Microscopic evaluation of the human dental pulp after full crown cementation with resin cement

LUIZ CARLOS SANTIAGO ; LUIZ FERNANDO PEGORARO**; ALBERTO CONSOLARO***; ACCÁCIO LINS DO VALLE**; GERSON BONFANTE***

This research was supported by CNPq

Abstract

This study evaluated microscopically the dental pulp reactions in human premolars prepared for metaloceramic crowns cemented with different luting agents and also measured the remaining dentin thickness (RDT) of the prepared teeth. Twenty-five teeth were selected from patients that needed exodontia for orthodontic reasons and were randomly divided in three groups: group 1- five teeth were not prepared to serve as a positive control group; groups - 2, and 3 the teeth were prepared for metaloceramic crowns cemented with calcium-hydroxide cement (Life) and resin cement (Panavia Ex 21), respectively. After the final cementation, the teeth remaining in function for periods of seven and forty-five days and were extracted and prepared for microscopic analysis of pulp tissue and detection of presence of bacteria in the dentin tubules. The RDT were measured in 6 different regions of the prepared surface and presented a mean thickness ranging from 1.53 to 1.58 mm. The microscopic analysis did not show an inflammatory reaction of the pulp and bacteria were not found in the dentinal tubules. The resin cement evaluated in this study showed to be as biocompatible as calcium-hydroxide cement and therefore there should not be a clinical preoccupation regarding to pulp reaction.

Uniterms

Resin cement; remaining dentin thickness; pulp response.

SANTIAGO, L.C et al. Avaliação microscópica da polpa dentária humana após cimentação de coroas totais com cimento resinoso. **Cienc Odontol Bras**, v.5, n.3, p. 6-12, set./dez.2002.

Resumo

Esta pesquisa teve como objetivo avaliar microscopicamente a polpa dentária humana de dentes pré-molares preparados para coras metalocerâmicas cimentadas com diferentes agentes cimentantes e também medir a espessura de dentina remanescente dos dentes preparados. Foram selecionados 25 pré-molares hígidos (superiores/inferiores), de pacientes com idade entre 12 e 15 anos, que seriam extraídos por indicação ortodôntica e divididos em 3 grupos: grupo 1: cinco dentes não receberam nenhum tipo de preparo e serviram como grupo controle positivo; Grupos 2 e 3: os dentes foram preparados para coroas metalocerâmicas e cimentadas com cimento à base de hidróxido de cálcio (Life) e com cimento resinoso Panavia Ex 21, respectivamente. Após cimentação das coroas, os dentes permaneceram em função na boca por períodos de 7 e 45 dias, após o que, foram extraídos para análise microscópica da polpa e presença de bactérias nos túbulos dentinários. A espessura de dentina remanescente medida em 6 regiões do dente preparado apresentou variação de 1,53 a 1,58mm. A análise microscópica não mostrou reação inflamatória na polpa e não foram encontradas bactérias nos túbulos dentinários. O cimento resinoso avaliado mostrou ser tão compatível quanto o cimento de hidróxido de cálcio, não devendo ser uma preocupação clínica em relação à reação pulpar.

Unitermos

Cimento resinoso; dentina remanescente; reação pulpar.

Introduction

Embryologically, histologically and functionally, dentin and the dental pulp are just one tissue

* Professor, Department of Prosthodontic and Dental Materials/UFRJ
** Professor, Department of Prosthodontic, São Paulo University, Bauru Dental School, Bauru, São Paulo, Brazil
*** Professor, Department of Pathology, São Paulo University, Bauru Dental School, Bauru, São Paulo, Brazil
Address: Faculdade de Odontologia de Bauru - Al. Octávio Pinheiro Brizolla, 9-75 - 17.043-101 - BAURU - São Paulo - Brasil - e-mail: cpg_fob@recad.usp.br - PHONE/FAX: 55 14 2231472

in two different phases. Thus in any circumstance in which dentin is injured by caries, abrasion, erosion, attrition or prosthetic dentistry procedures, some sort of dental pulp reaction will occur.

