

In Vitro Evaluation of Microleakage of Various Types of Dental Cements

Vesna Medić¹, Kosovka Obradović-Djuričić¹, Slobodan Dodić¹, Renata Petrović²

¹Clinic for Prosthodontics, School of Denistry, University of Belgrade, Belgrade, Serbia;

²Clinic for Restorative Dentistry and Endontics, School of Denistry, University of Belgrade, Belgrade, Serbia

SUMMARY

Introduction Microleakage is defined as the clinically undetectable seepage of oral fluids containing bacteria and debris between cement layer and tooth restoration.

Objective This in vitro study investigated the effect of different dental cements (zinc-phosphate, polycarboxylate, glass-ionomer and resin cement) on microleakage in different ceramic crown systems (metal ceramic crown, metal ceramic crown with a porcelain margin, Empress 2 and In Ceram all-ceramic crowns) fixed on extracted human teeth.

Methods One hundred and sixty intact human premolars were randomized to four groups of forty teeth each, according to the different ceramic crown systems. They were prepared in a standardized manner for metal-ceramic and all-ceramic crowns. Crowns were made following a standard laboratory technique, and each group of crowns were divided into four groups according to the different cement agents and cemented on their respective abutments. The specimens were subjected to thermocycling, placed in methylene blue solutions, embedded in resin blocks and vertically cut in the bucco-oral and meso-distal direction. The microleakage in the area of tooth-cement interface was defined as linear penetration of methylene blue and was determined with a microscope to assign microleakage scores using a five-point scale.

Results A significant association was found between a cement type and degree of microleakage ($p=0.001$). No statistically significant differences were found among the different ceramic crown systems luted with the same dental cement. The smallest degree of microleakage was observed in specimens luted with resin cement ($\bar{X}=1.73$), followed by glass-ionomer cement ($\bar{X}=2.45$) and polycarboxylate cement ($\bar{X}=3.20$). The greatest degree of microleakage was detected in the crowns fixed with zinc-phosphate cement ($\bar{X}=3.33$).

Conclusion The investigated dental cements revealed different sealing abilities. The use of resin cement resulted in the percentage of 0 microleakage scores. Due to this feature, the resin cement is to be recommended in everyday clinical practice.

Keywords: microleakage; marginal seal; dental cements

INTRODUCTION

Therapeutic effects and longevity of fixed restorations are the result of a number of factors. However, two factors are of primary importance: retention that defines correct and permanent position of the fixed restoration in situ and marginal seal that enables adaptation of the restoration and surfaces of the prepared teeth. Among numerous determinants responsible for the quality of retention and marginal seal, cement characteristics used for cementing of the fixed restorations enabling intimate contact between the surfaces of prepared teeth and fixed restorations are to be particularly emphasized [1, 2]. Cement disintegration through its decomposition or dissolution in oral fluids, shrinkage on setting, the strength and weakening of the bond between the cement and dentine or cement and restoration are reported as possible causes of microleakage and loss of bonding effect [3]. Mechanical loading to which restoration is exposed after cementing as well as temperature changes are considered to be factors favouring microleakage [4].

Microleakage is a dynamic phenomenon defined as clinically undetectable penetration

of fluid, bacteria, molecules and ions between the cavity wall and mounted restorative material. It is manifested by recurrent caries, post-operative hypersensitivity, pulpal inflammation and eventually the need for replacement of restoration [5].

Leakage occurring at the tooth-cement interface has greater biological significance in comparison to the one occurring on the cement-restoration interface, since it is a frequent cause of development of secondary caries, postoperative sensitivity, inflammation and necrosis of the pulp. [6].

Zöllner and Gaengler [7], who analysed the causes of failure of 121 fixed restorations in a 11-year period, revealed that within a 5-year period 10% of the restorations made on the vital teeth (after treatment of deep caries) needed to be replaced due to endodontic complications after cementing.

Mitchell et al. [8] compared the frequency of pathological changes on the pulp of the abutments supporting the fixed restorations and non-prepared teeth within a 7-year period. Results of the study evidenced 15% incidence of the pulp necrosis of the abutment of the fixed restorations in comparison to 3% inci-

Correspondence to:

Vesna MEDİĆ
Clinic for Prosthodontics
School of Denistry
Rankeova 4, 11000 Belgrade
Serbia
meda32000@yahoo.com

dence of pulp necrosis affecting the non-prepared teeth. The pulp necrosis of unknown aetiology tended to affect almost exclusively the teeth supporting the fixed restorations. These results as well as the similar ones obtained in longitudinal studies bring the results of the therapeutic procedures in direct collision with the basic objectives of the professional procedures aimed at prosthetic management in question.

