

Evaluation of Internal Adaptation and Degree of Porosity of Total Crowns After Cementation

Avaliação da Adaptação Interna e do Grau de Porosidade Após Cimentação de Coroas Totais

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Abstract

The present study evaluated the marginal fit, the internal filling volume and the degree of porosity in cemented metallic total crowns. Then, 12 metal crowns cast in titanium (Ti) were made on bovine teeth with total preparations and 90° shoulder terminal line. The samples were divided into 4 groups according to the type of cement used and the cementation techniques, 2 groups were used Zinc phosphate (SS White) with the partial insertion of the cementing agent filling the inner crown surface (FP) and total filling (FT), and in the other 2 groups, dual resin cement (RelyX ARC 3M) with the partial insertion of cement (RP) and total insertion (RT) were used. The results showed that cervical marginal fit after cementation was clinically adequate in all groups (<100µm), and for the internal filling volume and porosity were: FP - 99.14% / 0.86%; FT = 98.82% / 1.18%; RP - 97.06% / 2.94% and RT - 97.76% / 2.24%. The statistical analysis was performed by Mann-Whitney test. In conclusion, the two types of cements obtained acceptable values of marginal fit, however, the zinc phosphate cement had better internal fill and lower porosity than the resin cement. Regarding the insertion technique, only the FP and FT groups had a statistically significant difference (p < 0.05) compared to the RP group.

Keywords: Fixed Partial Denture. X-Ray Microtomography. Dental Cements.

Resumo

O presente trabalho avaliou o desajuste marginal, o volume de preenchimento interno e o grau de porosidade em cimentações de coroas totais metálicas. A partir de dentes bovinos com preparos periféricos totais e terminos cervicais do tipo ombro de 90°, foram confeccionadas 12 coroas metálicas fundidas em titânio (Ti). As amostras foram divididas em 4 grupos de acordo com o tipo de cimento utilizado e as técnicas de cimentação, dentre estes, em 2 grupos foram usados Fosfato de zinco (SS White) com inserção parcial do agente cimentante preenchendo a superfície interna da coroa (FP) e preenchimento total (FT), e nos outros 2 grupos foram usados Cimento resinoso dual (RelyX ARC 3M) com inserção parcial do cimento (RP) e total (RT). As análises foram feitas por microtomografia computadorizada por raios X. Os resultados mostraram que o desajuste marginal cervical após a cimentação estava adequado clinicamente em todos os grupos (<100µm), e para o volume de preenchimento interno e porosidade foram respectivamente: FP - 99,14%/0,86%; FT - 98,82%/1,18%; RP - 97,06%/2,94% e RT - 97,76%/2,24%. Na análise estatística utilizou-se o teste de Mann-Whitney para amostras independentes. Concluiu-se que os dois tipos de cimentos obtiveram valores aceitáveis de desajuste marginal, contudo o cimento de fosfato de zinco apresentou melhor preenchimento interno e menor porosidade que o cimento resinoso. Em relação à técnica de inserção, apenas os grupos FP e FT tiveram diferença estatística significativa (p<0,05) comparado ao grupo RP.

Palavras-chave: Prótese Parcial Fixa. Microtomografia por Raio-X. Cimentos Dentários.

1 Introduction

Cements, in fixed partial dentures, are used to fill the tooth-denture interface, and should confer prosthetic retention, resistance and longevity¹. The desired properties for this important material, according to Parisay and Khazaei² are: biocompatibility, low solubility in oral fluids, proper marginal sealing, low cement thickness, easy handling and sufficient working time with fast adjustment. Cement is a determining factor for the restoration success, but in addition to its adequate choice, the follow-up of the cementation protocol is essential.

Nevertheless, one of the causes of failures in cement restorations is due to their incorrect application before the piece is seated. Anusavice³ reports that the presence of

bubbles, especially in the occlusal region, may lead to crown fracture by excessive masticatory forces. Therefore, cement should have a thin layer to minimize the quantity of pores, in addition to being applied uniformly.

It is important to emphasize that zinc phosphate cement has been used in dentistry since 1800 and is recommended to metal, metal-ceramics and porcelain crowns cementation until now^{4,5}. Its adhesion occurs by mechanical imbrication, therefore, it depends on the tooth preparation and a dry environment during the piece seating, due to its high solubility in oral fluids³.

With the discovery of adhesion in 1955, new materials with other properties began to be presented. Adhesive or resin cements have a great connection to the dental structure, low

solubility and high traction and compression resistance. This material can be classified by its setting reaction in: chemically activated, photoactivated or duals, combining the two previous activation forms. Dual cements can be used for cementation of all types of prosthetic parts, however, the indication of photoactivated ones should be for those that allow the passage of light^{6,7}.