When a full crown preparation is performed, approximately 1 to 2 million dentin tubules (30.000 to 40.000 dentin tubules per mm2) are exposed and the risk of pulpal damage during and after preparation depends on various factors: heat generated by bur attrition, amount of remaining dentin, dentin permeability, procedures used in the construction of the provisional crowns, quality of the cements used for temporary and final cementation and degree of marginal infiltration.[22]

According to Cox[5], there are two reasons for the occurrence of dental pulp inflammation after restorative procedures: toxicity of the material and bacterial infection.

The toxicity of materials is directly related to dentin permeability that varies according to the localization, depth, age, duration of exposure, amount of sclerotic dentin, change of fluid direction due to evaporation, and thermal stimuli caused by the preparative trauma.[22] As a consequence, some sort of pulp irritation will always occur.

According to several authors[8,11,17,18,21], the reduction of the remaining dentin thickness, increases dentin permeability because of the greater[22] numbers or width of exposed dentin tubules as they come closer to the dental pulp, increasing the dental pulp irritation potential .These alterations can yet be influenced by the remotion of the smear layer[20] and by hydraulic pressure caused in the moment of cementation[19] with different effects depending on which aspect of the tooth is prepared[21].

For reducing the risk of inflammatory responses in the dental pulp after prosthetic procedures, Brännström[3] recommends some precautions during the pre-cementation phase as: perfect sealing of the provisional restoration, earlier definite cementation, removal of the superficial smear layer and the dentin must be treated with an antibacterial solution and then covered with a varnish to reduce dentin permeability. These materials must be easily removed before final cementation to provide a great mechanical union and a perfect occlusion adjustment.

With regards to the effects of the luting agents on the human dental pulp, some studies report about toxicity of some of the components[1,28,29].

For many decades the material most utilized by clinicians for definitive cementation has been zinc phosphate cement, even though it has some limitations such as a great capacity to cause pulpal irritation due to its low pH and also its inability to adhere to dental structures[10,23]. This second limitation has always led the dentist to remove a great amount of healthy tooth structures in order to achieve retention by biomechanical principles, even though irreversible pulp reactions may occur.

When glass ionomers are used as luting agents some of their ideal properties are their adhesive capacity to enamel, dentin and metal and also the liberation of fluoride[15]. But they also present some disadvantages such as post-operative sensitivity, low resistance to tensile stress, short working time, and the extensive time during which the pH remains acid[18].

With the advent and acceptance of resin-bonded fixed prostheses, resin cements underwent several modifications and in spite of the advances in their composition, they still exhibit a much weaker mechanical bond to dentin than to enamel.

Even though the physical-mechanical properties of these new cements as luting agents for various types of restorations have been reported, few studies exists regarding the biocompatibility of these materials. In these studies, slight and moderate inflammatory responses in the short evaluation periods and a tendency to return to normality with an increase of the evaluation period[2,7,12] are shown. These results are normally associated with thickness of dentin remaining (< 1mm).

Thus, the purpose of this study was to evaluate microscopically the dental pulp of healthy human premolars prepared for full metaloceramic crowns cemented with Panavia 21 and Life cements and also to measure the remaining dentin thickness (RDT) of the prepared teeth.

MATERIAL AND METHODS

Eleven patients were selected with ages ranging between 12 to 15 years old (mean age 13.5 years).

For orthodontic reasons these patients needed removal of the maxillary and mandibular premolars.

Twenty-five selected teeth were randomly divided in 3 groups. Five of these teeth were not treated, so as to serve as a positive control group (Group 1). The other twenty teeth were prepared for full metaloceramic crowns (Figuras 1, 2 e 3) and divided in to 2 groups of 10 each, as follows: Group 2 had crowns cemented with calcium hydroxide cement (Life-Sybron-Ker, Ind. E Com. Ltd. São Paulo, SP) and Group 3 had crowns cemented with resin cement - Panavia Ex 21 (Kuraray Co. Osaka, Japan).