Some authors attempted to explain secondary caries, inflammation and pulp necrosis by the procedures related to teeth preparation or chemical irritation caused by restorative materials while others gave considerably greater significance to chronic and cumulative effects of microleakage [9].

In vitro evaluation of microleakage remains an essential method in the initial screening of dental materials and acts as an indicator of the theoretical amount of leakage that may or may not occur in vivo.

The degree of microleakage varies significantly between different cements [10].

The review of microleakage results obtained with zinc-phosphate, glass-ionomer and resin cements evidenced zinc-phosphate cement to be less successful in reduction of microleakage in comparison to glass-ionomer and resin cement. A possible explanation may lie in the fact that solubility of the zinc-phosphate cement is higher in comparison to glass-ionomer and resin cements as well as in the nature of its dentine bond which is exclusively mechanical. However, in spite of these shortcomings, clinical studies evidenced long-term stability of the restorations cemented with zinc-phosphate cement. Glass-ionomer and resin cements are less soluble and their chemical composition enables chemical and micromechanical bonding with dentine. In experimental conditions, better results were evidenced with respect to microleakage in comparison to those accomplished with zinc-phosphate cement. However, the results of long-term clinical trials on durability of the restorations cemented with these types of cements that will confirm their advantages are still lacking [11, 12].

In the period between 1992 and 1998, more than 300 studies on microleakage were published. A review of the literature by Raskin et al. [13] showed that 62.5% out of 144 studies on microleakage evaluated microleakage in class V cavities, while only 4.3% evaluated microleakage of the crown restorations. A special group of microleakage studies includes comparative investigations of microleakage and marginal discrepancies. Rossetti et al. [14] reported a lack of positive correlation between microleakage and marginal discrepancies. However, the significance of the marginal discrepancies and microleakage of crown restorations and their clinical consequence remain to be determined.

OBJECTIVE

This in vitro study investigated the effect of different dental cements (zinc-phosphate, polycarboxylate, glass-ionomer and resin cement) on microleakage in different ceramic crown systems (metal ceramic crown, metal ceramic crown with a porcelain margin, Empress 2 and In Ceram all-ceramic crowns) fixed on extracted human teeth.

METHODS

The study material comprised 160 human teeth extracted from the patients affected with periodontal disease, 160 artificial crowns (metal ceramic, metal-ceramic with porcelain margin and ceramic crowns made using two different techniques) and four different types of cements for permanent bonding of the fixed restorations (zinc-phosphate, polycarboxylate, glass-ionomer and resin). The selection criteria of the teeth to be included in the experiment were the following: intact tooth, similar dimensions and teeth from the upper premolar class.

For the purpose of the acceptance of the appropriate artificial crowns, all the teeth were prepared using a standard, uniform procedure with high-speed machines with water cooling, diamond burs of the appropriate shape and size. The cervical preparation margins were designed as chamfers on the teeth accepting metal-ceramic crowns and metal-ceramic crowns with porcelain margins. The teeth prepared for the acceptance of ceramic crowns had shoulder preparation with the rounded internal angle and width of 1.2 mm. The margin was localized along its full length to the dentine at the level of the cement-enamel junction. Average length of the prepared teeth was 6 ± 1 mm with inclination of the axial surfaces of 4° .

Control of axial inclination of the burred teeth as well as their correction was performed using parallelometer.

The repaired teeth were placed in plaster models of the upper jaw and the impression was thereafter made with a 1-phase vinyl polysiloxane material and poured into Type IV stone.

Metal-ceramic and metal-ceramic crowns with porcelain margin as well as ceramic crowns IPS Empress 2 and In Ceram Alumina were made using contemporary laboratory procedures and, accordingly, four experimental groups were made with 40 artificial crowns in each.

Four cements of different chemical structure and tooth hard tissue bonding were selected for permanent bonding of the fixed restorations. Basic characteristics of the cements used in the experiment are presented in Table 1.

