Comparative Study on the Adhesive Capacity of Four Adhesives Habitually used in Fixed Orthodontics

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The objective of the present study was to check the debonding strength in four types of orthodontic adhesives frequently purchased at present in our country: Ortho-Loc, Transbond XT, Tranasbond Self Etching Primer and Grengloo. For this study forty patients with integral maxillary arches and minor dental-maxillary abnormalities were selected and further randomly divided into four groups (one for each adhesive), each group being bonded with Resolve® Classic Bracket-type metal brackets. After one month, during which the brackets were subjecte to the action of oral factors, they were debonded using the force measurement FK model of the SAUTER device. There were no signficant differences between the four types of adhesives, nevertheless, the highest values were obtained for Transbond XT. All four types of adhesives were within the clinically acceptable interval being able to be safely used by clinicians.

Key words: orthodontic adhesives, brackets, self-etching, debonding strengths

The emergence of fixed orthodontics with the subsequent development of treatment techniques represented a great step forward in the treatment of dental-maxillary disorders. If cementation of bands around molars does not pose problems, these being bondable by use of various types of cements (such as zinc oxyphosphate cements, ionomeric cements, etc.), cementation of brackets on enamel was far more difficult. The use of classical cements (FOZ type, zinc polycarboxylate or the first types of ionomeric cements) was not successfull because bracketts were easily detached. This is why the use of bonding agents between enamel and the base of the bracket, with the capacity to adhere to dental enamel was attempted. An important step was achieved in 1955 with the discovery of enamel etching by Buonocore.

By etching, a certain degree of porosity with a depth of 10μ is achieved on the enamel surface after removal of the bacterial plaque and enamel layer. In this area some mineral cristals are also removed resulting in an increased reactive surface with a decreased superficial tension thus facilitating adhesion. In this area the adhesive will penetrate by creating digitations. This concept of micromechanical adhesion has been used in orthodontics only since 1965 by Newman, in combination with diacrylic composite resins. Initially, orthodontics used adheisve polymers similar to those used in odontology or prosthetics. It was only with the introduction of 3rd generation resins that diacrylic resins exclusively for orthodontics came into use.

The most important stage in the development of adhesives for orthodontic use was that of diacrylic composite resins. These evolved in their turn, but essentially they are similar to those used in odontology, with a comparable chemical structure. Modern adhesive systems (AS) used in orthodontics are classified as: AS based upon acrylic resins; AS based upon composite diacrylic resins; AS containing self-etching substances; and the last generation of AS for use in humid environment. At present, almost every manufacturer of dental materials has a section for orthodontic products.

Due to this abundant offer, the orthodontist finds it difficult to decide what products to purchase; should he or she remain faithful to already known products, already tested or should new materials on the market, with superior qualities, be tried on? The qestion still remains as the time for consulting references with adequate scientific studies is limitted.

Experimental part

Materials and methods

Starting with the conditions which orthodontic adhesives must fulfill, the most important quality still remains the debonding strength. No matter how difficult the case and how much effort from both dentist and patient it requires, nothing compares to the discomfort created by the accidental debonding of brackets. This is why, the *aim* of this study is to compare the debonding strength of four types of orthodontic adhesives frequently purchased at present in our country.

The study included metal brackets due to their qualities: easy to manipulate, superior mechanical qualities and, last but not least, a relatively low price. Even though the esthetic aspect is a draw back, they are still the most frequently used in orthodontics. In the present study we used the Resolve® Classic Bracket type B with 22 slot (Dentsply GAC). This B type has the following characteristics: torque in base, low-profile rhomboid shape, compound contoured, recessed single mesh base design, mid-size design with ample tie-wings for easy ligation, generous parallel tie-wings facilitate easy ligation. It is available in Roth and MBT Rx.

Forty subjects aged between 15 and 18 who volunteered for this study were selected. The condition was a complete maxillary arch (with no dental extractions, vestibular or crown fillings) regardless of the wisdom molars being erupted or not. They also had to be free of major DMAs in order not to influence the study results; slight dental crowding or interdental spacing were still accepted. A protocol was then signed containg the study details and

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procedures, as well as the needed patient behaviour throughout the study. Each patient received a set of standard instructions on the way feeding and oral hygiene were to be conducted during the study period in order to avoid any discomfort.

The 40 subjects were randomly classified into 4 groups, a different type of orthodontic adhesive being used in each of these groups. Even though there are in vivo and in vitro studies on brackets resistence to debonding forces, we chose this type of in vivo study because the debonding strength is measured in natural settings which are impossible to achieve in laboratry conditions. Among the factors acting in the oral cavity we mention the following: the mastication forces, especially if the patient does not entirely adhere to the received instructions; temperature differences due to the consumption of very hot or very cold foods; *p*H variation caused by certain aliments; *p*H decrease due to the activity of the oral microflora, as in patients with brackets oral hygiene is much more difficult thus facilitating plaque accumulation; but the forces induced at the moment when the archwire is inserted into the slot must not be excluded.

