Importance of Waxing Techniques for the Marginal Fit of Cast Metal Crowns

A scanning electron microscope technique study

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Crown preparation and cementation are two critical parameters for the success of a prosthetic treatment. Marginal fit is important because a large marginal opening allows plaque and oral liquids to penetrate, resulting in micro-leakage, caries and periodontal disease. The purpose of this study is evaluating and comparing the marginal fit of Cr-Ni metallic crowns using three different wax-up techniques made on molars, extracted because of orthodontic reasons. The freshly extracted teeth were kept in artificial saliva to reduce penetration of microorganisms and simulating oral environment. In vitro cementation with Ketac Cem was carried out after disinfection and drying. Samples were maintained for 24 h at 37°C in distilled water and then gold plated. The marginal gap was analyzed using scanning technique with an electronic microscope in several points for every surface of each tooth. Data were statistically analyzed. Measuring the internal fit requires sectioning of specimens and allows obtaining a small number of samples (1-2 per specimen) which means a limited number of measurements per specimen. Another problem consists in the reduced size of the samples after sectioning. The scanning technique enhances measurements of the marginal gap without sectioning and provides an objective evaluation of preparation and cementation techniques.

Key words: scanning electron microscopy, marginal gap, crowns

A perfect marginal fit is an essential requirement which insures the success of fixed prosthetic treatments [1]. A poor marginal adaptation leads without any doubts to micro leakage, decays and periodontal disease.

Over 50 years ago the first studies were made which show that the inflammatory responses of the periodontal tissues in close proximity to the marginal area of fixed dentures is induced by plaque (1953 Waerhang) [2]. Bjorn et al. [2] emphasized that a poor marginal fit is related to the changes occurring in the alveolar bone.

Sjorensen [3]. demonstrated that a strong implication has been established between rough, over-contoured restorations and periodontal disease Felton [4]. shows that there is a direct correlation between marginal discrepancy and gingival index as well as between marginal discrepancies and crevicular fluid volume.

The present study is part of an extended research aiming to improve the marginal fit of cast single unit restorations through better tooth preparation, laboratory wax pattern technique as well as improvement of cementation techniques.

Marginal fit of metal non-noble crowns obtained through different wax pattern lab techniques was studied using scanning electron microscope (SEM) technique. The analysis was performed before and after cementation and results were then compared.

Experimental part

Material and method

Third healthy molars extracted for orthodontic reasons were kept in artificial saliva for minimizing bacterial impregnation and for simulating the oral environment.

Teeth preparation was performed following the clinical protocol [5] at 310.000 rpm, under constant water cooling, with new diamond burs in order to avoid heating of hard tissues. Shoulder preparation at 90 degrees [6] and chamfer preparation [7] were used and then the samples were stored in artificial saliva. Preparations without long bevels were chosen in order to maximize crown seating and accuracy [6].

For the impression we have used the wash-technique and putty and low viscosity condensation silicone Optosil/ Xantopren (Heraeus Kulzer).

The dies were obtained immediately by pouring into the impressions class IV plaster Fuji Rock (GC) and Dowel pins. Different studies showed that the complete seating of the crowns cemented with zinc phosphate cement is obtained when at least 40 microns of cement space was provided [8]. A thin layer of die spacer was applied onto the dies. Different lab procedures were used for obtaining

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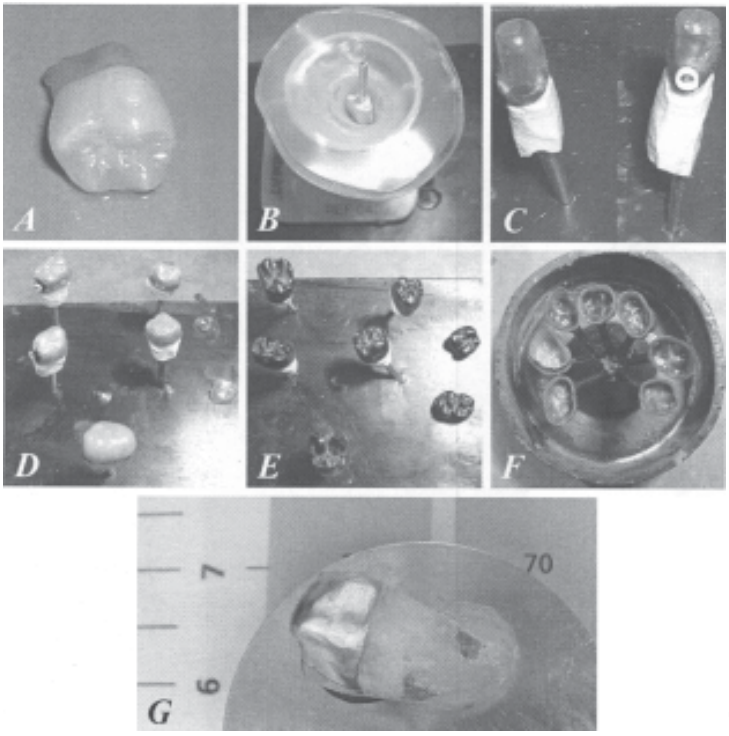