Table 1. Description of used cementing agents

Cement type	Manufacturer	Code	Chemical composition	Bond with dentine
Zinc-phosphate	Harvard, Richter-Hoffman, Berlin	ZnP	ZnO, MgO, phosphoric acid	Mechanical
Polycarboxylate	Harvard, Richter-Hoffman, Berlin	PC	ZnO, MgO, Al ₂ O ₃ , polyacrylic acid	Chemical
Glass-ionomer	Fuji I GC, America	GJ	Alumino-silicate glass, polyacrylic and citric acid	Chemical
Resin cement	Panavia 21 Kuraray, Medical Inc.	CC	BIS-GMA, TEGDMA barium, silicium glass	Micro-mechanical

BisGMA – bisfenol-A diglycidyl ether dimethacrylate; TEGDMA – triethylene glycol dimethacrylate

Each of the four experimental groups of artificial crowns was further sub-classified to four sub-groups with 10 experimental pairs in each, depending on cement type used for fixation of the crown on the burred tooth.

Relative identity of the cement mixtures used for each of the pairs (burred tooth/crown) was determined based on the measurement of: a) quantity of powder, paste (using precision electronic scale); b) quantity of liquid (soaking with a pipette); and c) mixing time.

Cement mixture was applied in a thin, even layer onto the internal crown surface and mounted on the prepared tooth by digital compression to be exposed immediately thereafter to 5 kg pressure for 10 minutes.

The cemented pairs were immersed in distilled water at 37°C for 7 days. The specimens were thereafter subjected to artificial ageing using the procedure of thermocycling. Thermocycling included alternative exposure of specimens to temperatures of 5 and 55°C for 30 seconds. The procedure was repeated 500 times.

After completion of thermocycling, apical opening on the tooth roots was closed with amalgam and the remaining surfaces of the teeth, except for the margin to the level of 2 mm, were covered with two layers of lacquer. The samples prepared in this way were immersed into 0.5% methylene blue solution for 24 hours.

Rinsed and dried specimens were placed into epoxy resin blocks in order to cut the specimens using 1 mm thick diamond gauge, parallel to the axial tooth axis in two directions, meso-distal and bucco-oral. In this way, 8 surfaces were obtained for each sample for measurement of dye penetration degree.

Penetration depth was measured with the Amsler optic microscope under 100× magnifications using the following scale: 0 – no dye penetration; 1 – penetration of dye along the whole step; 2 – dye penetration to 1/3 of axial surface length; 3 – dye penetration to 2/3 of axial surface length; 4 – penetration along the whole axial surface; and 5 – dye penetration to the occlusal surface.

The results of the measurements are presented both in tabular and graphic form.

RESULTS

Table 2 presents a degree of microleakage in different crowns cemented with the same type of cement at 8 observed points. Microleakage of the same type of cement under different types of crowns was relatively even.

The analysis of dye penetration depth revealed no statistically significant difference between different types of crowns cemented with the same type of cement at none of the observed points.

Table 3 presents microleakage associated with different types of cement. According to the analysis of the measured values, dye penetration depth for zinc-phosphate, polycarboxylate and glass-ionomer cements was most frequently graded with 3 points, meaning that the dye was diffused up to the 1/3 of the axial surface length. Dye penetration up to 2/3 of the axial surface length was observed on 123 points (38.4%) in zinc-phosphate cement, while somewhat lower values, i.e. 110 points (34.4%) were observed with polycarboxylate cement. As opposed to glass-ionomer cement, these two cements had a small number of points and they were graded as 0 and 1. As for glass-ionomer cement, dye penetration depth was more even in comparison to those observed with zinc-phosphate and polycarboxylate cements.

Characteristically, in case of resin cement, in most of the cases the dye was diffused only in demarcation zone while in 30 observed points (9.4%) dye penetration was not observed.

The analysis of the influence of cement on dye penetration depths (Graphs 1 and 2), measured at eight observed points evidenced a statistically significant difference in dye penetration depth between the observed measurement points (two-factor variance analysis with repeated measurements, measurement point factor $p=0.001$) as well as a statistically

Table 2. Microleakage of different crowns cemented with same cement based on 8 measurements for each crown

