Comparison of Two Evaluating Methods for Establishing the Marginal Fit on Four Heat - Pressed Resin Inlays

SORANA BACIU[1], CRISTIAN BERECE[1], ADRIAN FLOREA[1], ANDRADA VOINA TONEA[1], ONDINE LUCACIU[1], ALEXANDRU VICTOR BURDE[1], MARA RUSNAC[1], MARIUS MANOLE[1]*, ADRIANA SACELEANU[2], AUREL MOHAN[3], KAMEL EARAR[4], AURELIANA CARAIANE[5]

[1]University of Medicine and Pharmacy Iuliu Hatieganu Cluj Napoca, 8 Victor Babes Str., 400012, Cluj Napoca, Romania
[2]University Lucian Blaga Sibiu, Faculty of Medicine, Strada Lucian Blaga 2A, 550169, Sibiu, Romania
[3]University University of Oradea, 1 Universitatii Str., 410087, Oradea, Romania
[4]Dunarea de Jos University of Galati, Medicine and Pharmacy Faculty, 47 Domneasca Str., 800008, Galati, Romania
[5]University Ovidius of Constanta, Faculty of Dental Medicine, 124 Mamaia Blvd., 900527, Constanta, Romania

In this study were compared two investigation methods, a bi- and tri-dimensional techniques by examining the marginal fit pressed in (BioHPP) Inlays. The study pruved that the BioHPP is a high performance polymer which provides very good clinical results.

Keywords: Marginal integrity, Scanning electron microscope (SEM), MicroCT (μCT)., inlay, ceramics

Clinical results of various prosthetic treatments have to be checked by specific and very exact methods in order to establish the limit of the acceptable clinical values [1-3]. This means that through paraclinical investigations, the maximal values are determined, for which there is no impact upon the behavior of the prosthetic restoration and an acceptable longevity is achieved. In our study we aim to compare two investigation methods, a bi-dimensional and a three-dimensional technique, by examining the marginal fit of pressed resin (BioHPP) inlays [4-8]. The null hypothesis of this study is that no statistically significant differences exist between the two evaluation methods: scanning electron microscopy (SEM) and micro-computer tomography (μCT). These evaluation methods are used in many research studies for evaluation the interfaces between biomaterials and human tissue [9-17].

Experimental part

Material and method

In our research we compared the above mentioned methods by investigating the marginal gap of four inlays made out of BioHPP – a heat pressed resin reinforced with ceramic particles. The inlays were manufactured into first class inlay cavities prepared on four molars. The four teeth were caries free, have been extracted from patients undergoing orthodontic treatment and have been kept less than half a year in 0.5% aqueous chloramine solution.

In an effort to standardize our research, the used methodology was the same as in our previous studies, as follows: a high speed carbide bur FG271(iSmile, Sacramento,Canada) with a 0.3 mm tip was used for entering and establishing the depth of the pulpal floor (at 2.5 mm). Then a FG169L (SS White, New Jersey, USA) high speed bur with a tip thickness of 0.5 mm, was used to extend the occlusal outline mesio-distally along the central groove, at a 3-5 degree divergence to the facial and lingual walls, as well as to accomplish the final extension in the triangular grooves. The final step of the cavity preparation was performed using a 6862 (Komet Dental, Lemgo, Germany) high speed diamond bur which was used to correct the enamel margins and to perform the rounding of the internal edges. All preparation steps were made under constant water-cooling [18-24].

Manufacturing the wax pattern stage is a very important factor in the success of the prosthetic reconstructions, along with other factors as burnishing the restoration -for cast inlays- and cementation (25-29). Blue casting wax and additive technique were used for obtaining the complete morphology. Sprues were attached, the wax patterns were covered with refractory material, the pack was heated at 630^0C, then the temperature raised to 850^0C in a preaheating oven in order to melt the wax down. After lowering the temperature at 400^0C, Bio Hpp was also melted down. The automatic pressing procedure was carried out with the help of a press plunger in the for 2 press system. After complete cooling devesting and polishing followed.

