AJMHS Vol. 48 (1/2): 40-48 © 2017

The Influence of Deepness of Preparation on Shear Bond Strength between Tooth and Ceramic – An Experimental Study

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Abstract

Background: Bonding strength is one of the most important features of the modern esthetic materials. It is shifting the conventional invasive dentistry, in a minimal invasive dentistry. Cementation of ceramic on dental tissues is broadly clinically used, but the shear bond strength between them especially on enamel, is fairly studied.

Aim: To compare the SBS of an esthetic material (a pressed ceramic) on two different depths of preparation, respectively in two different tissues of the tooth: enamel and dentin.

Study design: This study was an in vitro experimentation, to measure the shear bond strength on preparation in enamel and dentine, on the same tooth. The preparations, cementations and measurements were done by the same operator. All the parameters, beside deepness of preparation were kept unchanged.

Method: We took 148 intact teeth, without caries and/or restorations, and prepared as many cilindrical pressed glass ceramics, with diameter 2.38 mm and hight around 3.5 mm. The cilindrical ceramics were cemented once on teeth prepared only on enamel, and then on the same teeth prepared on dentine deepness. It was followed strictly the same protocol, with the same materials, from the same operator. The only parameter changed was the deepness of preparation. The comparison between the bond strength on dofferent deepnesses of preparation, was valued with paired t test.

Result: The difference between shear bond strength was statistically different between two depths of preparation, being higher when the preparation was restricted on enamel

Conclusion: In this study, the shear bond strength was higher on enamel then on dentine, so we can conclude that saving the tooth structure during preparation, beside fullfilling the biologic principle, we also achieve a higher bond strength.

Key words: preparation, adhesion, ceramic, enamel, dentine, shear bond strength

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INTRODUCTION

Esthetics in dentistry is going hand by hand with adhesive dentistry. Dental materials that adhere to dental tissues are developing very fast, in effectiveness and easiness of use.

Conventional restorative materials need a specific thickness for their efficacy in retention, esthetics and longevity. This thickness requires grounding the tooth tissue, to create space and form, adequate for the material. On the other side this tooth grounding, weakens its own structure, and may cause different pathologies to the pulp (1).

Modern adhesive dentistry, pretends to shift this model idea into a minimum invasive preparation. Since 1955, when Buonocore gave hope to adhesion, bringing the idea of etching (2), there have come out many generations of adhesives, resins, ceramics, etc.

One of the features, where these materials need to be effective, is bonding strength, in a way that it could resist the masticatory forces from different angles, the fatigue with time and the oral environment. According to De Munck et al. the most used tests to evaluate it, are: shear, tensile and push out test, micro and macro for each one (3). Between them, the most used, is Shear Bond Strength (SBS) test, with 26% of scientific papers, according to Burke (4), this test fulfills also the requirements of the design of our experiment. As defined by Sirisha et al. the SBS test consists of *two materials connected via an adhesive agent and loaded in shear until fracture occurs* (5).

Therefore, the aim of this study is to compare the SBS of an esthetic material (a pressed ceramic) on two different depths of preparation, respectively in two different tissues of the tooth: enamel and dentin.

The null hypothesis is: The deepness of preparation does not influence the SBS between ceramic and the tooth.

MATERIALS AND METHOD

Study design

This in vitro study included 148 out of 257 extracted teeth from different clinicians in Albania, mainly due to orthodontic, periodontal problems or third molars extracted for prophilacticy. Criteria used for inclusion were lack of caries and/or restorations. Damages to enamel during preparation for measurements indicated the exclusion of the tooth. SBS on enamel and dentin were measured on the same tooth for all included teeth.

The protocols of preparation of the surfaces of two substrates (tooth and ceramic) for cementation are summerized in Tab.1 (a&b).

In a dental laboratory were prepared cilindrical pressed glass ceramics (Ceramay, Buchbraunen, Ulm Germany) with diameter 2.38 mm and hight around 3mm to 3.5mm.

The resin luting cement was a lightcured, porcelain laminate veneer cement (Permashade LC, Ultradent, Utah, USA). It was used the same colour for all the specimens, in enamel and dentine, the transparent colour.