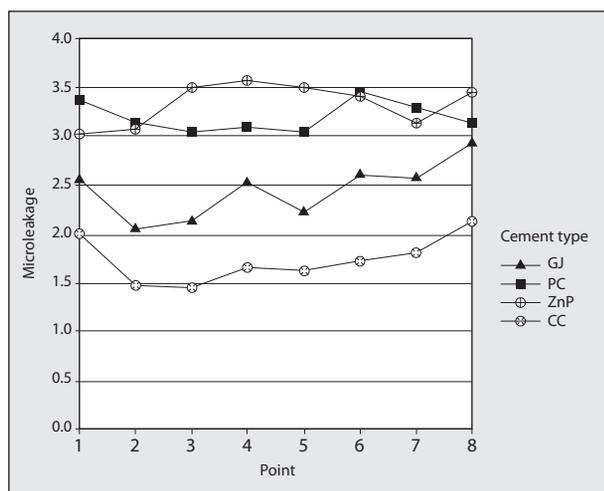
Point of measurements	Type of crown				p
	MK	MK-RK	V-K	I-K	
1	2.70±1.30	2.63±1.31	2.70±1.16	2.95±1.15	0.663
2	2.45±1.26	2.30±1.18	2.42±1.36	2.58±1.06	0.795
3	2.42±1.26	2.53±1.15	2.58±1.20	2.60±1.15	0.917
4	2.75±1.10	2.65±1.03	2.70±1.20	2.75±1.24	0.976
5	2.88±1.16	2.53±1.15	2.70±0.94	2.75±1.24	0.146
6	3.03±2.09	2.83±1.20	2.70±1.32	2.65±1.05	0.673
7	2.65±1.10	2.68±1.19	2.75±1.15	2.73±1.22	0.980
8	2.98±0.86	2.98±1.17	2.85±1.27	2.83±1.34	0.906

MK – metal ceramic crown; MK-RK – metal ceramic crown with a porcelain margin; V-K – In Ceram ceramic crowns; I-K – IPS Empress 2 ceramic crown

Table 3. Frequency of microleakage score (%), mean values (\bar{X}) and standard deviation (SD) based on 320 measurements for each cement

Cement type	Microleakage score (%)						\bar{X}	SD
	0	1	2	3	4	5		
ZnP	1 (0.3)	36 (11.3)	147 (45.9)	123 (38.4)	9 (2.8)	4 (1.3)	3.33	0.84
PC	3 (0.9)	55 (17.2)	141 (44.1)	110 (34.4)	7 (2.2)	3 (0.9)	3.20	1.09
GJ	16 (5.0)	141 (34.1)	97 (30.3)	63 (19.7)	2 (0.6)	1 (0.3)	2.45	1.17
CC	30 (9.4)	233 (72.9)	32 (10.0)	25 (7.8)	0 (0.0)	0 (0.0)	1.73	1.02

ZnP – Zinc-phosphate; PC – Polycarboxylate; GJ – Glass-ionomer; CC – Resin cement



Graph 1. Mean value for microleakage of different cements based on 8 measurements for each cement

ZnP – Zinc-phosphate; PC – Polycarboxylate; GJ – Glass-ionomer; CC – Resin cement

significant change of difference in dye penetration depth between the cements at the observed measurement points (two-factor analysis of variance, measurement point factor; cement type; $p=0.042$).

Statistically significantly, the lowest values of microleakage were observed in resin cement, to be somewhat higher in glass-ionomer cement while the values of the observed parameter were the highest in zinc-phosphate and polycarboxylate cements.

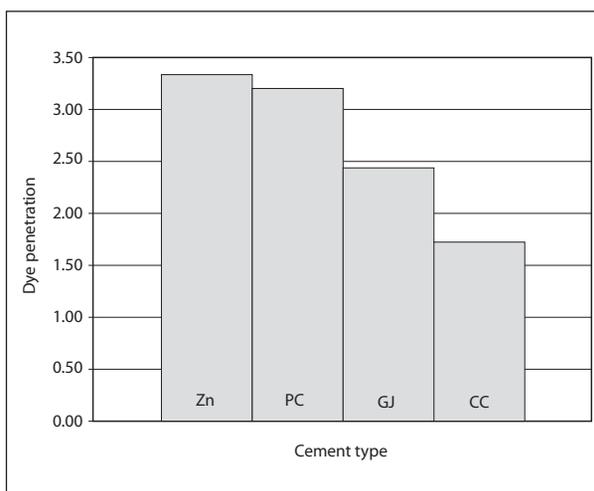
DISCUSSION

Investigations on marginal sealing by measurement of leakage may be carried out using different types of dyes, chemical markers, radioactive isotopes, air pressure, bacteria, technique with artificial caries-induced lesions and electrochemical method [15].

The most commonly applied methods in *in vitro* studies were those with stained solutions – methylene blue, aniline blue, fluorescein, eosin, erythrosine and Indian ink [13].