Before bonding the brackets on the teeth, these were professionally cleaned and then isolated to create optimal working conditions. In order to eliminate working style differences, all brackets were applied by the same dentist.

Group I: we used the Ortho-Loc (Dentsply Gac) adhesive. This product is composed of two adhesives: one liquid and a paste and the mixing of the two components is not needed. The teeth were etched with 37% orthophosphoric acid for 30 seconds, washed under a water flow, isolated and dried for 10 seconds with the air spray. The liquid adhesor – the primer was brushed on the enamel surface and the paste was applied on the base of the bracket. Then, by pressing the B against the enamel the polymerization was initiated. The composite in excess was removed before complete polymerization occured as it would be very difficult to remove it after polymerization is complete, its color being similar to that of the enamel. This type of self-polymerizing diacrylic resins (with chemical initiation – bicomponent system) is more rarely used than the monocomponent system of photopolymerizing resins. In order to ensure a complete polymerization it is advisable to insert the archwire only after 10 minutes.

Group II: we used the Transbond XT (3M Unitek) adhesive, monocomponent, photopolymerizable system, available in the form of prefilled syringe or capsules. It may be used for bonding metal brackets but also for ceramic ones, both on the enamel surface and on ceramic crowns. After enamel etching with 37% orthophosphoric acid for 30 seconds, washing, isolation and drying, the primer is applied in a thin layer and the excess is removed with the air spray. The adhesive paste is then applied which is polymerized most effectively for 20 seconds starting from the mesial and then from the distal area. It is important that the light beam to act for seconds from both directions in order to achieve a rapid and complete polymerization. The composite in excess is gently cleaned around the brackets and the archwire may be immediately inserted after polymerzation is complete.

Group III: we used the Transbond Self Etching Primer (3M Unitek) with fluoride release. The first step is the isolation of teeth. The innovation in this system consists of the fact that the acid for etching and the primer are simultaneously applied by mixing the two components inside the reservoir of the applicator. Then, the resulting solution is applied on the surface of the teeth, brushing with a slight pressure for 3-5 seconds on each tooth. The solution in excess is removed by air spray. Immediately afterwards, the bracket is inserted in the right position with the aid of the addhesive photopolymerizable paste and the composite in excess is removed. A real advantage of this system is that the primer is composed of a hydrophilic material which can act both in a moist and in a dry environment. This adhesive system also contains F.

Group IV: we used Grengloo (Ormco), an adhesive system with changeable colour: when reaching body temperature the colour becomes lighter and at lower temperatures it becomes greenish due to a thermosensitive component. Thus, the elimination of composite in excess after bonding is very easy to perform; similarly, the elimination of the composite used to bond B at the end of the treatment may be done with no risk of enamel damage. Still, the green coloration at low temperatures prohibits the use of this composite with transparent brackets. After etching with 37% phosphoric acid, washing, drying and isolation, the Ortho Solo solution is applied in a thin layer on the enamel and then a small amount of composite on the base of the bracket which is further pressed against the tooth. The excess is then removed and polymerization with the photopolymerization lamp is performed. The comparative features of the 4 adhesives are presented in table 1.

Table 1
COMPARATIVE FEATURES OF THE 4 USED ADHESIVES

Adhesive used	Initiation of polymerization	Use	Features	Comments
Ortho-loc	One step self-polymerization, without mixing	Liquid is applied on the etched enamel and the paste is applied on the bracket base	Uneven polymerization by pressing the 2 liquid-paste components	Not recommended with thick adhesives: e.g. molar tubes
Transbonb XT	photopolymerization	Primer applied on etched enamel and paste on the bracket base Relatively long working time	Even polymerization especially if photo lamp is positioned to work from all directions	Good alternative to previous adhesives, used at large scale (or similar adhesives)
Transbond Self Etching Primer	photopolymerization	Solution containing the etching agent is applied together with the paste on the braket base Short working time	Even polymerization especially if photo lamp is positioned to work from all directions Releases fluoride	Modern system, increasingly used due to shortening of the working time
Grengloo	photopolymerization	Primer applied on etched enamel and paste on the bracket base Relatively long working time	Even polymerization especially if photo lamp is positioned to work from all directions Easy to remove the composite in excess	Modern system, pleasant use due to thermosensitivity of the adhesor

Once brackets were bonded, they remained in place for one month during which time they were subject to the action of oral factors. After this period, the brackets were removed with a special device which measured the applied force. In this case force values were measured in N. In order to find out the resistence of the adhesive bonding between the enamel surface and the metallic brackets expressed in Mpa, the applied force must be divided by the brackets surface: N/mm^2.