After preparations and prior to the construction of the temporary crowns by a direct technique, the teeth were treated with a diluted calcium hydroxide solution, for 5 minutes, followed by application of two layers of copal varnish to prevent direct contact of the resin monomer with the dentinal tubules. The provisional crowns were cemented with calcium hydroxide cement, and remained in the oral cavity for seven days, the necessary time for construction of the full crowns.

The impressions, models, waxing, investing and casting procedures were performed according to the protocol normally employed for these procedures. A Ni-Cr alloy (Durabond-Marquart Cia. Ltd. São Paulo, Brazil) was used because of its capacity for bonding to Panavia resin, as already reported by Rubo et al.[25]

Considering the high cost and time-consuming preparation of metaloceramic crowns, it was decided to utilize metaloplastic crowns for the final prostheses. After adapting the metal structures to the prepared teeth, application of acrylic resin, occlusal adjustments, finishing and polishing procedures, the crowns were internally air-abraded with 50 m diameter particles of aluminum oxide and cemented with the calcium hydroxide cement or the resin cement in accordance with the manufacturer's instructions.

After the final cementation, the teeth remained in function in the oral cavity for periods of seven and forty-five days and the post-operative sensitivity was determined using thermal (cold/hot) tests.

To avoid pressure on the pulp at the cervical region of the teeth, exodontia was performed without utilizing forceps. The teeth were immediately sectioned at the level of the cervical third of the root and stored in 10% formol solution for forty-eight hours. After this period the teeth were submerged in EDTA (ethylene diamine tetraacetic acid) for demineralization of their inorganic components.

Once the process of demineralization was complete, the teeth were dehydrated, cleared[24], and embedded in paraffin (Paraplast - Oxford Labware, ST. Louis, USA). A microtome (Leica RM 2045 - Aotec Scientific Instruments) was used to cut serial slices 5m thickness, always in the buccal-lingual direction following the long axis of the teeth in order to prepare the histological slices. For microscopic analysis of the pulp tissue and detection of the presence of bacteria in the dentin tubules, the slices were stained with hematoxylin-eosin and Masson's trichrome[27] and with Brown and Brenn stain[18], respectively.

The slices were examined by light microscopy (Jenamed 2 - Carl Zeiss Jena microscope) to analyze the quality and the intensity of acute or chronic inflammation of pulp tissue and graduated into scores according to the cellular characteristics identified by Sayegh and Reed[26]. The odontoblastic layer around the pulp chamber was analyzed for its cellular characteristics and the uniformity of the alignment of its cells. As well hyperemia, hemorrhage, presence or absence of acute or chronic inflammation, the occurrence of bacteria and formation of reactive dentin were assessed.

To test for a possible correlation between the remaining dentin thickness (RDT) and pulp reaction, measurements of dentin thickness were made in 6 different regions of the prepared surface: (A) cervical-buccal (B) occlusal-buccal, (C) on the buccal dental pulp horn (D) on the lingual pulp horn, (E) occlusal-lingual and (F) cervical lingual (Figura 4). A comparative microscope (Mitutoyo Corporation, Japan) performed the measurements directly on the histological slices.