The advantages of the method with stained solutions include precision in assessment of marginal sealing, the possibility of direct reading of the diffused marker under the microscope and simplicity of application. The disadvantage of the method is reflected in considerably smaller diameter of the marker particle in comparison to the bacterial toxin molecule and bacteria themselves. Thus some authors believe that the results obtained in this way are not clinically relevant. Therefore, they recommend application of clinically relevant materials such as liposaccharides and cell wall materials inducing inflammatory reaction of the pulp. However, it has been observed that application of dye or liposaccharides labeled with radioisotopes is equally effective for visualization of microleakage as well as that the level of dye penetration along the dentine-cement interface is similar in both cases [16].

Pashley [17] presented the opinion that the result on cement capacity to reduce microleakage in *in vitro* conditions was less favourable in comparison to the results obtained



Graph 2. Mean values for dye penetration at tooth cement interface for each cement

ZnP – Zinc-phosphate; PC – Polycarboxylate; GJ – Glass-ionomer; CC – Resin cement

in *in vivo* studies for several reasons. One of them is the already mentioned difference in the size of marker particles and the size of bacterial toxins. Also, the dentinal fluid in vital teeth may contrast molecular penetration and the buildup of proteins in the marginal opening may improve the seal. Based on the above, it may be concluded that if the cement material resists penetration of markers in *in vitro* conditions, its *in vivo* response is expected to be better.

It should be pointed out that the results of microleakage studies carried out *in vitro* depend on a number of factors such as biological dentine properties, applied experimental model (teeth storage, teeth preparation, thermocycling, occlusal loading) and cement properties [18]. Having in mind the fact that all the factors in this study were relatively similar except for cement type, it may be concluded that properties of the applied bonding material – cement, have played the decisive role in formation of micro cracks.

The results of the investigation of microleakage obtained by measurement of depth of linear dye penetration are presented in Table 2. As for the different crowns cemented with the same cement, no statistically significant differences were observed at any of the observed points. It may be concluded that the crown type is not a decisive factor influencing microleakage and it allows comparison of the degrees of microleakage to be performed only with respect to the cement type. In this way, it enabled the microleakage degree of different cements to be compared based on the results obtained by the analysis of 40 crowns cemented with the same type of cement at 8 points on each crown. The number of teeth in experimental groups employed in microleakage studies ranged from ten (44%) to twenty and more (2.6%) [13]. Most of the authors agree that the small number of specimens limits the choice of a method for a statistical test that might be used. Indeed, only nonparametric tests could be used, and these are less powerful than parametric tests which were used in this study.

The results might have been different if the crowns were exposed to mechanical loading since the behaviour of different materials from which the crowns were made should have been different under loading. Stress in the region of

the crown margins induces tensile and shear strengths in the cement layer to which low resistance of the cements is known. The above may be the cause of weakening of the bond between the cement and dentine surface, the onset of micro cracks and microleakage.

The consensus is lacking on the influence of mechanical stress in *in vitro* conditions on the increase of microleakage. The results of experimental studies are diverse. Some authors emphasize that occlusal loading in experimental conditions has no influence on the increase of microleakage [19]. This is in contradiction with attitudes of other authors who evidenced that the exposure of tooth restoration to loading resulted in the increase of microleakage [20, 21].

The analysis of the influence of different cement types on crown microleakage measured at 8 points evidenced a statistically significant difference in microleakage values between different cement types at all the observed points (Table 3, Graphs 1 and 2). The lowest statistically significant values were evidenced in resin cement, somewhat higher values were recorded with glass-ionomer cement, while zinc-phosphate and polycarboxylate cements had the highest values of the observed parameter.

Methodology and cementing agents used in this study are different from those applied in other studies and thus direct comparison of our results with the results of other authors is not possible [22, 23, 24].

Nevertheless, if the results of microleakage degrees in different types of cements obtained in this study are compared to the results obtained by other authors, the same order of the cements with respect to the capacity of reduction of microleakage may be observed:

resin cement < glass-ionomer < polycarboxylate cement < zinc-phosphate cement [25].

The highest degree of microleakage observed in zinc-phosphate cement is consistent with the results of numerous studies dealing with the similar analyses [26]. A possible reason for this unfavourable result related to zinc-phosphate cement lies in the mechanical type of bond with dental tissue. An additional factor that may influence the results is cement solubility caused by keeping of the specimens in water.

The second interesting explanation for poor results of zinc-phosphate cement in reduction of microleakage is reported by Shimada [27].

