An Electron Microscope Comparative Study of the Marginal Fit of Cast Metal Crowns Using Several Waxing Techniques and Different Cervical Preparation Techniques

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Crown preparation and wax pattern technique are two key factors for the success of a cemented restoration. A poor marginal fit is the main cause of plaque penetration and leakage of oral liquids enhancing thus caries and periodontal disease [1, 2] The present study compares the marginal fit of full metallic crowns restoring caries free extracted molars using different types of marginal preparation as well as different wax-up techniques. The marginal gap was analyzed using scanning technique with an electronic microscope before and after in vitro cementation in several points for every surface of each tooth. Data were statistically analyzed and compared. The scanning technique enhances measurements of the marginal gap without sectioning and provides an objective evaluation of preparation and cementation techniques.

Keywords: scanning electron microscopy, marginal gap, crowns, wax pattern techniques, marginal preparation techniques

The first researches on periodontal inflammation related to bacterial plaque and marginal fit of fixed restorations was made over 50 years ago (1953 Waerhang) [3]. Bjorn et al (quoted from [3]) show a strong relationship between a poor marginal fit of cemented restoration and changes occurred in the alveolar bone).

The purpose of our study is to analyze and compare-using scanning electron microscope (SEM) technique – two key parameters: marginal tooth preparation, laboratory wax pattern technique aiming to improve the marginal fit of metallic crowns.

Experimental part

Material and method

After extraction of third caries free molars, shoulder preparation at 90 degrees, beveled 90 degree preparation, and chamfer preparation [4] were chosen fulfilled and then the samples were stored in artificial saliva in order to simulate the oral environment [5].

Class IV plaster Fuji Rock (GC) was poured into the impressions (we used Optosil/Xantopren -Heraeus Kulzer with two different viscosities) and dies have been obtained using Dowel pins. A thin layer of die spacer was applied onto the dies. Because the literature shows the influence of cement space on adaptation of cemented crowns [6], the following waxing techniques were used for obtaining the wax patterns: simple cap, double cap and valve [5]. In the table no 1 the correlations between different wax pattern technique and cervical preparation technique are shown.

The coronal morphology was completed with casting wax and subsequently investing and casting was done after attaching the sprues. Non precious cast metal crowns were obtained (Vera Bond 2 alloy).

The crowns were set on the teeth, sputtered with gold and scanned with a scanning electron microscope (JEOL JSM 25 Japan) [5].

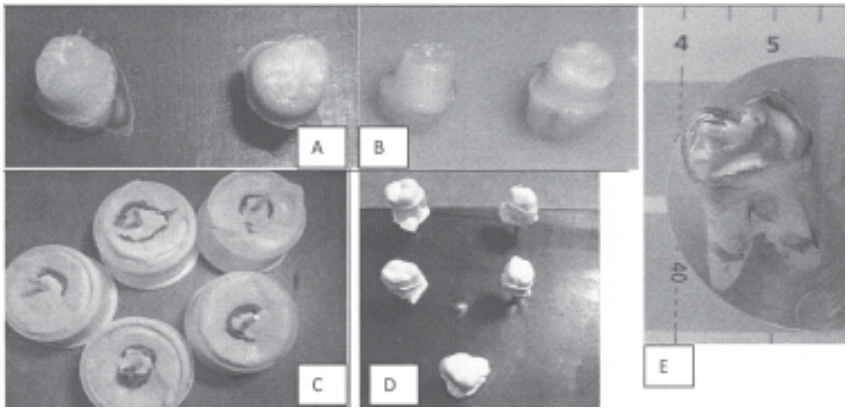

Image 1. A and B – marginal preparations on third molars; C- pouring of dental plaster into the impressions; D- ddies with Dowel pins; E- casted crown on S1

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sample	Lab technique	Marginal preparation
1	Valve	90 degree angle
2	Simple cap	beveled 90 degree angle
3	Simple cap	90 degree angle
4	Double cap	beveled 90 degree angle
5	Valve	chamfer
6	Double Cap	chamfer

Table 1
TYPES OF MARGINAL PREPARATION AND WAX PATTERN TECHNIQUES USED ON EACH SAMPLE

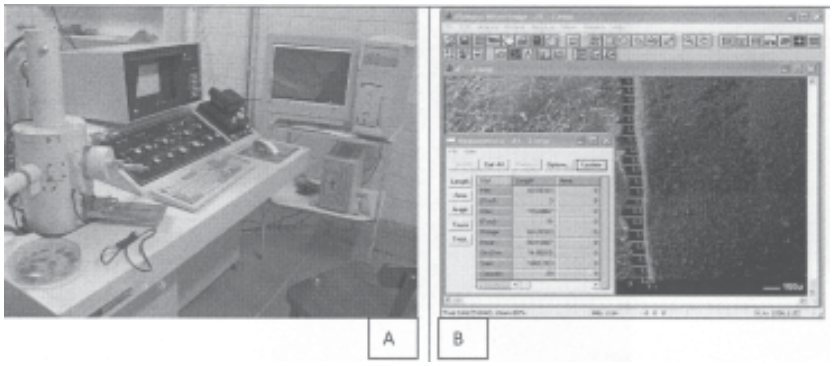


Image 2 A. JEOL JSM 25 Japan electron microscope; B: the Olympus MicroImage Programme