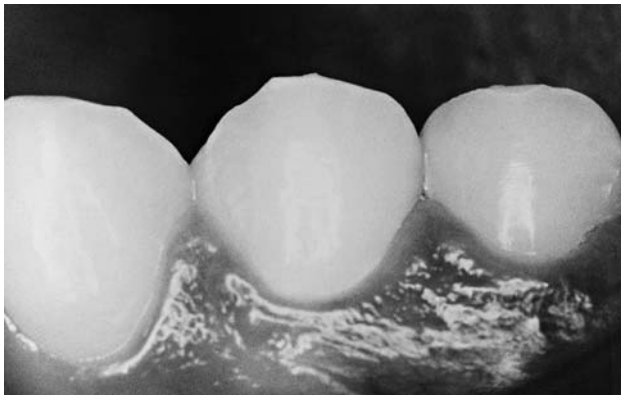

FIGURE 1 – Higid upper bicusp

FIGURE 2 - Half of tooth preparation

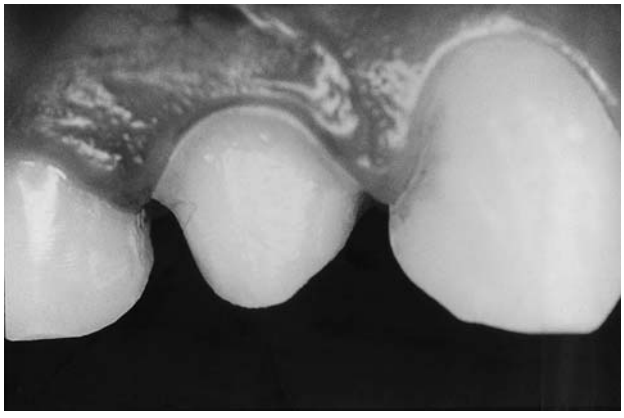

FIGURE 3 - Completed preparation for metaloceramic restoration

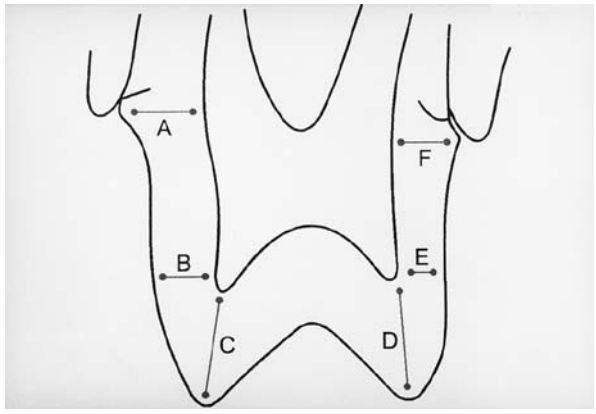

FIGURE 4 - Diagram Showing RDP Measurements

Results

Though this was not the objective of this study, important data could be observed from post-operatory thermal tests. As no positive response was shown, we can conclude that operatory procedures realized previously to definite cementation of the crowns didn't cause pulp reaction, which could mask obtained results.

From the RDT measurements, all specimens had a mean thickness in each region ranging from 1.53 to 1.58 mm that is within the parameters established by Stanley[27]. He recognized that specimens with a remaining dentin thickness greater than 2 mm are irrelevant for this type of research because that thickness acts as a natural barrier against possible deleterious effects of the material components on the dental pulp.

The microscopical analysis followed the criteria of Sayegh and Reed[23] and demonstrated that the odontoblastic layer of the experimental groups showed discrete vacuolation close to the pulp horns but of moderate intensity, without intracanalicular cellular displacement and without cellular death, both for the seven and forty-five day groups. So, no difference in the odontoblastic layer of the three groups was found.

Hyperemia, hemorrhage, acute or chronic inflammation and reactive dentin formation were not observed neither in the control nor in experimental groups (Figuras 5; 6A, B;7A, B). Bacteria were not found in the dentin tubules of either the control or the experimental groups.

As no value was applied to the specimens during the histological characteristics exams , independent of the group, it was not necessary to apply statistic tests for results analysis.

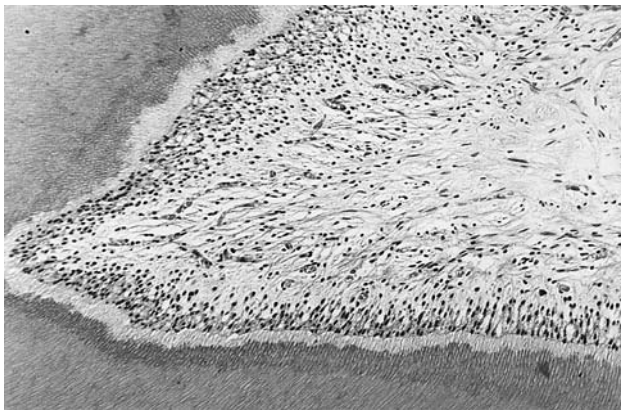

FIGURE 5 - Group 1 (Control) - (H.E; 40x)

