samples during tests and during their reconditioning avoiding the necessity of fixing the human teeth on cements or polymer slots in order to be used for different types of tests.

Studying the adhesive resistance the emphasis is on how it behave in loading conditions as new and of course how is behaving after use that is why the bovine bone is the best choice even from dental point of view it does not fit all the requirements. Being porous the bovine bone allows a better adhesion of composite on the surface and in the case of debonding the amount of composite remained on the tooth surface is quite large.

Removal of residual bonding resin after orthodontic bracket debonding results in an irreversible damage to the enamel ranging from 30 to 60 mm of surface enamel loss. Therefore, an orthodontic adhesive that leaves less or no adhesive remnant is highly preferable in terms of minimizing irreversible damage to the enamel. Further, a high-speed tungsten carbide bur takes approximately 40 seconds to remove all composite remnants on a single tooth, and thus, cleaning the entire adhesive remnant on the upper and lower arches can be quite time consuming [18].

Results and discussions

Preliminary tests were developed to verify the opportunity of using bovine rib bone as human teeth simulator by meaning of qualitative analysis. Generally debonding of the bracket has not to deteriorate the tooth. In natural conditions for accidents occurring during mastication it is possible as certain amounts of dental enamel to be detached causing irreversible damages of teeth. Adhesive producers are seeking for solutions that fit the medical requirements – the ones which in case of accidental debonding are not letting large amounts of polymer or composite on the dental surface but from the mechanical point of view that is equivalent with generating cracks on the dental enamel surface enabling further deteriorations. Six teeth were tested and their surfaces and the brackets were analyzed by microscope (fig. 2. and fig. 3.)

For this study the twenty tooth simulators were gripped on an universal testing machine from CTR being fixed along a steel stripe in order to avoid the natural bending of the bone during the test (fig. 4. and 5.). The force at break was measured at a speed of 0.5 mm/s. Twenty teeth made from bovine bone were tested and the results are shown in

Fig. 3. Microscope photos before and after debonding. The fracture of the composite may be observed

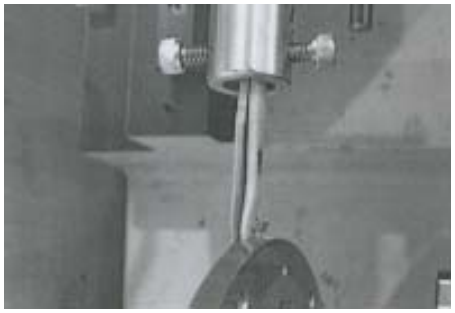

Fig. 4. Gripping of tooth simulator

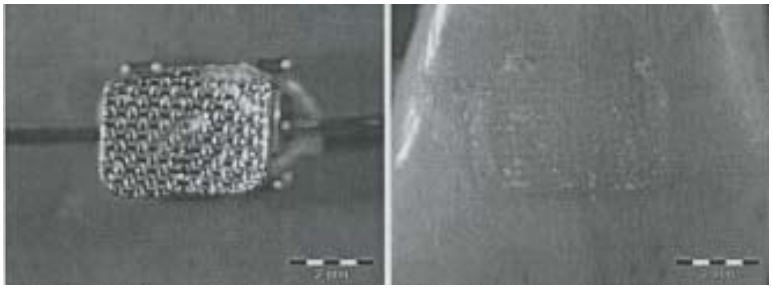

Fig. 6. Bracket and dental surface of sample no. 6 after debonding (accidental failure)

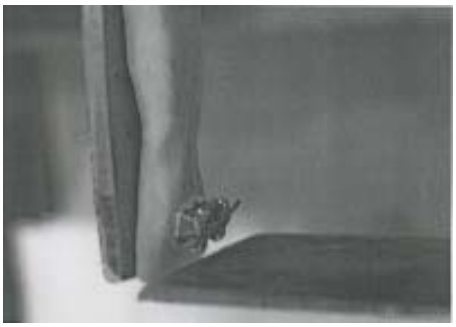

Fig. 5. Bracket position for accidental debonding

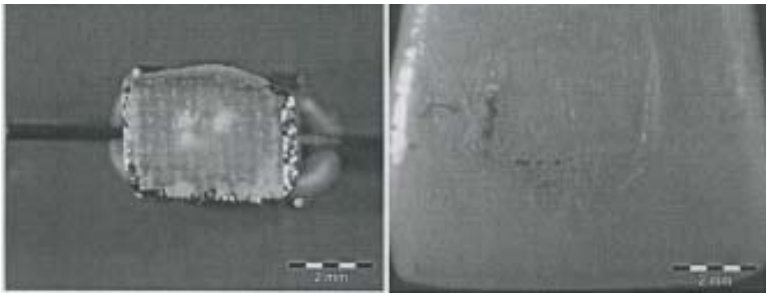

Fig. 7. Bracket and dental surface after debonding for sample no. 1 – the composites is on the bracket

Sample	1	2	3	4	5	6	7	8	9	10
Force [N]	64,30	16,52	3,93	59,88	0,01	40,06	0,42	50,67	0,01	0,01

Sample	11	12	13	14	15	16	17	18	19	20
Force [N]	53,20	24,06	6,50	7,05	12,76	26,18	20,06	1,21	25,42	6,45

Table 1
SHEAR RESISTANCE VALUES

table 1. These results revealed some deficiencies in brackets installation (as the cases of samples 6, 9 and 10) to which, practically, the brackets are not fixed due to the poor adhesion between bracket and composite fig. 6. In the case of sample numbered 1 the highest force value is reached and as it can be noticed in figure 7 almost the entire amount of composite is detached together with the bracket.

Statistical analysis of data was performed by using Chauvenet and Pierce criteria and the mean value of shear resistance was obtained as 21 N. Both of the two tests could not identify the aberrant values. Analyzing data by the Grubbs criterion the three smallest values were considered as aberrant and the mean value of the shear resistance was evaluated at 27.8N.

Conclusions

Using bovine rib bone is possible to simulate human teeth in studies regarding the bond resistance of the polymer or of the composite used as bridge between tooth and bracket. The use of such material ensures test repetition and results reproduction being also cheap and easy to prepare for tests. The obtained results are in accordance with results reported by other authors regarding the shear resistance of the bond.

Further studies have to take into account larger lots of samples in order to eliminate the difficulties supposed by the statistical analysis with small number of data. For further studies also more attention has to be paid for brackets installation. It might seem easier to fix brackets on some samples detached from the patient mouth but, in fact some reflexes are developed in practice and they cannot be avoided when the operator is asked to perform the same actions in other conditions.

The accidental debonding have been studied by measurement of shear resistance of bond between bracket and tooth [19]. This type of failure intervene when an obstacle appears in the natural movement of the tooth – in fact the movement of the teeth is controlled but the presence of the bracket is neglected (in the very first period of installation of an orthodontic system) so the bracket movement could be stopped by a hard bone (pork, lamb, duck, etc.) fragment or woody kernel of a peach, a plum or an apricot.

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