Fig. 1 A: Third molar before clinical preparation; B: obtaining the polyethylene cap; C: double cap and valve; D: different cap techniques: valve, simple and double cap; E: several types of wax patterns; F: attaching the sprue to the wax patterns and preparing for investing; G: non precious cast metal crown adapted on the prepared tooth;

several types of wax patterns: simple cap, double cap and valve.

The valve technique (teeth/samples 1 and 2) uses a valve applied onto the plastic foil which allows excess of GI cement to escape, providing thus improved cementation.

Simple cap implies using a single polyethylene foil closely adapted onto the die spacer (teeth/samples 3 and 4).

Double cap technique implies the use of two sheets of polyethylene foil: the first one lies directly on the die spacer, whereas the second one is tightly molded over the first one. The first sheet is then removed, so a small space is obtained under the second plastic foil. (teeth/samples 5 and 6)

Blue casting wax and additive technique were used for obtaining the complete morphology over the caps. Sprues were attached to each wax pattern and then, after investing and casting by conventional technique (9), the final non precious cast metal crowns were obtained (Vera Bond 2 alloy).

tooth	Lab technique
1	Valve
5	Valve
3	Simple cap
2	Simple cap
4	Double cap
6	Double Cap

The crowns were set on the teeth, sputtered with gold and scanned with a scanning electron microscope (JEOL JSM 25 Japan). On each tooth at least 40 measurements per side were made (in all around 160/tooth), at 200 microns, as follows: from the mesiobuccal to the distobuccal margin, from the distobuccal to the distolingual margin; from the distolingual to the mesiolingual margin and from the mesiolingual to the mesiobuccal margin of each tooth.

The number of measurements was higher than in other researches. As Groten shows [10] reduction from 230 to about 50 measurements caused less than ±5 μm variability for arithmetic means. Analysis of standard errors in the mentioned study shows slowly increasing values smaller than 3 μm, both indicating no relevant impact on the quality of results. Smaller data sizes yielded accelerated increase of standard errors and divergent variability of mean.

The lowest and highest distance between the prepared tooth and the crown margin was measured as well as average and standard deviation. The data were analized and a statistical study was made using Olympus MicroImageProgramme. For each examined tooth a flip chart was produced using different colours for representing the values obtained before and after cementation.

Disinfection and degreasing of teeth was carried out following the rules of cementation used in-office. Ketac Cem single capsules (3M ESPE) were used for cementation. Automated mixing improves the

Clinical stage	sample	technique	Measurement no	average	Standard deviation
Before cementation	S1	Valve	358	61.36	25.92
Before cementation	S5	Valve	165	40.49	20.85
Before cementation	S4	Double cap	239	39.32	35.26
Before cementation	S6	Double cap	175	49.32	22.11
Before cementation	S3	Simple cap	168	126.55	29.78
Before cementation	S2	Simple cap	144	119.11	61.09

Table 1
DATA FOR THE MARGINAL GAP VALUES OBTAINED BEFORE CEMENTATION

Clinical stage	sample	technique	Measurement no	average
Before cementation	S1, S5	Valve	261	50.92
Before cementation	S4, S6	Double cap	202	44.32
Before cementation	S3, S2	Simple cap	156	122,83

Table 2
AVERAGE DATA OF THE MARGINAL GAP VALUES FOR THE 3 WAXING TECHNIQUES USED

Clinical stage	sample	technique	Measurement no	Average	Standard deviation
After cementation	S1	Valve	237	76,64	46,79
After cementation	S5	Valve	172	69,86	46,75
After cementation	S4	Double cap	163	74,63	19,18
After cementation	S6	Double cap	168	98,84	42,88
After cementation	S3	Simple cap	195	130,20	35,26
After cementation	S2	Simple cap	145	124,70	52,07

