Comparison of two different debonding techniques in orthodontic treatment

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Summary

***Aim*. The purpose of this research is to investigate whether and how the adhesive bond failure site varied in relation to the material used for the orthodontic bonding and debonding technique applied.**
***Materials and methods*. Two different methods of orthodontic debonding were included in our survey; cutters for orthodontics and debonding plier. Three different materials for the adhesion of the bracket: composite light curing, self-curing composite and glass ionomer cement. The remaining amount of adhesive on the tooth surface is an important parameter that gives information on how the location of the posting site varied during the debonding. 60 dental elements, maxillary and mandibular, previously extracted for orthodontic reasons, as well as periodontal, were included in our research. We investigated a possible significant correlation between different variables (debonding technique and materials for membership) and the ARI index.**
***Conclusions*. The use of orthodontic cutters or debonding pliers does not affect the adhesive bond failure site and both techniques have a tendency to leave a significant amount of adhesive on the surface enamel. In the resin-reinforced glass ionomer cements, detachment occurs at the interface enamel-adhesive and this pattern of detachment increases the risk of the enamel damage during debonding. In both types of composite resins (photopolymerizable or self-curing), the detachment occurs at the interface bracketing adhesive. In this case the amount of remaining adhesive material on the tooth must be removed with further methods, which in addition, increase the risk of iatrogenic injury as well as the working hours.**

Key words: orthodontics, debonding, adhesion.

Introduction

In order to guarantee the success of a fixed orthodontic treatment, efficient adhesion of the bracket on the surface of the tooth is required for the duration of the orthodontic treatment, which prevents an eventual detachment or change of its initial position during the application of orthodontic force.
On the other hand, at the end of the treatment, the procedure of debonding should be able to be implemented effectively, allowing the detachment of the bracket from the tooth surface as well as leaving the enamel surface intact.
The adhesive system for orthodontic attachments should fulfill two tasks which in fact are mutually exclusive, therefore the majority of the studies in this field of orthodontics has focused on the evaluation of the mechanical and physical properties of the adhesive materials used for the direct bonding of orthodontic brackets, including their adhesive strength and enamel condition during, and at the end of the treatment (1, 2).
It has been shown that each material presents different molecular structures and different physico-mechanical properties, which also justifies the different behaviors in response to the applied force during the debonding procedures. In particular, it was shown that the forces applied to allow the detachment of the bracket from the enamel surface do not act in a homogenous way, but focus mainly on specific weaknesses of the adhesive bond (3-5).
In detail regarding the failure of the adhesive bond site, Artun and Bergland in 1984 developed an index called ARI (Adhesive Remnant Index), thus identifying two different failure patterns in the tooth-bracket-adhesive system, namely the formation of a gap in the enamel-adhesive or bracket-adhesive bonding surfaces.
Inquiring about the posting site is crucial due to the fact, that both failure modes have 0 clinical implications that should be considered during an orthodontic

treatment. In the first case, namely in the event of a detachment at the enamel-adhesive interface increases the risk of fractures and permanent damage to the enamel, whilst in the second case when following the fact that the gap formed between the bracket and adhesive leaving a large amount of composite on the vestibular surface of the tooth, the risk of damage to the enamel will be reduced but additional procedures to remove the composite from the tooth surface will be necessary, which will then result in an increase of working time (6).
In light of the above and the growing scientific interest on the subject, it seemed interesting to focus on the matter and in particular investigate whether and how the adhesive bond failure site varied in relation to the material used for the orthodontic bonding and debonding technique used. The purpose of this research is to evaluate the possible influence of two different methods of orthodontic debonding: Cutters for Orthodontics and debonding pliers.

Materials and methods

Three different materials for the adhesion of the bracket were used:
1. Composite light curing
2. Self-curing composite
3. Glass ionomer cement.

The remaining amount of adhesive on the tooth surface is an important parameter that gives information on how the location of the posting site varied during the debonding.
The study is divided into four different phases:
1. Preparation and subdivision of the sample:
the sample has been properly prepared and divided into groups;
2. Bonding:
three different materials were used to allow the adhesion of the bracket to the extracted teeth;
3. Debonding:
we used two different methods of debonding to remove the bracket previously applied to the vestibular surface of the teeth;
4. Evaluation of sticker remaining:
we evaluated the remaining amount of composite or cement on the surface of the tooth through the ARI index;
5. Statistical analysis of data:
we investigated a possible significant correlation between variables (debonding technique and materials for membership) and the ARI index.