Zinc-phosphate cement, together with polycarboxylate cement and glass-ionomer cement, belongs to the group of acid-base cements. All the cements contain acid as a component which is responsible for high acidity of cement mixture during cementation. Acidity of the zinc-phosphate cement at the moment of application to the dental tissues is 1.6, to be subsequently increased during the cement setting. Acid component of the cement may demineralize smear layer and intact dentine. Cement mixture consistency is creamy and it is not capable of diffusing through the demineralized dentine. Exposed collagen fibres surrounded by empty spaces of demineralized dentine undergo hydrolysis over time under the influence of oral fluids and water, which impairs the accomplished bond and leads to the devel-

opment of micro cracks and microleakage. Based on the above, the author concluded that zinc-phosphate cement was actually the first self-etching cement [27].

High permeability of the crowns cemented using zinc-phosphate cement indicates low probability of satisfactory marginal sealing with this type of cement.

Resin cement may effectively reduce microleakage and thus it is superior over other cements used in this study. It may be attributed to formation of a hybrid layer with excellent quality at the dentine, which ensures adhesion and resistance to various stresses. Dentine-binding agents also have the ability to seal the cut dentinal tubules and therefore to protect the pulp from possible consequences of leakage [28].

The results of the studies could have been influenced by hygroscopic expansion of the resin cement since the specimens were kept in distilled water for 7 days. Water absorption causes expansion of the resin cement that may compensate contraction and thus reduce dye penetration. On the other hand, thermal stresses caused by thermocycling may cause repeated formation of cracks.

The analysis of the obtained results may reveal that in most of the cases (72.9%) dye was diffused only on the shoulder, while dye penetration was not evidenced at 30 (9.4%) observed points. Microleakage detected in the shoulder area would be clinically less dangerous than microleakage occurring along the axial walls, due to the small number of dentine tubules present in this area. In the region of cement-enamel junction, the most critical area for bonding, superficial and middle dentine layers are mostly composed of intertubular dentine and less dentine tubules.

The adhesive interface between a tooth and resin cement at the gingival margin is acknowledged as a problematic zone in terms of microleakage. Polymerization shrinkage is commonly believed to be the primary cause of marginal gap formation and microleakage.

The contraction that accompanies polymerization of these materials reduces the initial volume of the material and induces tensile forces at the cement-tooth interface. Due to the centric tensile forces, the material is detached from the tooth structures to which it was bound, thus forming micro cracks [29].

Resin cements used for cementing fixed restorations have small volume and small contractions owing to the minimal space between the restoration and tooth surface, which reduces stress generated as a consequence of polymerization contraction of the material. On the other hand, the flow in thin films of composites during polymerization contraction has been shown to be severely restricted by bonding to the opposing walls of the tooth structure and restorations. There are virtually no unbonded or free surfaces available, i.e. the C-factor or ratio of bonded surface area to unbonded surface area, as described by Feilzer et al. [30]. Restraint of the cement flow causes the polymerization contraction to be directed almost solely perpendicular to the walls.

Feilzer et al. [30] analysed and measured WTW (wall to wall) contraction of resin material in thin layers. They have observed that WTW contraction was increased along with

the decrease of WTW distance. Theoretically, the WTW contraction equals the free linear contraction. However, the effective WTW polymerization contraction exceeds the free-linear contraction value by factor three.

Polycarboxylate cement microleakage is statistically significantly lower in comparison to microleakage associated with zinc-phosphate cement, however it is observed both on dentine/cement and restoration/cement interface and within the cement layer. In most of the cementing systems, microleakage is observed only on dentine/cement interface. This type of microleakage associated with carboxylate cement is most probably the result of porosity and solubility of the bonding agent in comparison to other cements [31].

Most authors agree that tooth-cement interface should still be considered the weakest link in the tooth-cement-fixed restoration system as well as that certain degree of microleakage is always present. Microleakage may progress at different times and in different regions of the artificial crown from the initial to higher values in absence of any clinical symptoms. It is most difficult to determine a degree of microleakage and moment of its transition from

“physiological” to “pathological” with clinically detectable consequences.

The results of the study offer useful information and help to clinicians in the choice of cementing material. The therapist must be well acquainted with all properties of the available cements as well as with the handling methods. Practical recommendation includes application of quality bonding agents depending on clinical situation, type of indicated fixed restoration and cost-effectiveness.

CONCLUSION

None of the tested bonding agents provide complete marginal sealing and elimination of microleakage. The best marginal sealing and the lowest degree of microleakage were observed with crowns cemented with resin cement. The lowest reduction of microleakage was observed with zinc-phosphate cement. Utilization of resin cement influences significantly the quality of marginal sealing and longevity of fixed restorations.