In summary, both materials have a great clinical application in the cementation of fixed metallic partial dentures, even with distinct properties. Thus, the present study used microtomography to analyze sectioned 3DS images of metallic crowns cemented by the two types of cements. Cement was applied in two ways: only at the margin of the piece and on all over the internal surface, allowing the analysis of the marginal piece adaptation, the most adequate form of the material application and the amount of failure in the cementation, factors which could be responsible for the eventual denture displacement and loss.

2 Material and Methods

2.1 Samples preparation

12 total metallic crowns cast in different titanium alloys on central incisors of bovine origin were performed. The teeth were kept in chemically activated acrylic resin (OrtoClass - Artigos Odontológicos Clássico Ltda. - Sao Paulo - SP, Brazil) in PVC tubes, prepared under refrigeration with the cervical terminal on a shoulder of 90°, width of 1.5 mm and angle of axial walls of 80° and 5 mm height. When there were pulp exposures, these were restored with composite resin (Prisma APH- Dentisply Ind. e Com. Ltda. - Petrópolis - RJ, Brazil). In order for the piece to always be in the same position, a notch was performed at the tooth cervical terminal and reproduced on the piece (Figure 1).

Figure 1 – Bovine tooth prepared with 90-degree terminal beside the metal crown



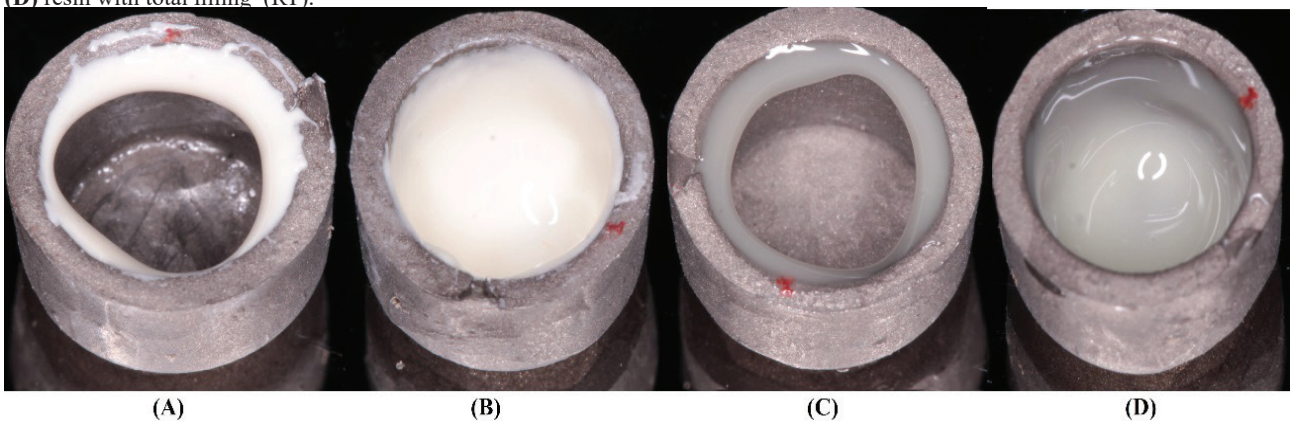
Source: Research data.

The crowns were obtained by the tooth molding by the double-mixing technique with silicone by addition (Aquasil-Dentisply DeTrey GmbH - Konstanz - Germany), and the material of dense consistency was initially used, made an internal relief of the impression material and then relined with the light consistency material. The impression material was hollowed with cast type IV (Exadur V - Polidental Indústria e Comércio Ltda. - Sao Paulo - SP, Brazil) and from these 0.7-mm thick wax foundry pattern castings were made for casting in Ti alloys.

2.2 Marginal fit after cementation

The 12 samples were divided into 4 groups ($n=3$), varying the cement type and the cement insertion technique in the crown. Two types of cements were used: zinc phosphate cement (SS White) and dual-type resin cement (RelyX ARC 3M). For each type of cement 2 material insertion techniques were used: partial only on the edge of the crown and total filling. Thus, the following groups were formed: zinc phosphate cement with partial (FP) and total filling (FT), and dual-type resin cement with partial (RP) and total (RT) filling, as it can be seen in Figure 2.

Figure 2 - Cements (A) zinc phosphate partial filling (FP); (B) zinc phosphate total filling (FT); (C) dual resin with partial filling (RP); (D) resin with total filling (RT).



Source: Research data.