Table 1a. Protocol of preparation of the tooth for cementation

	Protocol of preparation of the tooth (enamel/dentin)
1	Acid etching (35% Phosphoric acid, Ultraetch) enamel (20 seconds)/dentin (15 seconds)
2	Rinsing with water 20 seconds/15seconds
3	Adhesive resin application (Peak Universal Bond) 10 seconds and air thinning
4	Polymerization 20 seconds

Table 1b. Preparation of ceramic for cementation

	Protocol of preparation of ceramic
1	Hydrofluoric etching (buferized 9% Ultradent Porcelain etch) 90 seconds
2	Rinsing with water 90 seconds
3	Cleaning of debridement with acid (H3PO4) 5 seconds
4	Rinsing with water 5 seconds
5	Silane coupling agent application (Ultradent Silane) 60 seconds
6	Cement (Permashade LC) application on the prepared side of the ceramic

For the preparation of the dental tissues, was used 35% Phosphoric acid (Ultretch, Ultradent, Utah, USA) for etching, and as adhesive was used Peak Universal Bond (Ultradent, Utah, USA)

For the preparation of the ceramic, was used hidrofluoric buferized acid 9% (Ultradent Porcelain Etch, Ultradent, Utah, USA) for etching, and for silanization was used Ultradent silane (Ultradent Products, Utah, USA

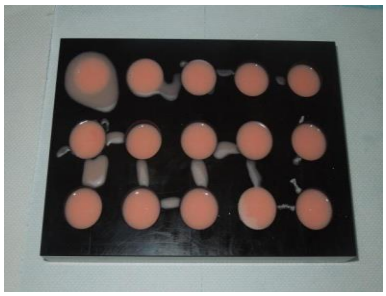
Experimental procedure

Preparation of bonding specimens: We separated the crown from the roots (Figure 1a), and the crown was kept. The pulp remnants of the coronal part were cleaned with ultrasonic tip with water. The teeth were kept all the time in saline water 0.9%, till the moment of cementation. This time was no longer then 6 months:

Figure 1.a-c. The separation of the crown from the root (a) Positioning of the crowns on the base of the 15 hole mold (b) the poured cold curing resin (c)

(a)

(b)



(c)

On the base of the 15 holes mold (Ultradent Products, South Jordan, UT,USA), was put a thin layer of putty (fig. 1.b,c) from a common impression material, without mixing with catalysator, so it could kept its putty consistency, to have the possibility to plunge a bit the crown, so, the surface would not be in contact with the cold curing resin (Mega Dur, Megadental Gmbh, Seeweg 20, Budingen, Germany), that was poured on it, to fix the teeth. The teeth were mounted, trying to position the flatter surface (at least a circle surface of 2.38 mm2), inside the putty, to let it exposed for the cementation of ceramic cylinder.

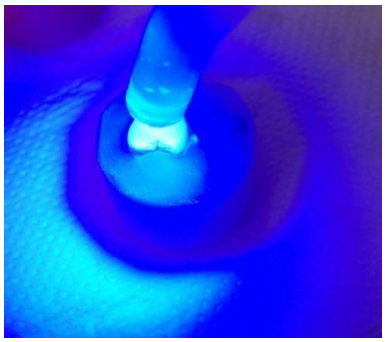
All the samples were labeled with a number, to follow them, in both preparations. After, the resin cured, the bonding specimens were cleaned and kept in saline water, till the moment of cementation.

The steps of cementation, were done according the instructions of the manufacturer of the resin luting cement.

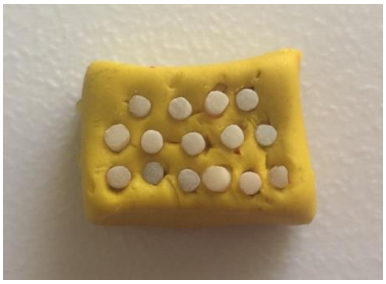
The preparation of teeth for cementation (fig.2.a&b): the flat surface of exposed enamel, was prepared only a little, staying in enamel, just to take off the aprismatic surface layer, keeping the flat surface, with a surface at least 2.38 mm2. The preparation was done with a dental bur (815/015 NorthBell, Italy), cooled with water, then dried with air of the dental unit syringe. The flat surface was etched (Ultraetch, Ultradent, Utah, USA) for 20 seconds, rinsed for 20 seconds, then was applied the adhesive (Peak Universal Bond, Ultradent Products, Utah, USA) rubbing for 10 seconds the surface, spreading it with a bit flow of air, and then polymerize for 20 seconds, with a LED lamp (Woodpecker, woodpecker Medical Instruments Co, LTD, Guangxi, China)

Figure 2. a-d. Steps of preparation for cementation: etching of the tooth(a) adhesive polymerization on the tooth (b) etched ceramic specimens with HF (c) cilindrical ceramic cemented on enamel (d)