Table 3
MARGINAL GAP MEASUREMENTS AFTER CEMENTATION

Clinical stage	sample	technique	Measurement no	Average
After cementation	S1, S5	Valve	204	73.25
After cementation	S4, S6	Double cap	165	86.73
After cementation	S3, S2	Simple cap	170	127,45

Table 4
AVERAGE DATA OF THE MARGINAL GAP VALUES FOR THE 3 WAXING TECHNIQUES USED. CLINICAL STAGE: AFTER CEMENTATION

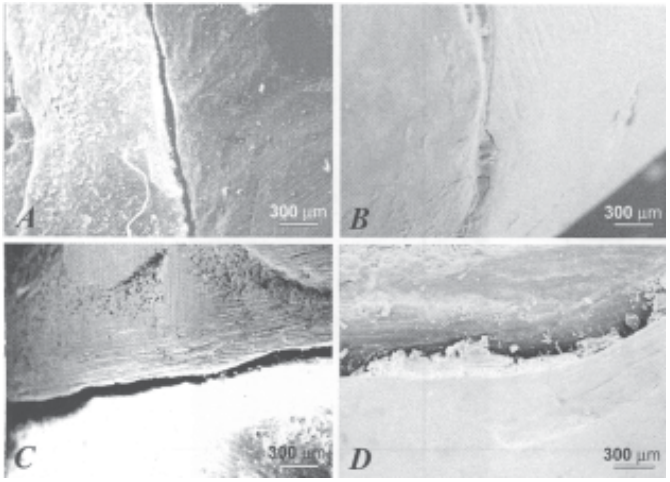


Fig.2A. Scanning electron microscope images of Teeth No 4 and 6 with double cap technique: A: teeth 4 before cementation; B: teeth 4 after cementation; C: teeth 6 before cementation; D: teeth 6 after cementation

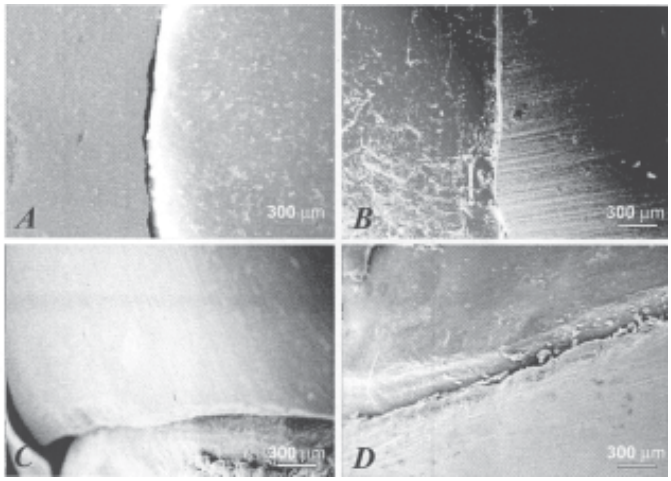


Fig.3A: Scanning electron microscope images of Teeth No 1 and 5 with valve technique: A: teeth 1 before cementation; B: teeth 1 after cementation; C: teeth 5 before cementation; D: teeth 5 after cementation;

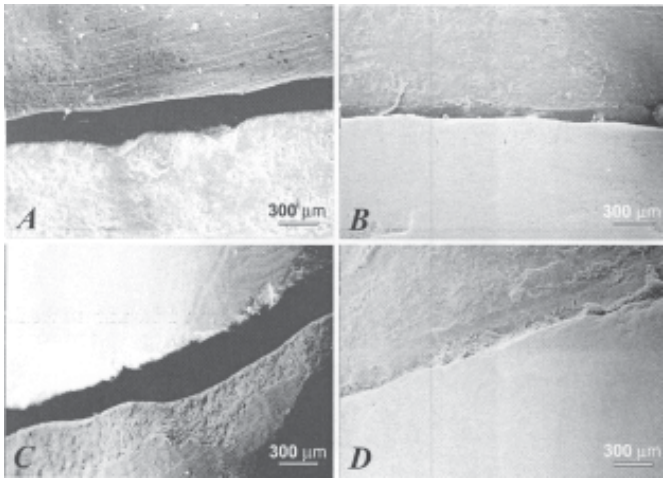
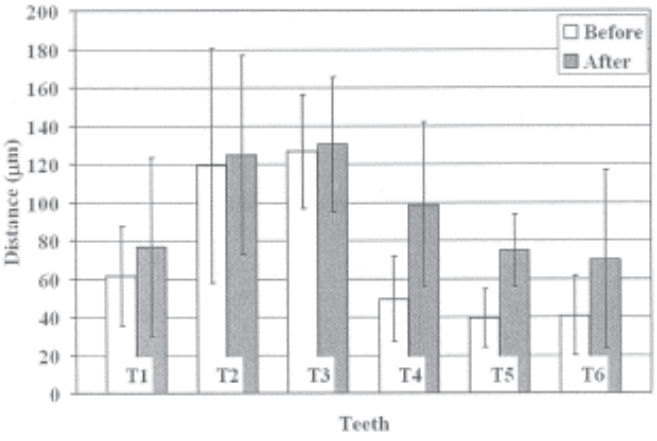