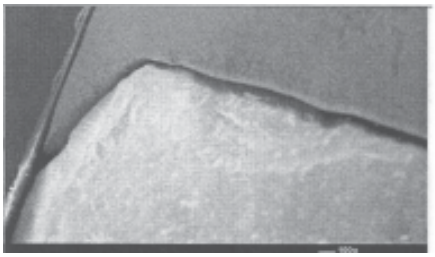


Image 3. S 1 before cementation

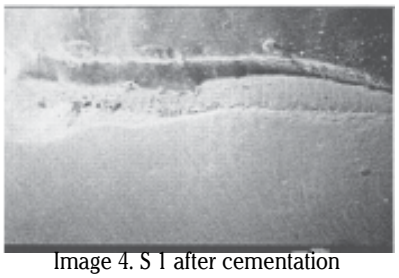


Image 4. S 1 after cementation

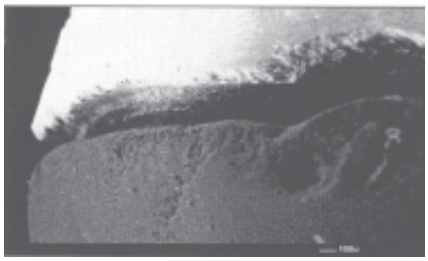


Image 5. Sample 2 before cementation

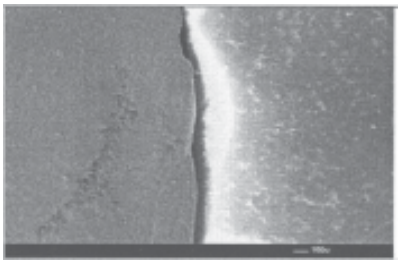


Image 6. Sample 3 after cementation

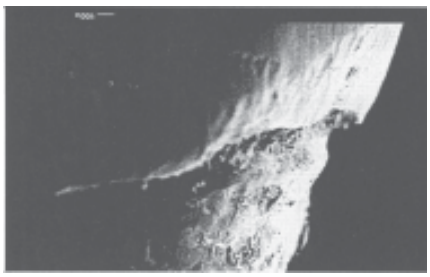


Image 7.Sample 4 after cementation

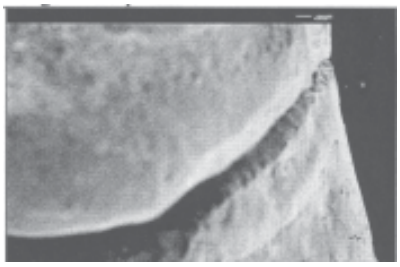


Image 8.Sample 5 after cementation

The average value of measurements for all samples before cementation was 208 and 180 after cementation. On each tooth the minimum measurements per side was 40, at 300 microns, as follows for each tooth: from the distolingual to the mesiolingual margin, from the mesiolingual to the mesiobuccal margin, from the mesiobuccal to the distobuccal margin, from the distobuccal to the distolingual margin.

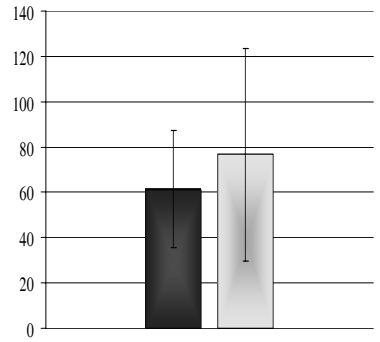
Previous to cementation, disinfection and degreasing of the samples was carried out. Ketac Cem single capsules (3M ESPE) were used for cementation and afterwards, the restored teeth were kept for 24 h in distilled water at 37 degrees C same protocol. Data were also included in a statistical study (Olympus MicroImage Programme) [5]. As before cementation, the samples were again platted with sputtered gold, repositioned in the same way for the electron microscope scanning, and scanned using the same protocol. Data were also included in a statistical study (Olympus MicroImage Programme) [5].