Preparation and subdivision of the sample

The sample consists of 60 dental elements, both maxillary and mandibular previously extracted for orthodontic reasons, as well as periodontal selected according to the following sample inclusion criteria:

- Intact vestibular surface
- Absence of caries
- No fillings
- Lack of enamel defects.

The extracted dental elements were thoroughly cleaned from any tissue and fluid and stored in distilled water and 1% thymol for 24 hours to prevent dehydration.
Subsequently they were stored in distilled water until the moment of their use.
Before use, the vestibular surface of all the teeth was cleaned and polished with a rubber pad mounted on a low-speed handpiece for 10 seconds.
The sample was divided into 6 groups each one consisting of 10 dental elements (Table 1).

Bonding of the bracket to the enamel surface

Procedures for bonding of the bracket in groups 1 and 2

MATERIALS: light-curing adhesive system
The vestibular surface of dental elements was etched using 37% orthophosphoric acid for 30 seconds, was subsequently rinsed for 15 seconds and dried with air jet to obtain a chalky appearance of the enamel.
It was then applied with a brush, the © Transbond XT primer (3M Unitek, Monrovia, California) on the previously etched surface and stretched by a gentle jet of air to obtain a thin layer of primer disposed uniformly on the enamel.
The primer was photoactivated using a curing light for 10 seconds.
At this point, we selected the self-ligating bracket corresponding to the teeth used, and after placing on the bracket base an adequate amount of light-curing composite © Transbond XT Adhesive Paste, the attack was positioned on the surface of the corresponding tooth with *DOOR pliers*.
Once we removed the excess material from the periphery of the bracket the composite was light-cured with a light power equal to 740 mW/cm^2 and a wavelength of 470 nm to 480 nm for 20 seconds on each side (mesial, distal, incisal and gingival).

Procedures for bonding of the bracket in groups 3 and 4

MATERIALS: self-curing adhesive system
The vestibular surface of the dental elements was etched using 37% orthophosphoric acid for 30 seconds, and was subsequently rinsed for 15 seconds and dried with air jet to obtain a chalky appearance of the enamel.
A thin layer of Ortho-one No Mix Primer (BISCO Inc. U.S.A.) was applied with a brush both on the tooth surface previously etched, and stretched with a faint jet of compressed air, or on the base of the bracket.
The primer in this case contains a catalyst molecule that once in contact with the adhesive paste initiates the curing process.

Table 1. Sample division into six groups.

	Etching	Primer	Adhesive composite	Debonding Technique	Bracket type
Group 1	37% Orthophosphoric acid (3M)	primer Transbond XT (3M)	Transbond XT (3M)	Cutters for Orthodontics	Self ligating bracket
Group 2	37% Orthophosphoric acid (3M)	primer Transbond XT (3M)	Transbond XT (3M)	Debonding plier	Self ligating bracket
Group 3	37% Orthophosphoric acid (3M)	Ortho-one No Mix Primer (Bisco)	Ortho one No Mix Paste (Bisco)	Cutters for Orthodontics	Self ligating bracket
Group 4	37% Orthophosphoric acid (3M)	Ortho-one No Mix Primer (Bisco)	Ortho-one No Mix Paste (Bisco)	Debonding plier	Self ligating bracket

	Etching	Liquid of glass onomer cement	Powder of glass ionomer cement	Debonding Technique	Bracket type
Group 5	10% Polyacrylic acid	Fuji Ortho liquid	Fuji Ortho powder	Cutters for Orthodontics	Self ligating bracket
Group 6	10% Polyacrylic acid	Fuji Ortho liquid	Fuji Ortho powder	Debonding plier	Self ligating bracket

At this point an adequate amount of adhesive paste (Ortho-one No Mix paste) is placed on the bracket base and the attack is positioned on the surface of the tooth with a clamp bracket, making sure to properly join the attack on the enamel surface and to remove any excess material from the periphery of the bracket.