For cementation with zinc phosphate cement, 3 portions of powder were arranged for 3 drops of the liquid in a glass plate at room temperature, according to the manufacturer as a consistent portion for cementation. Thus, the powder was divided into 4 equal parts, the last part being divided into 3 portions (one of 50% and two of 25% of the total quantity), the mixture was made in less than 1 and a half minute, and when the cement surface was clean and dry, the material was inserted and kept under pressure for 4 minutes with a force of 9 kgf. Whereas for the cement with resin cement, this was also arranged in glass plate and the two mixtures are arranged together due to the *clicker system*, mixed and for 10 min, from the mixture, the pieces were cemented by chemical polymerization with a force of 9 kgf.

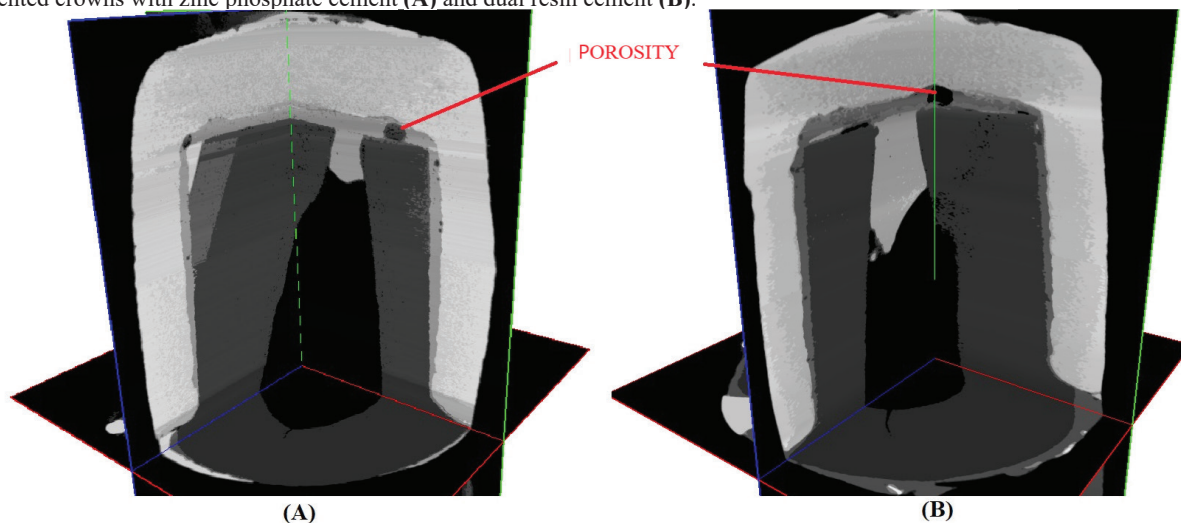
The analysis of marginal fit after cementation was measured by an X-ray microtomography (Sky Scan 1173 – Kontich – Belgium), belonging to the X-ray Analysis Laboratory (LARX) of State University of Londrina (UEL). The samples were placed in the microtomography where there was an interaction with X-rays using a voltage of 100 kV and

a current of 80 µA. This was captured by a CCD camera that generated several sections and a reconstruction algorithm provided the two-dimensional images of the sample. From programs such as CTan and Data Viewer, 3D images could also be reconstructed. In order to evaluate the marginal fit, the region of interest (ROI) and 4 measured equidistant points were determined in the crown marked with a number 2 ball bur (KG Sorensen – Barueri – SP, Brazil) in low rotation. Each point was evaluated 3 times and calculated its arithmetic mean. To identify the points in the gray reading scale, 0,6 mm orthodontic wires with 3 mm in average size were bonded over the tooth markings with dual resin cement (RelyX ARC, 3M).

2.3 Analysis of cement volume and degree of porosity

In addition to marginal fit, the total cement volume was defined and in the dark areas contained as lack of material or porosity. Thus, the difference between the cement groups and the material insertion technique was analyzed to verify the best performance and indication (Figure 3).

Figure 3 – 3D images made by the SkyScan 1173 X-ray microtomography and reconstructed by the Data Viewer® program of cemented crowns with zinc phosphate cement (A) and dual resin cement (B).



Source: Research data.

2.4 Statistical analysis

Data from cement groups and material insertion techniques on internal filling volume were analyzed by a statistical software program (IBM SPSS Statistics, v22; IBM Corp), and the Mann-Whitney test was performed with a significance of 5%.

3 Results and Discussion

3.1 Cervical marginal fit

Chart 1 brings the cervical marginal fits after cementation. The values obtained were between 36.41 and 87.08µm. The lowest fit was found in the RT group (36.41µm) and the largest in the FT group (87.08µm).