Fig.4 A: Scanning electron microscope images of Teeth No 2 and 3 with simple cap technique: A: teeth 2 before cementation; B: teeth 2 after cementation; C: teeth 3 before cementation; D: teeth 3 after cementation



Graphic no 5. Graphic representation of the values of marginal gap before and after cementation for the different waxing techniques

homogeneity of liquid and powder and insures a low film thickness which optimizes fit and marginal integrity of the crowns.

The restored teeth with the cemented crowns were preserved for 24 hours in distilled water at 37°C and then again platted with sputtered gold and scanned in the same manner as before, trying to re-establish the exact same position of the sample while scanning.

After cementation each specimen had at least 150 measurements (27/side or more), the number being related to the position of the tooth onto the scanning instrument and its size. The average number of measurements overpasses by far the minimum number of measurements required to ensure relevant results for gap analysis [11]. The same scanning protocol was used and data were also included in a statistical study (Olympus MicroImage Programme).

Results and discussions

The results of our study, that included over 1000 measurements of marginal gap, were included in table 1 to 4 as well as in graphic no 5.

Our results have showed the lowest gap measurements for the double cap technique (average 39.32 µm +/- 35.26 for S4 and 49.32 µm +/- 22.11 for S6 at the try-in phase and 74.63µm +/- 19.18 for S4 and 98.84µm +/- 42.88 for S6 after cementation), followed by the valve technique technique (average 61.36 µm +/- 25.92 for S1 and 40.49

μm +/- 20.85 for S5 at the try-in phase and 76.64 μm +/- 46.79 for S1 and 69,86μm +/- 46.75 for S5 after cementation).The highest values for gap measurements were those for the simple cap technique: (average 126,55 μm +/- 29.78 for S3 and 119.11 μm +/- 61.09 for S2 at the try-in phase and 130.20 μm +/- 35.26 for S3 and124.70 μm +/- 52.07 for S2 after cementation.

Measuring of the marginal fit in fixed single unit restorations is a difficult task from the technical and conceptual point of view. Different lab techniques along with clinical ones were developed in order to improve marginal fit of fixed restorations. The measuring techniques are diverse, each permitting a more or less accurate measuring of the distance between the preparation limit and the margin of the crown. Different methods present advantages and disadvantages as well. The computerized method using image enlargement allows the projection of the scanned image and permits image freezing. The drawback consists in the lack of uniformity in measuring the distance between the tooth and the limit of the prosthetic restoration [12]. The vagueness arises because of the fact that there is no overall accepted technique with regard to the level of the measurements: at the internal [7] at the external limit of the shoulder preparation, at 100, 200 or 300 or even at 500 micrometers in order to obtain the average value.

Some authors [13] assert that the restoration can have an under- or over-extended outline at the external angle [14] while at 100 microns the thickness of 0.1mm offers no strength for a good marginal fit.

On the other hand a good marginal fit at 100 microns can be associated with a larger gap at 200 or 300 microns. Moreover this technique requires slice-cutting with a microtome and offers a limited number of measurements.

In the present study casting was made using a single crucible for ensuring the exact same conditions for all six crowns and for avoiding the use of different parameters during preheating, heating, casting and cooling.

The obtained values are within acceptable limits cited in the literature (40-120 microns) [15]. The lowest values were obtained for the double cap and valve technique. Closer values were obtained for the valve technique before and after cementation because of the possibility of the GIC to escape, reducing thus the plunger effect, in the double cap technique the lowest values were obtained before cementation, but after cementation the values increased and were higher than in the valve technique. Previous studies presume that particles in the cement caused this effect [16].