In this case the polymerization, made possible by the catalyst contained in the primer, occurred in about 5 minutes.

Procedures for bonding of the bracket in groups 5 and 6

MATERIALS: glass ionomer cement

The vestibular surface of the teeth was conditioned with 10% polyacrylic acid for 20 seconds, subsequently rinsed for 15 seconds, and adequately dried with an air jet afterwards.

The paste and liquid components of the glass ionomer cement (Fuji Ortho and Fuji Ortho liquid powder) were mixed according to the manufacturer's instructions, and once it reached the desired consistency, the glass ionomer cement was applied with a brush in a thin layer on the bracket base. The attack was positioned on the surface of the corresponding tooth, which was previously cleaned and polished. Excess material from the periphery of the bracket was removed with a calliper bracket. The material was light cured with a light power equal to 740 mW/cm^2 and a wavelength of 470 nm to 480 nm for 20 seconds on each side (mesial, distal, gingival and incisal).

Bracket used

In all six groups metallic self-ligating brackets were used, the base of the bracket had a single 80 gauge mesh morphology with a mesh spacing equal to $3{,}2 \times 10^{-2}$ mm^2.

Debonding

Procedures in groups 1-3-5 debonding
METHOD USED: cutters for orthodontics
The brackets attached to the surface of the dental elements were removed through the use of nippers for orthodontics, by placing the beaks of the pliers at the base of the bracket fins and applying a force directed mesio-distally to promote the detachment of the bracket from the enamel surface.

Procedures in groups 2-4-6 debonding
METHOD USED: debonding plier
The dental elements were subjected to a debonding procedure through the use of a dedicated tool. The beaks of the pliers of the debonding chisel were positioned as near as possible to the base of the bracket and shear force was applied to allow the detachment of the bracket.

Evaluation of the remaining quantity of adhesive material on the dental surface

Scan 3D
The dental elements, after the debonding procedures were subjected to 3D scans.
The scanner used was a SYNERGY SCAN, which is a sophisticated 3D optical scanner that can acquire non-contact three-dimensional shapes.
The technology used in the scanner is called active stereo vision and is the projection of a structured light pattern on the surface of interest that is captured through two cameras.
Advanced image processing algorithms to retrieve the aquiered surface's depth were used and a reconstruction of a three-dimensional image that can be easily viewed and manipulated on the PC screen was achieved.
The entire scanning step is fully automated with the help of an automated rotating table that allows us to acquire different views of the object.
The teeth were placed on Support Single Silicon and dulled by spray cleaner before being subjected to scanning.
This is because many objects have a surface that is not easy to detect with the light beam used by the scanner.
If the objects are transparent, too dark, opaque, or black they have refractive and reflective qualities, which do not allow the camera to detect the ray of light which is deformed or reflected erratically. In these cases it is impossible to perform the scanning unless you opacify the object with preferably a white opaque layer, which renders the area appropriate. The spray used (Renfert - scan spray) allows treating the surface at an optimal level for the scan.

Calculation of the ari index
To determine the remaining amount of adhesive on the labial surface of the dental elements after debonding, we processed the images of the digitized scans with a special software which made it possible to calculate the perimeter and the area occupied by the residual material (Fig.1).
By calculating the area occupied by the remaining adhesive material and having available the information relating to the area of the base of the bracket used it was possible to calculate the index ARI (Adhesive Remnant Index) described by Artun and Bergland.
The ARI Index involves the assignment of values ranging from 0 to 3:
0: Absence of adhesive material remaining on the tooth surface
1: Presence of less than half of the adhesive material remaining on the tooth surface
2: Presence of more than half of the adhesive material remaining on the tooth surface
3: Presence of all of the adhesive material on the tooth surface.

Statistical analysis

Statistical analysis was performed using SPSS Inc. ver. 13.0, Chicago, IL, USA. Chi-squared test was used for statistical evaluation of proportions. In cases of more than 2 independent means we used the ANOVA test. A p-value of less than 0.05 was considered significant. A 95% CI was used in all of the analysis. In order to assure data reliability, data were entered in two different personal computers by two examiners; the two data files were compared in order to detect entry errors. The two files resulted identical. Statistical tests were performed, to investigate any significant correlations between the type of material, the debonding technique and the ARI index. For further analysis, the statistical Chi-square test was used. The Chi-square test is a nonparametric statistical test, which allows the comparison of two related reports or frequencies, in order to exclude, with a certain degree of probability, that their difference is due to the chance. Any statistical program will result in a transformation of the test result in probability (p). This probability of error should also be assessed according to the level of significance chosen by the investigator.