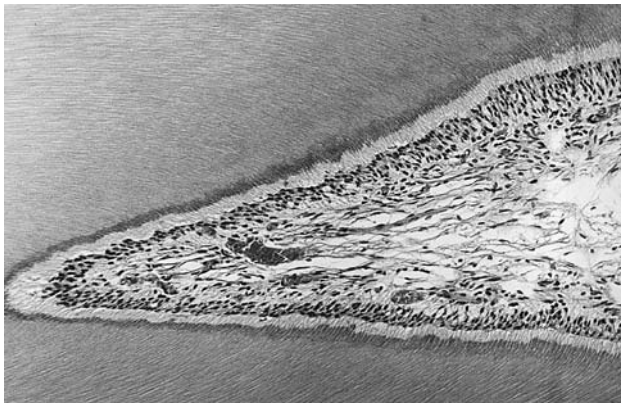

FIGURE 6A - Group 2 - Life Cement: 7 days (H.E; 40x)

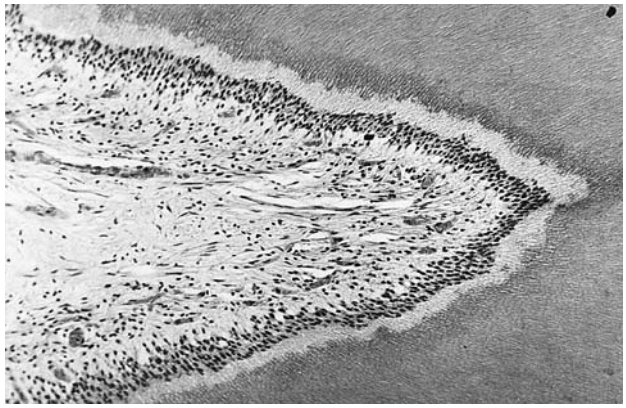

FIGURE 6B - Group 2 - Life Cement: 45 days (H.E; 40x)

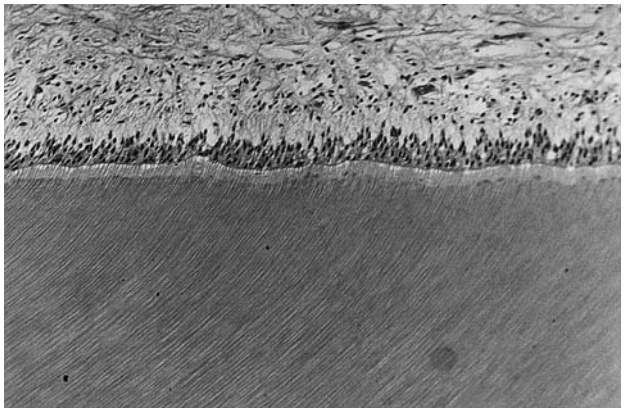

FIGURE 7A - Group 3 - Panavia 21: 7days (H.E;40x)

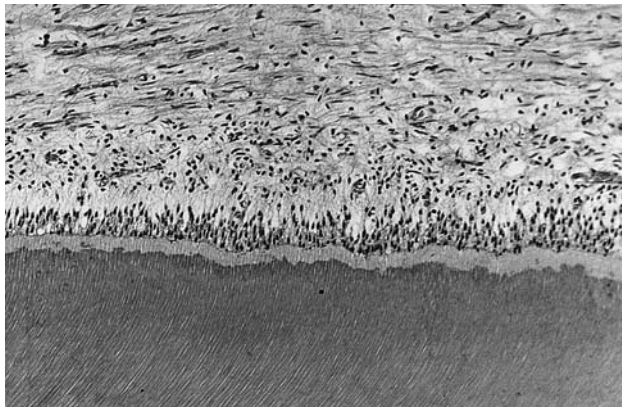

FIGURE 7B - Group 3 - Panavia 21: 45 days (H.E;40x)

Discussion

The protection of the dentin pulp complex should be of the upmost concern for the practitioner from the initial step and through all the protocol for the construction of the restorations. According to Fusayama[9], pulpal irritation is caused by dentin abrasion, by the material components that come in contact with dentin, by bacterial infiltration and by inadequate adjustment of the restorations.