REFERENCES

- Rosenstiel SF, Land MF, Fujimoto J. Contemporary Fixed Prosthodontics. 3rd ed. St. Louis: Mosby; 2001.
- Piemjai M. Effect of seating force, margin design and cement on marginal seal and retention of complete metal crowns. *Int J Prosthodont.* 2001; 14:412-6.
- Irie M, Suzuki K. Current luting cements: marginal gap formation of composite inlay and their mechanical properties. *Dent Mater.* 2001; 17:347-53.
- Bedran-de-Castro AK, Cardoso PE, Ambrosano GM, Pimenta LA. Thermal and mechanical load cycling on microleakage and shear bond strength to dentin. *Oper Dent.* 2004; 29:42-8.
- Piwoarczyk A, Lauer HC, Sorensen JA. Microleakage of various cementing agents for full cast crowns. *Dent Mater.* 2005; 21:445-53.
- About I, Murray PE, Franquin JC, Remusat M, Smith AJ. The effect of cavity restoration variables on odontoblast cell numbers and dental repair. *J Dent.* 2001; 29:109-17.
- Zöllner A, Gaengler P. Pulp reactions to different preparation techniques on teeth exhibiting periodontal disease. *J Oral Rehabil.* 2000; 27:93-102.
- Mitchell CA, Abbariki M, Orrijf. The influence of luting cement on the probabilities of survival and modes of failure of cast full-coverage crowns. *Dent Mater.* 2000; 16:198-206.
- Murray EP, Hafez AA, Smith JA, Cox CF. Bacterial microleakage and pulp inflammation associated with various restorative materials. *Dent Mater.* 2002; 18:470-8.
- Gu X, Kern M. Marginal discrepancies and leakage of all-ceramic crowns: influence of luting agents and aging conditions. *Int J Prosthodont.* 2003; 16:109-16.
- Gerdolle AD, Mortier E, Loos-Ayav C, Jacpot B, Panighi MM. In vitro evaluation of microleakage of indirect composite inlays cemented with four luting agents. *J Prosthet Dent.* 2005; 93:563-70.
- Goodcare CJ, BernalG, Rungcharassaeng K, Kan JYK. Clinical complications in fixed prosthodontics. *J Prosthet Dent.* 2003; 90:31-41.
- Raskin A, D'Hoore W, Gonther S. Reliability of in vitro microleakage tests: literature review. *J Adhesive Dent.* 2001; 3:295-308.
- Rossetti PHO, Valle AL, Carvalho RM. Correlation between margin fit and microleakage in complete crowns cemented with three luting agents. *J Appl Oral Sci.* 2008; 16:64-9.
- Heintze S, Forjanic M, Cavalleri A. Microleakage of class II restorations with different tracers-comparison with SEM quantitative analysis. *J Adhes Dent.* 2008; 78:259-67.
- Coleman JA, Moses SM, Haig HD, Rickerby HD. Macromolecular leakage beneath full cast crowns: a two-year in vitro investigation. *J Prosthet Dent.* 2001; 85:20-5.
- Pashley DH. Clinical considerations of microleakage. *J Endod.* 1990; 16:70-7.
- Idriss S, Abduljabbar T, Habib C, Omar R. Factors associated with microleakage in class II resin composite restorations. *Oper Dent.* 2007; 32:60-6.
- Arisu HD, Üctasli MB, Eligüzeloglu E, Özcan S, Ömürlü H. The effect of occlusal loading on the microleakage of class V restorations. *Oper Dent.* 2008; 33:135-41.
- Pongprueksa P, Kuphasuk W, Senawongse P. Effect of elastic cavity wall and occlusal loading on microleakage and dentin bond strength. *Oper Dent.* 2007; 32:466-75.
- Campos PEG, Barcelheiro MDO, Sampaio-Filho HR, Martins LRM. Evaluation of the cervical integrity during occlusal loading of class II restorations. *Oper Dent.* 2008; 33:59-64.
- Lindquist TJ, Connolly J. In vitro microleakage of cementing agents and crown foundation material. *J Prosthet Dent.* 2001; 85:292-8.
- Schenke F, Hiller KA, Schmalz G, Federlin M. Marginal integrity of partial ceramic crowns within dentin with different luting techniques and materials. *Oper Dent.* 2008; 33:516-22.
- Toman M, Toksavul S, Artunc C, Türkün M, Schamag P, Nergiz I. Influence of luting agent on the microleakage of all-ceramic crowns. *J Adhes Dent.* 2007; 9:39-47.
- Piemja M, Miyasaka K, Iwasaki Y, Nakabayashi N. Comparison of microleakage of three acid-base luting cements versus one resin bonded cement for class V direct composite inlays. *J Prosthet Dent.* 2002; 88:598-603.
- Francine EA, El-Mowafy MO. Marginal adaption and microleakage of Procera All Ceram crowns with four cements. *Int J Prosthodont.* 2004; 17:529-35.
- Shimada Y, Kondo Y, Inokoshi S, Tagami J, Antonucci JM. Demineralizing effect of dental cements on human dentin. *Quintessence Int.* 1999; 30:267-73.
- Rosentritt M, Behr M, Lang R, Handel G. Influence of cement type on the marginal adaptation of all-ceramic MOD inlays. *Dent Mater.* 2004; 20:463-9.
- Calheiros FC, Sadek FT, Boaro LCC, Braga RR. Polymerization stress related to radiant exposure and its effect on microleakage of composite restorations. *J Dent.* 2007; 35:946-52.
- Feilzer AJ, De Gee AJ, Davidson CL. Increased wall-to-wall curing contraction in thin bonded resin layers. *J Dent Res.* 1989; 68:48-50.
- Milutinović-Nikolić DA, Medić BV, Vuković MZ. Porosity of different dental luting cements. *Dent Mater.* 2007; 23:674-8.