Results

We carried out two different surveys.
In the first we compared the different materials used for the bonding and the ARI index, while in the second we compared the debonding techniques to the ARI index.

Survey 1
In this study we used the statistical Chi-square test with 95% confidence interval, to determine any significant correlation between the three different materials used for orthodontic bonding (a light-curing composite, a composite and a self-curing glass ionomer cement), and the ARI index.

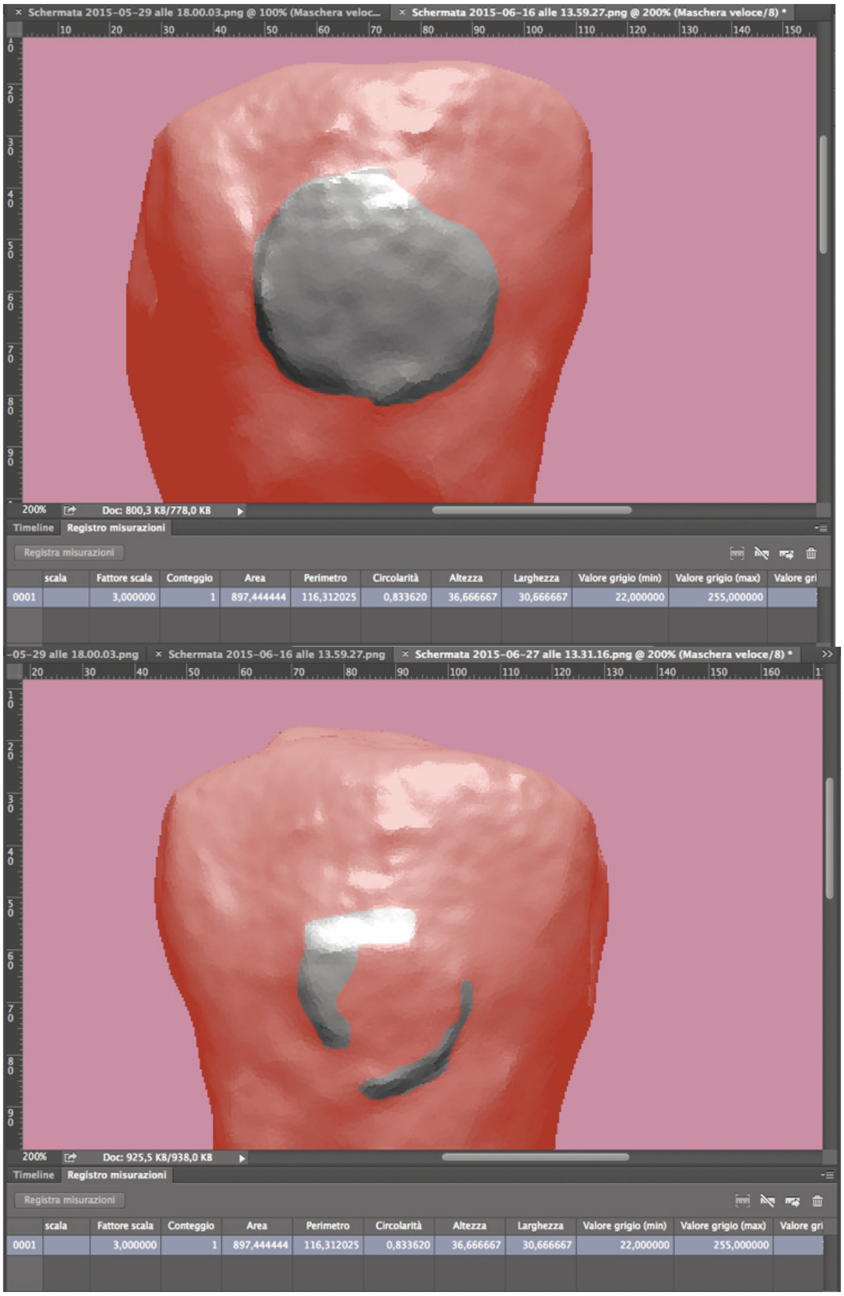

Figure 1. Digitized scans.