As the tooth preparation for prosthetic purposes is one of the possible causes for pulp inflammation, since it is directly related with the RDT, we could verify that the technique performed according to esthetics and functional requirements for metaloceramic restorations, was able to maintain a considerable layer of dentin over the dental pulp, even in young teeth with voluminous pulps. These results can be compared with those of Pameijer & Stalnley[19], who did not find pulp reaction with resin cement when the RDT was greaten than 1mm, inferring that these cements should be well tolerated by the human dental pulp, as long as the necessary clinical precautions are observed.

Research performed by Matsuura et al.[13] and Costa et al.[4] to evaluate the biocompatibility of Panavia EX ST resin cement, came to the conclusion that even though there was a slight inflammation initially, there was a total recuperation by thirty days and that this material can be utilized whenever dentin is superficially exposed.

Matsuura et al.[14] and Aoki et al.[2] evaluated the biocompatibility of Panavia 21 in dogs and humans and they inferred as we did in this research, that the clinical and pathological examinations indicated excellent biological results after short or long-term evaluation.

Recently Inokoshi et al.[12], studying resin cement biocompatibility in class V preparations in monkeys, detected several pulpal reactions after three days, directly correlated with the preparation trauma but without evidence of irreversible pulpal alterations. In long-term evaluations (ninety days), inflammatory reactions were not observed. The authors also evaluated the RDT after preparation and found a mean of 1.26mm. This value is close to that found in our study where the mean was 1.55 mm.

The majority of studies on the biocompatibility of adhesive systems have found slight or moderate inflammatory responses in short-period evaluations but with a return to normality with longer evaluation periods[2,12,13]. These results were from studies in which the RDT was < 1mm unlike the results from the present study.

The Brown and Brenn stain did not reveal any bacteria in the dentinal tubules, demonstrating that bacterial penetration had not occurred where the dentinal tubules were exposed to the oral environment [6,7,16].

Although clinical studies that try to correlate pulp reactions with restorative procedures have limitations with regard to bacterial flora, eating and hygiene patterns, occluding forces and others directly relationed to the restorative material, this study may suggest, supported by the results found that the adhesive cements utilized didn't cause any dental pulp inflammation.

Conclusions

Within the limits of this study, the following conclusions were drawn:

1. The two cements used in this study did not cause any type of pulp inflammatory reaction in the prepared teeth;

2. The remaining dentin thickness of about 1.5 mm was probably a relevant factor in maintenance of the health of the dental pulp;

3. The resin cement used as luting agent should be as biocompatible as calcium-hydroxide cement and should not be a clinical concern with regard to pulp reaction, provided there is an adequate thickness of dentin overlying the pulp.

REFERENCES

1. AL-DAWOOD A, WENNBERG A. Biocompatibility of dentin bonding agents. **Endodontic Dent Traumatol**, v. 9, p. 1-7, 1993.

2. AOKI S et al. Pulp response to a new adhesive resin cement (Panavia 21). Part I. In case of application to prepared cavities using human teeth. **Jpn J Conservative Dent**, v. 37, p963-73, 1994 .

3. BRÄNNSTRÖM, M. Reducing the risk of sensitivity and pulpal complications after the placement of crowns and fixed partial dentures. v. 27, p. 673-8, 1996.

4. COSTA C.A.S. et al. Compatibilidade biológica da Panavia Ex quando aplicada sobre dentina em pré-molares permanentes íntegros de humanos. **Rev Odontol UNESP**, L, v. 21, p. 79-86. 1992

5. COX, C.F. Biocompatibility of dental materials in the absence of -bacterial infection. **Oper Dent**, v. 12, p.146-52, 1987.

6. DAHL, B.L. Dentine/pulp reactions to full crown preparation procedures **J Oral Rehabil**, v. 4, p. 247-54, 1997.

7. EALBAUM, R.; Pgnoly C, Brouillet JL. A histologic study of the biocompatibility of a dentinal bonding system. **Quintessence Int,** v. 22, p.901-10, 1991.