Measuring the gap between the preparation and the crown limit through electronic microscopy has a major advantage over other techniques, namely that there is no need for sectioning the tooth or crown, which can be technical difficult and needs special equipment [17]. At the same time this technique enhances the acquisition of a large but variable number of measurements depending of the size of the tooth [12].

Of general importance is also the clinical step of cementation, the mixing technique and time, the measured or the standardized ratio of liquid and powder for GIC.

The main disadvantages of these methods are: removing the cement in excess at the optimal consistency without submitting the cement film to fractures; repositioning the sample after the cementation in the same position as before cementation; the variable diameter of the prepared teeth lead to a high but inconstant number of measurements.

Conclusions

The main goal of the present study: to determine the best marginal fit of all metallic crowns cemented on teeth with different marginal preparations, was reached. As mentioned before, the scanning technique enhances measurements of the marginal gap without sectioning of the samples, and provides an objective evaluation of preparation and cementation techniques. Electronic microscopy used for measuring the marginal fit provides reliable results and is more affordable than other methods. More precise results can be obtained using microCT but with higher costs. For this reason a micro CT study of the marginal fit of cemented restorations on lateral human teeth will be the topic of our next research.

References

1. FERRARI, M., Cement Thickness and Microleakage Under Dicor Crowns: An In Vivo Investigation The International Journal od Prosthodontics Vol4, no 2, 1991: 126-131.

2.GELBARD S,AOSKAR Y, M.ZALKIND, NOAH STERN- Effect of impression materials and techniques on the marginal fit of castings Journal of Prosthetic dentistry Vol 71 no 1 January 1994: 1-6.

3.SORENSEN JA A rationale for comparison of plaque-retaining properties of crown systems. *J Prosthet Dent.* 1989; 62: 264–269.

4.FELTON DA, KANOY B.E, BAYNE SC, WIRTHMAN GP. Effect of in vivo crown margin discrepancies on periodontal health. *J Prosthet Dent.* 1991; 65: 357–364.

5.SHILLINGBURG HT, HOBO S, WHITTSET LW- Fundamentals of fixed prosthodontics, 3rd Edition, Chicago: Quitessence; 1997: 225.

6.HUNTER AJ, HUNTER AR. Gingival margins for crowns: a review and discussion. Part II: Discrepancies and configurations. J Prosthet Dent. 1990; 64: 636–642.

7.BINDL A, MÖRMANN WH. Marginal and internal fit of all-ceramic CAD/CAM crown-copings on chamfer preparations. J Oral Rehabil. 2005; 32: 441–447.

8.Wu JC, Wilson PR Optimal cement space for resin luting cements. Int J Prosthodont; 7: 209-15.

9.WHITE SN, YU Z, TOM JF, SANGSURASAK S. In vivo micro leakage of luting cements for cast crowns. J Prosthet Dent. 1994; 71: 333–338.

10.GROTEN M, AXMANN D, PRÖBSTER L, WEBER H. Determination of the minimum number of marginal gap measurements required for practical in-vitro testing. J Prosthet Dent. 2000; 83: 40–49.

11.GASSINO G, BARONE MONFRIN S, SCANU M, SPINA G, PRETI G. Marginal adaptation of fixed prosthodontics: a new in vitro 360-degree external examination procedure. Int J Prosthodont. 2004; 17: 218–223.

12.ESTHER GONZALO, MARIA J SUAREZ, BENJAMIN SERRANO, JOSE F Z LOZANO A comparison of the marginal vertical discrepancies of zirconium and metal ceramic posterior fixed dental prostheses before and after cementation

13.SORENSEN JA. A rationale for comparison of plaque-retaining properties of crown systems. J Prosthet Dent. 1989; 62: 264–269.

14.IWAI T, KOMINE F, KOBAYASHI K, SAITO A, MATSUMURA H . Influence of convergence angle and cement space on adaptation of zirconium dioxide ceramic copings. Acta Odontol Scand. 2008; 66:214–218.

15.IN-SUNG YEO, JAE-HO YANG, JAI-BONG LEE- In vitro marginal fit of three all-ceramic crown systems, J. Prosthet Dent, 2003, 90, 5: 459-463.

16.WILSON PR. Effect of increasing cement space on cementation of artificial crowns. J Prosthet Dent. 1994; 71: 560–564.

17.SORENSEN JA. A standardized method for determination of crown margin fidelity. J Prosthet Dent. 1990; 64:18–24.

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