Between the dental elements in which a light-cured composite for the bonding of orthodontic brackets was used on a total of 20 teeth:

- 1 element reported value of ARI 0
- 5 elements have reported a value of ARI 1
- 11 elements have reported a value of ARI 2
- 3 elements have reported a value of ARI 3.

Between the dental elements in which a self-curing composite for the bonding of orthodontic brackets was used on a total of 20 teeth:

- 4 items reported a value of ARI 0
- 4 elements have reported a value of ARI 1
- 5 elements have reported a value of ARI 2
- 7 elements have reported a value of ARI 3.

Between the elements where dental self-curing composite for the bonding of orthodontic brackets was used on a total of 20 teeth:

- 4 items reported a value of ARI 0
- 4 elements have reported a value of ARI 1
- 5 elements have reported a value of ARI 2
- 7 elements have reported a value of ARI 3 (Fig. 2).

The graph shows that among the elements in which a glass ionomer cement was used, 61% of the sample presented a value of ARI 0 (no remaining sticker on the surface of the tooth) compared to 8% of the items in which a light-curing composite was used and 31% among the elements in which a self-curing composite was used (Fig. 3).

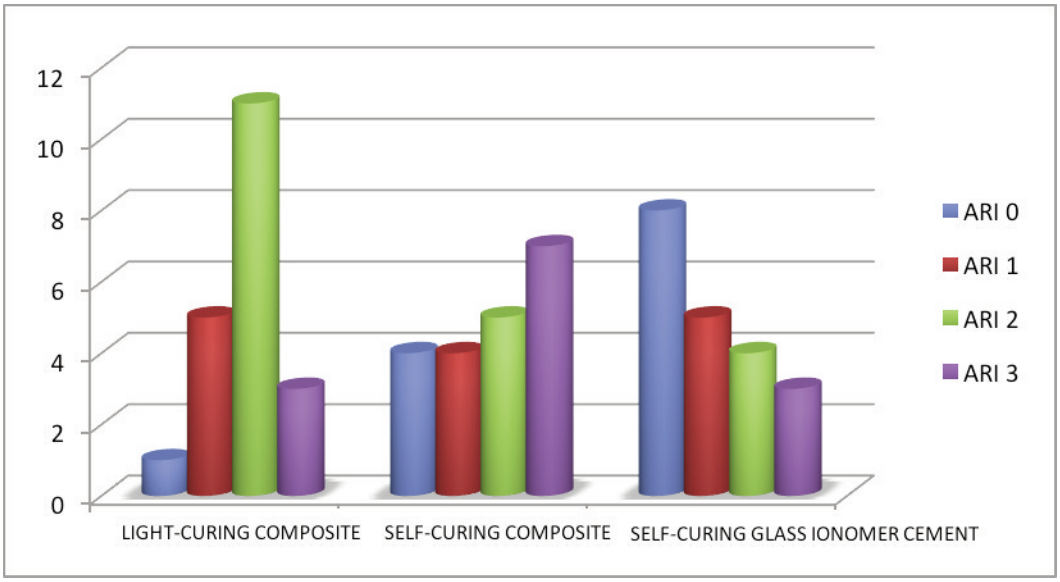

Figure 2. First survey (p value = 0.05).