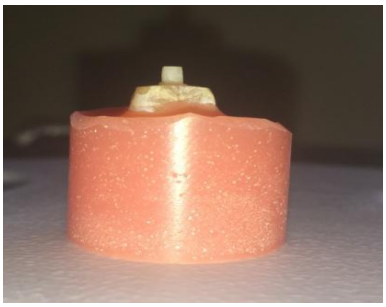
(a)



(b)



(c)



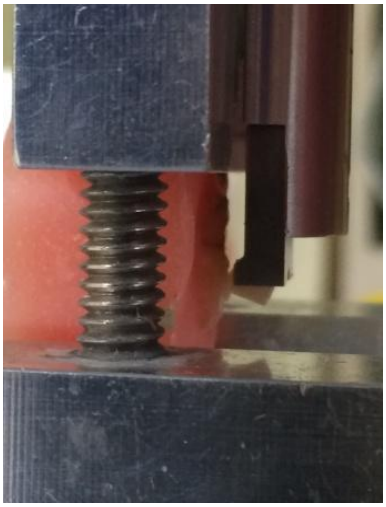
(d)

The preparation of ceramic specimens for cementation (fig.2.c): the ceramic cilinders were etched for 90 seconds, with a hydrofluoric acid (Ultradent Porcelain etch 9%). They were rinsed with water, then the debris were treated for 5 seconds with phosphoric acid (Ultraetch, Ultradent, Utah, USA), rinsed again with water from the dental unit syringe, dried, and a layer of silane (Ultradent silane, Ultradent Products, Utah, USA) was applied for 60 seconds

Cementation: when both the substrates were ready for cementation, the operator put the resin luting cement (Permashade LC T, Ultradent Products, Utah, USA), on one side of the ceramic piece, and pressed it on the flat surface, with hand pressure (like in a clinical situation) polymerize for 2 seconds, took off the excessive mass of cement, end finished the polymerization for 20 seconds on two opposite sides (fig. 2.d)

All the prepared specimens, were kept for 24 hours in 37 degrees, then were underwent the measurements in Ultratester (Ultradent Products,Utah,USA). The specimens were put in a relation with the loading crosshead, to stay as close as possible, with the bonding interface. The loading crosshead moved with 1mm/min, till the ceramic was detached (fig. 3), this maximum load was memorised by the machine, and the results were registered in a Microsoft Office Excel 2007 sheet.

Figure 3. The moment of detachment of the ceramic after shear loading



All the teeth specimens, from the first measurements, were underwent to another preparation, on a dental trimmer cooled with

water, using a grinding mandrel and a T-slot grinding Plate (Ultradent Products, Ultradent, Utah, USA), to keep the parallelism of the bonding surface, with the base of the specimen, so it could be perpendicular with the loading crosshead. The teeth were grounded till the dentine was exposed.

Then were done again all the preparations of the teeth and the ceramic pieces, after the manufacturer's instructions. It had only one difference during the preparation of the dentinal surface for bonding, it was etched only for 15 seconds with the phosphoric acid.

Figure 4. Ceramic cemented on dentin

Also in dentine, the cementation (figure 4) was done the same way, and the specimens were kept for 24 hours in 37 degress Celsius. To all the cemented specimens were done the measurements of SBS in Ultratester (Ultradent Products,Utah,USA), and the results were recorded.

Statistical analysis

SPSS programme was used for the analysis of the SBS data. Paired student t test was selected to analyse the differences of means between SBS on enamel and on dentin. The categorical variables were expressed as absolute value and corrisponding percentages while continous variables were expressed as mean values and standart deviation. The p-values ≤ 0.05 was considered as significant.

RESULTS

Measurements for enamel and dentine SBS are summarized in Table 2.

SBS on preppared enamel varied from 2.10 MPa to 42.80MPa, with a mean value of 13.20 ± 7.93 MPa. It was noticed that SBS values were 12.72 ± 8.17 MPa and 13.46 ± 7.73 for anterior teeth and posterior teeth, respectively. This did not reach statistical significance, like it is shown in the first boxplot graphic, where the boxes overlap with both medians, in figure 5a.