8. FOGEL, H.M.; MARSHALL, F.J. Pashley DH. Effects of distance from the pulp and thickness on the permeability of human radicular dentin. **J Dent Res**, v. 67, p. 1381-5, 1988.

9. FUSAYAMA, T. Factors and prevention of pulp irritation by adhesive composite resin restorations. **Quintessence Int**, v. 18, p. 633-41, 1987.

10. GOTO, G.; JORDAN; R.E. The pulpal effects of 50 per cent phosphoric acid. **J Canad Dent Assoc**, v. 38, p.248, 1972.

11. HAMID, A.; HUME, W.R. The effect of dentine thickness on diffusion of resin monomers *in vitro*. **J Oral Rehabil**, v. 24, p.20, 1997.

12. INOKOSHI, S. et al. Monkey pulpal responses to conventional and adhesive luting cements. **Oper Dent**, v. 23, p. 21-9, 1998.

13. MATSUURA, T. et al. Histopathological study of pulpal irritation of dental adhesive resin. Part I: Panavia Ex. **J Jpn Prosthod Soc**, v. 31, p.104-15, 1987.

14. MATSUURA, T. et al. Study of pulpal irritation of new dental adhesive cement - **IN: INTERNATIONAL CONGRESS ON DENTALMATE RIALS, Anais.** 1993.

15. MCLEAN, J.W.; WILSON, A.D. The clinical development of the glass ionomer cement. I- Formulations and properties. **Aust Dent J**, v. 22, p.31-6, 1977.

16. NAGAOKA, S. et al. Bacterial invasion into dentinal tubules of human vital and nonvital teeth. **J Endodontics**, v. 21, p.70-3,1995.

17. OUTHWAITE, W.C.; LIVINGSTON, M.J.; PASHLEY, D.H. Effects of changes in surface area, thickness, temperature and post-extraction time on human dentin permeability. **Arch Oral Biologic**, v. 21, p.599-603, 1976.

18. PAMEIJER, C.H.; STANLEY, H.R.; ECKER, G. Biocompatibility of a glass ionomer luting agent. Part II: Crown cementation. **Amer J Dent**, v. 4, p.132-42, 1991.

19. PAMEIJER, C.H.; STANLEY, H.R. Pulp reaction to resin cements. **Amer J Dent**, v. 5, p.81-7, 1992.

20. PASHLEY, D.H.; GALLOWAY, S.E. The effects of oxalate treatment on the smear layer of ground surfaces of human dentin. **Arch Oral Biologic**, v. 30, p.731-7.

21. PASHLEY, D.H. Consideration of dentine permeability in citotoxicity testing. **Int Endodontic J**, v.21, p.143-54, 1988.

22. PASLHEY, D.H. Dynamics of the pulp-dentin complex. **Crit Rev Oral Biol Med** v. 7, p.104-33, 1996.

23. RETIEF, D.H.; AUSTIN, J.C.; FATTI, L.P. Pulpal response to phosphoric acid**. J Oral Pathol**, v. 3, p.114-122, 1974.

24. ROBERTSON, D. et al. A clearing technique for the study of root canal systems. **J Endodontic**, v. 6, p.421-4, 1980.

25. RUBO, J.; PEGORARO, L.F.; FERREIRA, P.M. A comparison of tensile bond strengths of resin-retained prostheses made using five alloys. **Int J Prosthodont**, v. 9, p. 277-81, 1996.

26. SAYEGH, F.S.; REED, A.J. Analysis of Histologic criteria commonly used in pulp studies. **Oral Surgery,** v. 37, p.457-62, 1974.

27. STANLEY, H.R. Design for a human pulp study. Part I**. Oral Surg, Oral Medical, Oral Patology,** v. 25, p. 633-47, 1968.

28. SUZUKI, S.; LEINFELDER, K.F.; SHINKAI, K. Wear resistance of resin cements. **Am J Dent**, v. 8, p.83-7, 1995.

29. WHITE, S.N. Adhesive cements and cementation. **J Calif Dent Assoc**, v. 21, p. 30-7, 1993.