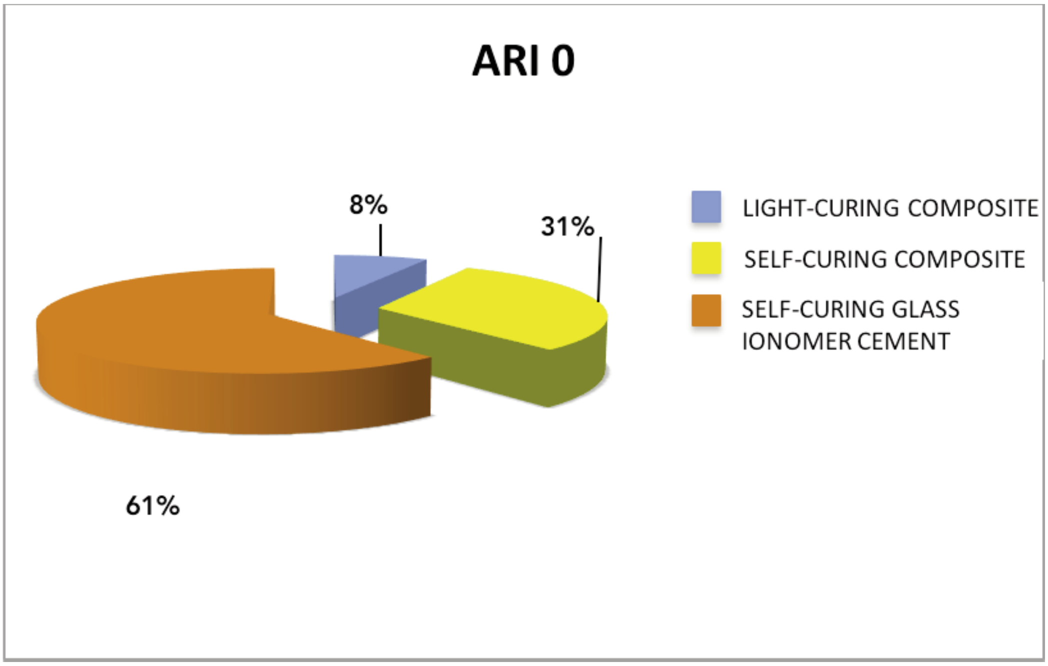

Figure 3. ARI 0 percentage in the three adhesive materials.

Survey 2

In this analysis we investigated by the use of the statistical Chi-square test, with a 95% confidence interval, any significant correlation between the two different debonding techniques and the ARI index.

Among the elements in which pliers were used to remove brackets from the vestibular surface, out of a total of 30 teeth:

- 4 elements reported a value of ARI 0
- 6 elements reported a value of ARI 1
- 12 elements reported a value of ARI 2
- 8 elements reported a value of ARI 3.

Among the elements in which a wire cutter for orthodontics was used to remove brackets from the buccal surface, out of a total of 30 teeth:

- 9 elements reported a value of ARI 0
- 8 elements reported a value of ARI 1
- 8 elements reported a value of ARI 2
- 5 elements reported a value of ARI 3.

This investigation showed no significant values (p value> α) (Fig. 4).

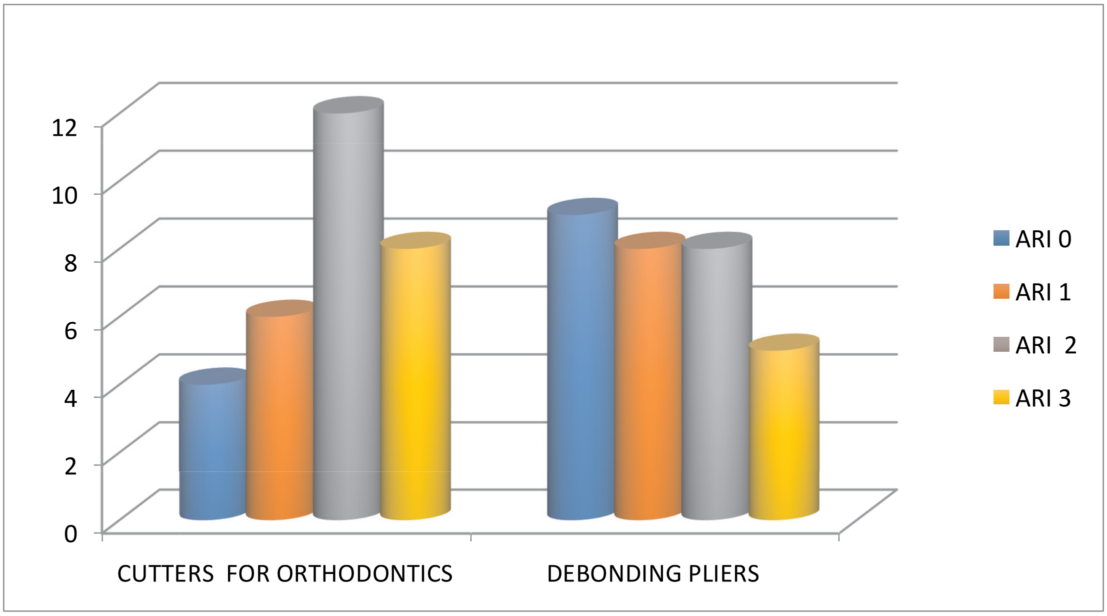

Figure 4. Correlation between the two different debonding techniques and the ARI index.