Испитивање микропропустљивости различитих врста денталних цемента *in vitro*

Весна Медић¹, Косовка Обрадовић-Ђуричић¹, Слободан Додић¹, Рената Петровић²

¹Клиника за стоматолошку протетику, Стоматолошки факултет, Универзитет у Београду, Београд, Србија;

²Клиника за болести зуба, Стоматолошки факултет, Универзитет у Београду, Београд, Србија

КРАТАК САДРЖАЈ

Увод Микропропустљивост је клинички неуочљиво продирање течности, бактерија, молекула и јона између цементног слоја и дентина или цементног слоја и надокнаде. Овај проблем је од великог практичног значаја за трајност фиксних надокнада.

Циљ рада Циљ овог истраживања *in vitro* био је да се испита утицај различитих денталних цемента (цинк-фосфатни, поликарбоксилатни, гласјономер и композитни цемент) на микропропустљивост круница израђених од различитих материјала (металокерамичке, металокерамичке с рубом у керамици и керамичке крунице *Empress2* и *In Ceram Alumina*), цементираних на експерименталним моделима екстрахованих зуба.

Методе рада Коришћено је 160 екстрахованих интактних премолара који су према врсти крунице сврстани у четири групе са по 40 узорака у свакој. Зуби су уобичајеним поступком припремљени за прихватање металокерамичких и керамичких круница. Одговарајућим лабораторијским поступком израђене су крунице. Унутар сваке групе извршена је додатна подела узорака на четири подгрупе од по 10 експерименталних парова, у зависности од типа цемента којим је круница цементрана. Цементирани парови су подвргнути термоциклирању, потопљени у раствор метилен-плавог, постављени у блокове епокси смоле, а затим сечени паралелно с аксијалном осом зуба у ме-

зиодисталном и букооралном правцу. Микропропустљивост је дефинисана као дубина линеарног продора боје дуж споја дентина и цемента, процењена је применом микроскопа и указана скалом са градијацијом у продору боје од 0 до 5 бодова.

Резултати Анализом добијених резултата уочена је статистички значајна повезаност између врсте цемента и степена микропропустљивости ($p=0,001$). Анализом дубине продора боје између различитих круница цементираних истом врстом цемента није уочена статистички значајна разлика. Статистички значајно најмање вредности микропропустљивости забележене су код композитног цемента (средња вредност бодова 1,73), нешто веће вредности показао је гласјономер (средња вредност бодова 2,45) и поликарбоксилатни цемент (средња вредност бодова 3,20). Највећи степен микропропустљивости уочен је код круница цементираних цинк-фосфатним цементом (средња вредност бодова 3,33).

Закључак Испитивани дентални цемента имају различиту способност рубног затварања. Најмања микропропустљивост, указана са 0 бодова, забележена је код композитног цемента, због чега се он препоручује за примену у свакодневној клиничкој пракси.

Кључне речи: микропропустљивост; рубно затварање; дентални цемента

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