For this purpose we used the model 250N of the Sauter FK digital dynamometer. The FK Sauter digital device for force measurement is a complex equipment which measures the compression and traction forces. With an ergonomic design, the FK Sauter digital device for force measurement has the following technical specifications: resolution from 0.00N, rate of data aquisition 100 Hz and precision at 0.5% of capacity. The FK Sauter digital device for force measurement consists of: internal sensor, large display with liquid crystals, reversibility (180^0 reversability of dispalyed values), "peak-hold" function for displaying the maximal measured value and accessories for performing the measurement. The weight of the FK Sauter digital device for force measurement is 600 g, being thus easy to use.

Results and discussions

During the one month period decided for the study, 5 brackets were debonded: 3 bonded with adhesive no. I in 3 different patients; 1 with adhesive no. III and 1 with adhesive no. IV. These brackets were eliminated from the analysis.

In group I we measured the force needed for debonding brackets in 10 patients, of whom: 7 patients x 10 teeth and 3 patients x 9 teeth and we calculated the mean force value/patient.

In group II we measured the force needed for debonding brackets in 10 patients, of whom: 10 patients x 10 teeth and we calcuated the mean force value/patient.

In group III we measured the force needed for debonding brackets in10 patients, of whom: 9 patients x 10 teeth and we calcuated the mean force value/patient.

In group IV we measured the force needed for debonding brackets in10 patients, of whom: 9 patients x 10 teeth and 1 patient x 9 teeth and we calcuated the mean force value/ patient.

The mean value of forces needed to debond brackets for each patient (expressed in N) are shown in table 2. If we consider the mean value of Resolve® Classic Bracket type B surface as around 10 mm^2, we may calculate the debonding force expressed in MPa (N/mm^2). These values are found in table 3.

There are many studies on the effectiveness of adhesives for brackets bonding. The adhesives we selected for the present study were chosen because Ortho-Loc and Transbond XT are frequently used by Romanian orthodontists, Transbond SEP is a relatively new adhesive, with special proprieties and a significantly decreased working time and Grengloo is also special due to its thermosensitivity. The results obtained in this study mostly coincide with data published by other authors [1- 17]. Maximal values of adhesive force were obtained for Transbond XT, followed by Grengloo and TSEP with almost equal values and Ortho-Loc came on the last place. Following the study, Transbond XT proved to be the best adhesive, this conclusion being concordant with most clinical studies [6, 9, 13-15]. It must be admitted that, even though most patients are reticent to using the TSEP adhesive due to lack of confidence in simultaneous etching and bonding, the results obtained in this study prove that we may be completely confident in its use [18]. An advantage is represented by the fact that it also releases fluoride, thus having a protective effect against dental caries [19]. Also, Grengloo is an adhesive with special results, easy to use and highly performant due to its ability to change colour which makes it attractive for patients too. Despite having the lowest values, Ortho-Loc adhesive gave good results, being positioned within the interval of clinical acceptability (F>58N), proving that self-polymerizing adhesives also deserve to be taken into consideration for orthodontic bonding.

Table 2

MEAN VALUE OF FORCES NEEDED TO DEBOND B FOR EACH PATIENT, EXPRESSED IN N, DEPENDING ON THE TYPE OF ADHESIVE USED

Group	Force expressed in N									
	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
I *Ortho-L*	70,14	63,15	82,22	59,16	90,78	73,24	48,58	68,88	84,12	81,25
II *T- XT*	98,73	124,53	104,14	78,15	100,43	90,14	85,64	120,78	88,15	96,24
III *T-SEP*	93,14	88,56	90,24	80.78	68,78	82,23	77,14	98,54	73,23	80,24
IV *Grengloo*	76,56	102,14	98,56	82,24	75,35	70,48	88,96	92,14	82,64	90,85

Table 3

MEAN VALUE OF DEBONDING FORCES FOR EACH PATIENT, EXPRESSED IN MPa (N/mm^2), DEPENDING ON THE TYPE OF ADHESIVE USED

Group	Debonding forces in Mpa									
	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
I *Ortho-Loc*	7,01	6,31	8,22	5,91	9,07	7,32	4,85	6,88	8,41	8,12
II *T- XT*	9,87	12,45	10,41	7,81	10,04	9,01	8,56	12,07	8,81	9,62
III *T-SEP*	9,31	8,85	9,02	8,07	6,87	8,22	7,71	9,85	7,32	8,02
IV *Grengloo*	7,65	10,21	9,85	8,22	7,53	7,04	8,89	9,21	8,26	9,08

Conclusions

According to the data obtained by this study, the most recommended orthodontic adhesive is Transbond XT.

We must not avoid the use of Transbond SEP as the results confirm that etching and bonding performed in one stage significantly shorten the working time and are effective.

The Grengloo adhesive is effective, useful for the orthodontist and interesting for the patient.

Ortho-Loc is an adhesive from a previous generation but it is effective and we may continue to use it with confidence.

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Manuscript received: 26.10.2011