Dentin preparations SBS varied from 1.20 – 35.70 MPa, with a mean value of 9.98±5.84. It was noticed that SBS values were 8.98±5.24 MPa and 11.07±6.16 for anterior and posterior teeth, respectively. This also, did not show a significant difference as shown in the second box plot graphic (Fig.5b)

The difference between the SBS values of enamel and dentin were statistically significant (p=0.001) (Tab.3). This significance was noticed even for anterior and posterior teeth separately, with p values of 0.007 and 0.03, respectively. (Tab.4)

Table 2. Description of the results of SBS, according the preparation and the type of the tooth (anterior or posterior)

Groups		Mean±SD	I95%	Range
Enamelprep	Anterior (n=66)	12.72±8.17	11.13-15.45	2.90-33.90
	Posterior (n=82)	13.46±7.73	11.73-15.21	2.10-42.80
	Total (n=148)	13.20±7.93	12.05-14.73	2.10-42.80
Dentinprep	Anterior (n=66)	8.98±5.24	7.46-10.26	1.20-22.00
	Posterior (n=82)	11.07±6.16	9.40-12.15	1.40-35.70
	Total (n=148)	9.98±5.84	8.98-10.97	1.20-35.70

Table 3. Evaluation of the differences of the means, between the two groups: enamel versus dentine

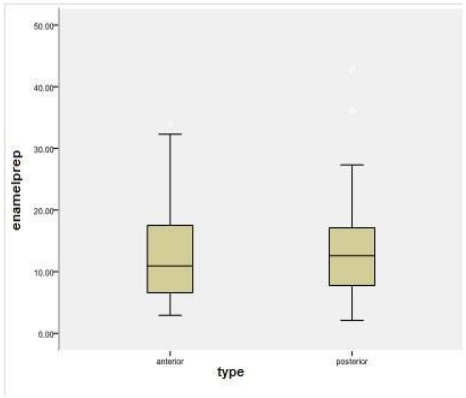
Groups	Nr	Mean	p value*
Enamelprep	148	13.2±7.93	0.001
Dentinprep	148	9.98±5.84	

* t test

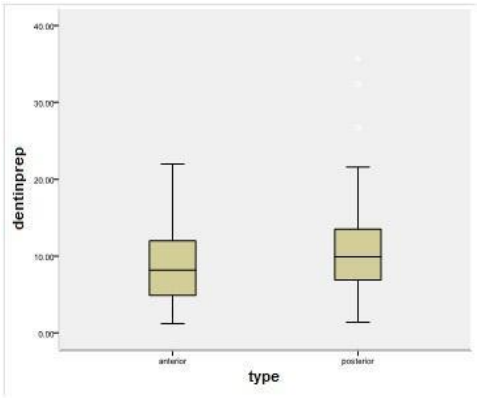
Table 4. Evaluation of the differences of the mean, regarding preparation and position of the tooth (anterior or posterior)

Type	Enamelprep	Dentinprep	p-value
Anterior (n=66)	12.72±8.17	8.98±5.24	0.007
Posterior (n=82)	13.46±7.73	11.07±6.16	0.03

Figure 5. Box-Plot of SBS according to the type of the tooth with preparation on enamel (a) and denin (b)



(a)



(b)

DISCUSSION

This study was designed , in a way that comparison of SBS between the two different depths of preparation, could be done in conditions as similar as possible. So, with the logic of Bayne et al, since 1991 (6) and that of FDI World Dental Federation study design and criteria evaluation (7), in 2007, followed also by Van Meerbeek et al. at KULeuven University, for their clinical trials in 2010 (8), which consider important the influence of the patient in

bond strength, we took it also in consideration. Despite the use of the same conditions of experimental steps following the manufacturer's' instructions, between two depths, the design to pair the comparing measurement on the same tooth, eliminates many confounding factors such as age, diet, culture and environment of the person from whom the tooth was obtained, giving in this way, more power to the results of this study.

The result of this study, rejected the null hypothesis, since it had a statistically difference between the means of SBS on enamel and dentin, and it was higher in enamel. These results, were in concordance with the review of De Munck (2) and that of Peumans (9) and also the clinical evaluations of Shaini et al., Dumfahrt et al. or Kramer et al. (10, 11, 12). A study done by Belli et al. showed that substrate location (occlusal, buccal, approximal) influenced in bond strength (13), to eliminate this, in the paired tooth samples of this study, was done a parallel grounding from enamel to dentin depth, so the measurements were done on the same tooth surface, for both tissues. In this study were included 66 anterior teeth and 82 posterior teeth. The results of the measurements revealed that there was no significant difference between measurements of both tissues, according to the teeth positions, so SBS was higher in enamel than in dentine , for each position separately. According to this, we may say, that the fact, that there were teeth from different groups, may have not influenced the overall result.