Discussion

The finding of a statistically significant correlation between the type of material used for orthodontic bonding and the Adhesive Remnant Index, confirms the data reported in the literature according to which, the adhesive bond failure site during the debonding varies depends on the material used for bonding (7).
In particular, the results show that in the elements in which a glass ionomer cement was used, the adhesive failure in the debonding procedures resulted mostly in the adhesive enamel interface, unlike elements in which a composite was used where the failure of the bond took place mostly in the bracket adhesive interface.
The reasons that the glass ionomer cements binds more efficiently to the metal base of the bracket in respect to composite resins are to be discovered, because unlike the latter, the glass ionomer cements permit a chemical bond both to the base of the bracket and the enamel.
In addition, in the glass ionomer cement, the mechanical component of the adhesive bond, which is made possible by the creation of micropores in the enamel, is greatly diminished, because these materials do not need an etching with strong acid (orthophosphoric acid at 37%) which demineralizes the enamel (8, 9), but rather need etching with a weak acid (10% polyacrylic acid), which demineralizes very mildly the enamel and has mainly the aim of cleaning the surface from the acquired film and debris (10-13).
As for the elements in which composite resins were used (photopolymerizable and self-curing) for orthodontic bonding, the adhesive failure in the debonding procedures, occurred for the majority of the samples at the bracket adhesive interface.
In particular the highest values of ARI index were recorded with the use of a light-cured composite.
This behavior is probably due to an incomplete polymerization of the resin below the base of the bracket due to the difficulty of the curing light to reach and activate the material located immediately below the metal base. In addition, the effect of air entrapment below the bracket during the procedures of bonding, allows the oxygen to cause a partial inhibition of the free radicals necessary for polymerization and can be responsible for the failure of the adhesive bond in bracket-adhesive interface. This effect is only reported in the literature for the light cured composites (14, 15).
The reasons for the same behavior of the self-curing composites, however, lie in their high rate of polymerization which create a very high adhesive force, giving an explanation for the material separation in the bracket adhesive interface.
It is reported in the literature that when you reach very high values of bond strength, applying a separation force to allow for the debonding of the bracket, a fracture plane is created that propagates into the material and at the interface-bracketing adhesive.
No statistically significant differences were found between the two debonding techniques used (orthodontic wire cutters and debonding pliers) in relation to the ARI index.
Both tools used have shown a tendency to leave a significant amount of adhesive on the enamel surface.
These findings are similar to data reported in several previous studies (3, 16-19).
Our results are in concordance with international literature and confirm that during debonding the type of force applied affects the remaining amount of adhesive and not the type of instrument used.

In particular by applying shear forces on the gap site localizes mainly to the interface bracket-adhesive, while applying tensile forces the posting site is transferred to the interface between the enamel and the adhesive (20).
Both debonding orthodontic instruments analyzed in the current study apply a shear force to the bracket which explains in both methods, the presence of a significant amount of adhesive on the surfaces of dental elements following the procedures of debonding.

Conclusions

The use of orthodontic cutters or debonding pliers, does not affect the adhesive bond failure site and both techniques have a tendency to leave a significant amount of adhesive on the surface enamel.
The type of material used for orthodontic bracket bonding significantly affects the release site. In particular, in the resin-reinforced glass ionomer cements, detachment occurs at the enamel-adhesive interface and this pattern of detachment increases the risk of the enamel damage during debonding.
In both types of composite resins (photopolymerizable or self-curing) the detachment occurs at the bracketing adhesive interface. In this case the amount of the remaining adhesive material on the tooth must be removed by resorting to subsequent steps which in addition increase the risk of iatrogenic injury as well as working hours.

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