Table 1 – Values, in µm, for marginal fit of metallic crowns after cementation

Cements Groups	Marginal fit (µm)
FP	71.66
FT	87.08
RP	79.30
RT	36.41

^A Abbreviations in the column represent: FP = partial zinc phosphate cement, FT = total zinc phosphate cement, RP = partial dual resin cement, RT = total dual resin cement.

Source: Research data.

The cervical marginal fit adopted by the American Dental Association (ADA) for cement film thickness is 25 µm, but clinically it is difficult to achieve this measurement⁸. To verify the fit, the dental-surgeon can use an exploratory probe or

radiographic examination, however the probe tip is between 50 and 130 μm in diameter, which makes it impossible to measure clinically smaller than this size⁹.

The present study adopted the same value as some authors such as Contreras, Muench, and Vaidya *et al.* who attributed to clinically acceptable marginal fit up to 100 μm ¹⁰⁻¹². Thus, it can be observed in Table 1 that the two types of cements were considered with clinically appropriate marginal fits.

The study by Vaidya *et al.*¹² evaluated metal *coppings* manufactured in the conventional and accelerated technique, and obtained fits between $38.17 \pm 14.92 \mu\text{m}$ for the first group and $42.25 \pm 18.02 \mu\text{m}$ for the second group. Other studies that adopted 120 μm as a clinically acceptable fit, also had results close to the present study. In this context, Park *et al.*⁸ obtained fits of $58.30 \pm 31.30 \mu\text{m}$ for metal *coppings* made by the casting technique, $88.90 \pm 39.40 \mu\text{m}$ by computer assisted drilling (CAD-CAM) and $103.30 \pm 43.00 \mu\text{m}$ by the metal laser direct sintering method (DMLS).

3.2 Filling volume and internal porosity

From the tomographic images, the internal filling percentage of each tooth crown and the mean of its respective groups were analyzed, present in Table 2. Among the groups, FP had better internal filling volume and lower internal porosity volume.

Table 2 – Analysis of the internal filling volume and porosity of each group

Types of Cement	Internal Filling Volume (%)	Internal Porosity Volume (%)
Partial zinc phosphate cement (FP)	99.14	0.86
Total zinc phosphate cement (FP)	98.82	1.18
Partial dual resin cement (RP)	97.06	2.94
Total dual resin cement (RT)	97.76	2.24

Source: Research data.

Regarding the cement insertion technique, Pergoraro recommends not to perform the total filling technique of the piece, since if this is only on the edge, it will decrease the hydrostatic pressure effect, which may cause an inadequate crown seating¹³. On the other hand, Mezzomo *et al.*¹⁴, report that partial restorations can be cemented with total filling of the piece using dual resin cement, since there is a greater flow of excess material, different from that of the total crowns. Whereas zinc phosphate cement is recommended to insert only into the cervical third because of the risk of causing marginal fit.

Regardless of the technique, filling of the internal volume of fixed dentures should be as close as 100%, since, as Anusavice states, all the space between tooth and denture should be occupied by the cement agent to prevent the flow of oral fluids and bacterial invasion³. As a result, there is a lower internal porosity value, which may be responsible for the denture fracture due to high masticatory forces.

3.3 Cement insertion technique in relation to internal filling volume

Through statistical analysis, the cement groups and their respective insertion techniques of the material on internal filling volume were compared as shown in Table 3.

Table 3 – Analysis between cement groups and insertion technique in relation to internal filling volume

Comparison Between the Cements Groups	<i>p</i>
FP X FT Group	0.60
FP X RP Group	0.01*
FP X RT Group	0.23
FT X RP Group	0.02*
FT X RT Group	0.33
RP X RT Group	0.45

*Statistically significant difference with $p < 0.05$.

Source: Research data.

It was verified that the samples distribution is not normal according to the Shapiro-Wilk test, so the Mann-Whitney test for 2 independent samples was performed, which showed that the FP and FT cements had a statistical difference ($p < 0,05$) in relation to the RP cement. One of the possible reasons for these results would be the lower thickness of zinc phosphate cement compared to resin cement, since it presents more filler particles hindering its flow during the seating of the piece¹⁵.

4 Conclusion

It was verified that the cervical marginal fit after the samples cementation with the two types of cements evaluated was clinically adequate ($<100 \mu\text{m}$).

It was also observed in the study that zinc phosphate cement was superior to dual-type resin cement, since it had a better internal filling volume of the tooth and denture interface and, consequently, a lower degree of porosity.

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