We encountered some experimental limitations in our in vitro study:

In this study, the cementation of ceramics was done immediately after preparation. While, in a clinical situation, this cannot be done. This may have brought us to higher values than in a clinical situation, with a normal bonding time. But in our study, there are not the values themselves important, but the difference, which we thought, may go parallel in in-vitro and in vivo situations.

Another limitation, is that in our in vitro study, the bonding is done in extracted teeth. We should keep in mind that, the environment of the tooth extracted has not the right wetting, that is needed for the one-bottle system of adhesive, that is used in our study. Because, according to a study by Iwaku et al. the resin tags in vivo are shorter than those in extracted teeth, since dentinal tubules are filled with fluid that reduces penetration (14). This fact also, may have brought us in different values, and logically higher SBS on dentin than in clinical situation. But there was still difference between bonding in enamel (without the tubular structure) and dentin SBS values. We may suppose, in this way, that clinically, this difference may be even bigger, because SBS of dentin may be even lower, and this may be done in other studies, in other conditions.

CONCLUSIONS

The Null hypothesis, that the deepness of the preparation does not influence on shear bond strength, was rejected, by our in vitro study. The shear bond strength of ceramic, was higher on enamel then on dentine. Beside the biological benefit, saving tooth structure, cementing on enamel, gives also more strength to the restoration. A higher bond strength, pushes our thinking further, that this connection, beside harder, may have also a longer lifetime, since it will need more force to detach the restoration.

Acknowledgements: Not available

C**onflict of interest disclosure**: Not available

REFERENCES

1. Simonsen RJ. Conservation of tooth structure in restorative dentistry. Quintessence Int 1985;16:15-24
2. Buonocore MG, A simple method of increasing the adhesion of acrylic filling materials to enamel surface. J Dent Res 955; 34:849-853
3. De Munck J. Mine A. Poitevin A. Van Ende A. VivanCardoso M. Van Landuyt KL. Peumans M. Van Meerbeek B. Meta-analytical review of parameters involved in dentin bonding J Dent Res 2012 ;94(4):351-57
4. Burke FJ, Hussain A. Nolan L, Fleming GJ Methods used in dentin bonding tests : An analysis of 102 investigations on bond strength. Eur J Prosth Rest Dent 2008;16:158-65
5. Sirisha K. Rambabu T. Shankar YR, Ravikamur P. Validity of bond strength tests: A critical review: Part I J Conserv Dent 2014;17:305-11
6. Bayne SC, Heymann HO, Sturdevant JR, Wilder AD, Sluder TB. Contributing co-variables in clinical trials. Am J Dent. 1991;4:247-50
7. Hickel R, Roulet JF, Bayne S, Heintze SD, Mjör IA, Peters M,et al. Recommendations for conducting controlled clinical studies of dental restorative materials. Science Committee Project 2/98 – FDI World Dental Federation study design (Part I) and criteria for evaluation (Part II) of direct and indirect restorations including onlays and partial crowns. J Adhes Dent 2007; 9(Suppl. 1):121–47 [Erratum in: J Adhes Dent 2007 9:546].
8. Van Meerbeek B. Peumans M. Mine A., Van Ende A., Neves A., de Munck J., Relationship between bond strength tests and clinical outcomes (review) Dent Mater 2010 ;26 (2): e100 - 21 doi:10.1016/j.dental.2009.11.148
9. Peumans M. Van Meerbeek B. Lambrechts P. Vanharte G. Porcelain veneers: a review of the literature. J Dent 2000;28:163-177
10. Shaini FJ, Shortall ACC, Marquis PM, Clinical performance of porcelain laminate veneers. A retrospective evaluation over a period of 6.5 years. J Oral Rehab 1997; 24: 553-59
11. Dumfahrt H. Schaffer H. Porcelain laminate veneers. A retrospective evaluation after 1-10 years of service: Part II clinical results. Int J Prosthodont 2000;13:9-18
12. Kramer N. Lohbauer U, Frankenberger R. Adhesives luting of indirect restorations. Am J Dent 2000;13:60-75
13. Belli S, Unlü N, Ozer F. Bonding strength to two different surfaces of dentin under simulated pulpal pressure. J Adhes Dent 2001;3:145-52.
14. Iwaku M, Nakamichi I, Nakamura K, Horie K, Suizu S, Fusayama T, Tags penetrating dentin of a new adfhesive resin. Bull Tokyo Med Dent Univ 1981;28:45-51