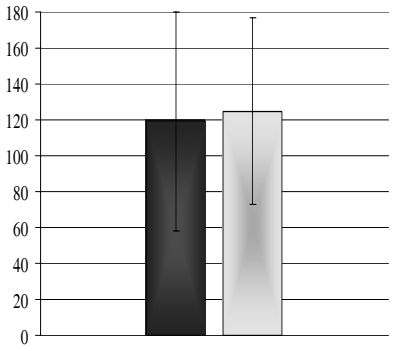
The lowest and highest distance between the prepared tooth and the crown margin was measured, as well as average and standard deviation.

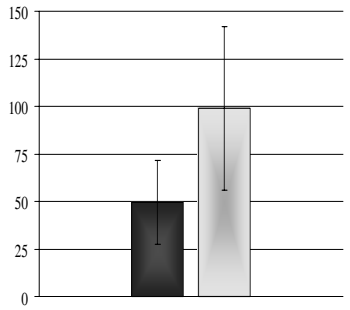
The data were analized and a statistical study was made using Olympus MicroImageProgramme [5]. Graphic charts were made for each samples to show the differences of measured gaps before and after cementation.

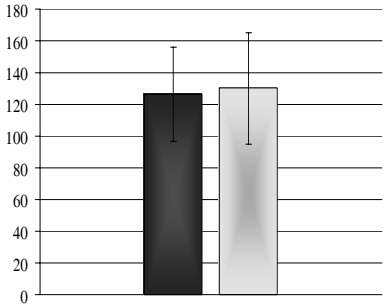
Results and discussions

For the sample 1, prepared with a 90 degree angle and valve, the following values were obtained before and after cementation: 61.36 μm and 76.64 μm. For sample 3 prepared with a 90 degree angle and using simple cap wax pattern the following values were obtained before and after cementation: 119.11μm and 124.7μm.

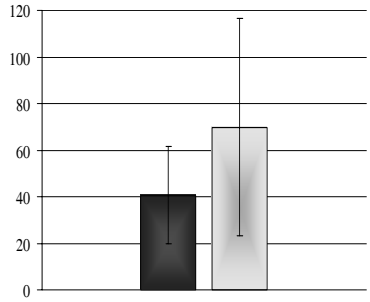


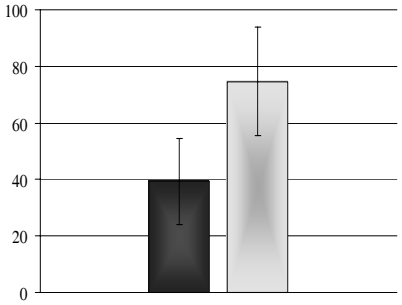






For sample 4 prepared with a beveled 90 degree angle and double cap the following values were obtained before and after cementation 49.32 μm and 98.84 μm. For sample 2 prepared with a beveled 90 degree angle and simple cap and technique the results were: 126.56 μm and 130.20 μm





For the samples 5 prepared with a chamfer preparation and valve, the results were: 39.55 μm and 75.12 μm before and after cementation, whereas for the samples 6 prepared with a chamfer preparation and double cap technique the results were: 39.32 μm and 76.63 μm.

Regarding the wax pattern technique used, the following data were obtained before cementation

sample	preparation	Wax pattern technique	Measurement no	average	Standard deviation
S1	90 degree angle	Valve	358	61.36	25.92
S3	90 degree angle	Simple cap	168	126.55	29.78
S2	Beveled 90 degree angle	Simple cap	144	119.11	61.09
S4	Beveled 90 degree angle	Double cap	239	39.32	35.26
S5	chamfer	Valve	165	40.49	20.85
S6	chamfer	Double cap	175	49.32	22.11

Table 2
DATA FOR THE MARGINAL GAP VALUES OF ALL SAMPLES OBTAINED BEFORE CEMENTATION

sample	technique	Measurement no	average
S1, S3	90 degree angle	263	94.09
S2, S4	Beveled 90 degree angle	191.5	79.21
S5, S6	Chamfer	170	44.90

Table 3
AVERAGE DATA OF THE MARGINAL GAP VALUES OF ALL SAMPLES BEFORE CEMENTATION FOR THE DIFFERENT MARGINAL PREPARATION

sample	preparation	technique	Measurement no	Average	Standard deviation
S1	90 degree angle	Valve	237	76.64	46.79
S3	90 degree angle	Simple cap	195	130.20	35.26
S2	Beveled 90 degree angle	Simple cap	145	124.70	52.07
S4	Beveled 90 degree angle	Double cap	163	74.63	19.18
S5	Chamfer	Valve	172	69.86	46.75
S6	Chamfer	Double cap	168	98.84	42.88

Table 4
MARGINAL GAP MEASUREMENTS OF ALL SAMPLES AFTER CEMENTATION

sample	technique	Measurement no	average
S1, S3	90 degree angle	216	103.42
S2, S4	Beveled 90 degree angle	154	99.66
S5, S6	Chamfer	170	84.35

Table 5
AVERAGE DATA OF THE MARGINAL GAP VALUES OF ALL SAMPLES AFTER CEMENTATION FOR THE DIFFERENT MARGINAL PREPARATIONS

Cervical adaptation of casted cemented restoration is the key factor for the longevity of these prosthetic treatments. The marginal fit depends on several clinical and technical factors such as: type of marginal preparation, an accurate impression, use of materials with high volumetric stability during setting and afterwards

(impression materials as well as cast materials), use of a good casting wax, type of lab technique used for obtaining the wax pattern, investing material, quality of the alloys and cementation techniques and materials.

The use of high quality condensation silicone with good dimensional stability and high precision allows the exact reproduction in the dies of morphological details of the prepared teeth. Class IV plaster Fuji Rock (GC) was immediately poured into the impression to avoid any distortions of the impression.

It has been showed that the use of a die spacer of 40 microns or more, enhances the complete seating of the cemented restorations, so we used a thin layer of die spacer which was applied onto the dies without extending it in the cervical area (up to 1mm).

Regarding the lab procedures for obtaining the wax patterns we used: simple cap, double cap and valve. The valve technique applied for samples 1 and 5 uses a valve set onto the plastic foil which allows excess of cementation material to escape. The simple cap technique (samples 2 and 3) uses a unique polyethylene foil which has an intimate contact with the die.

For the double cap technique two sheets of polyethylene foil have been used, the first one applied onto the die and the second one is tightly molded over the first one. By removing of the inner foil a small space for the cementation material is obtained.

A factor of high importance is the measuring technique of the marginal gap. A very precise technique but which implies higher costs is the micro CT technique. The use of this technique for establishing the marginal gap will be the topic of our next research. It allows after scanning virtual 3D imaging of the gap as well as to calculate its overall volume or measuring at different and precise levels of the distance between the tooth and the restoration. There are several techniques, used in different researches which measure the gap at the internal, at the external limit of the shoulder preparation, at 100, 200 or 300 or even at 500 microns [7]. These multiple possibilities of measuring the gap can- on the other hand- create confusion because there is no general accepted technique quoted in literature.

An important advantage of electronic microscopy as a measuring technique of the marginal gap, is that there is no need for slicing the tooth or crown, and that is allows a large number of measurements per specimen, depending on its size. Its main disadvantage consists in the difficulty of repositioning the teeth for scanning after cementation. Difficulties arise also during the removing of the excess of GI cement without fracturing the thin cement layer at the margin of the preparation. Also this technique allows an inconstant number of measurements, strictly related to the size of the analyzed tooth.

It is known that the nonprecious Vera Bond 2 alloy leads to a poorer cervical adaptation than precious alloys, that's why our research will be extended in the future also in this direction.

When comparing the results we find out that la poorer marginal fit is present in S3 and S2 which both used the simple cap technique. Although the marginal preparation was different for S3 (90 degree angle) and S2 (90 degree beveled angle), the values for marginal gap measurements were very close to each other and were very similar, before as well as after cementation for each sample which show that not necessary the marginal preparation technique but the wax pattern technique may be responsible for the obtained results. We emphazise that the values are higher than in other wax pattern techniques.

S 1 and 5 used also both the same wax pattern technique- valve technique. With this specific technique we obtained the lowest values for the marginal gap measurements and it is to underline that the values before and after cementation were the closest of all samples. S1 was prepared with a 90 degree angle whereas S5 was prepared with a chamfer. Knowing that the valve technique allows the exceeding cement to escape [7] we can presume that this technique improves the marginal adaptation of cemented crowns.

On S4 and S6 was used the double cap technique. The obtained values were slightly higher for the 90 degree beveled angle than for the chamfer preparation. The values after cementation were just higher that in the valve technique so that we consider that the double cap technique is also a reliable wax pattern technique for keeping also after cementation a good marginal fit.

On the other hand when we regard the values before cementation we can observe that the lowest values are for the chamfer preparation and followed by the 90 degree technique and that the beveled 90 degree technique.

Conclusions

The main goal of the present study: to compare the marginal fit of all metallic crowns obtained using different waxing techniques, cemented on teeth with different marginal preparations, was reached. By summing up the gathered data we can conclude that the wax pattern technique pays a more important role in the complete seating and final adaptation of the cemented restorations, presuming that no knife edge preparation is used. All three types of marginal preparation used offer a good marginal adaptation. The obtained values are within acceptable limits quoted in the literature (40-120 microns) [8].

Electronic microscopy used for measuring the marginal fit provides reliable results and is more affordable than other methods. Our field of research will be extended in the future upon noble alloys and ceramics and will use micro CT as a more precise and accurate methods for establishing the marginal fit of single unit cemented restorations.

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Manuscript received: 17.10.2014