The four pressed resin inlays placed into the cavities without luting were analyzed first through μCT and only then trough SEM because the electron microscopy needs gold sputtering which would have made afterwards μCT examination impossible. The marginal gap was scanned using a Skyscan 1172 desktop μCT scanner (Skyscan Bruker, Kontich, Belgium) using an aluminum and copper filter at 100 μA and 80 kV. The specimens rotated 180^o with a rotation step of 0.4o had an exposure time of 500 ms. The scanning took approximately 75 min per specimen and the obtained image pixel size was 6.92μm. The x-ray beam was pointed perpendicularly to the preparation long axis of each molar. The used reconstruction program was Nrecon, SkyScan's volumetric reconstruction software. The acquired set of angular projections were used to create cross section slices through the object which were then saved as BMP files. CTAn software (Skyscan, Aartselaar, Belgium) was used to obtain Cross-section images through the center of the teeth (along the Z-axis) and also to make measurements with the line measurement tool. After visualizing the marginal gap at the occlusal surface of each restoration, the distance between the restoration and the tooth was measured circumferentially in 100μm steps.

As shown in our previous study [22,23], SEM is as a measuring technique of the marginal gap that needs no slicing of the sample or restoration, and that allows a large

* emaill: mnole22@yahoo.com

All authors have participated equally in developing this study

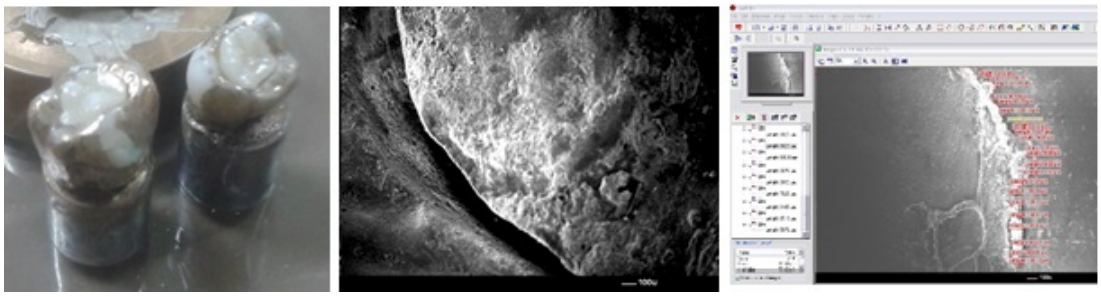

Fig. 1. SEM analysis of the BioHPP inlays

number of measurements per specimen, depending on its size. Its main disadvantage consists in the difficulty of repositioning the teeth for scanning after cementation. This technique allows an inconstant number of measurements, strictly related to the size of the analyzed tooth. Again, for standardizing our researches, we used the same methodology as in our previous study regarding the marginal fit of inlays using SEM technology [23]. For SEM analysis, aluminium holders of 10 mm/Ø9 mm (from BioRad, USA) were covered with carbon bio-adhesive tabs (from Electron Microscopy Sciences, USA) on which the four molars were positioned vertically, keeping all 4 samples at a sufficient distance from the lens of the microscope. Next, a drop of colloidal silver (Agar Scientific, Austria) dropped with an automatic pipette (200µL) Brand (Brand GmbH, Wertheim, Germany) was used to establish the electric conductivity between the surface of the coverslips and the metallic holders. The colloidal silver was dried and the holders were introduced into a Polaron E-5100 sputter coater. In the chamber of the sputter coater, under high vacuum and argon atmosphere, the teeth were covered with a thin layer of several nm of gold atoms (at 2400 V and 20 mA for 45 s).

SEM examination of the metalized samples was carried out with a Jeol JSM-25S scanning electron microscope operating at 25 kV, and magnifications of 45 x. Olympus Micro Image Program was used to analyze the obtained data, which were subsequently included in the statistical study.

Results and discussions

For the Bio HPP inlays analyzed with micro CT, minimal and maximal values were: 31.9 µ (on the forth molar) and 159.1 µ (on the second molar). The minimal and maximal values found on all four molars were: 34.4 and 145.3 on the first molar; 34.6 and 159.1 µ on the second molar; 34.6 and 152.2 µ on the third molar and 31.9 and 148.2 µ on the fourth molar. For Bio HPP analyzed with micro CT the average values were: 84.057 (M1), 91.469(M2), 87.597 (M3) and 68.061 (M4) and the standard deviations were: 35.538 (M1), 37.868(M2), 38.330(M3), 39.081(M4). For BioHPP inlays analyzed with SEM, minimal and maximal values were 28.3 (on the second molar) and 163 µ (on the second molar as well). The minimal and maximal values found on all four molars were: 33.2 and 154 on the first molar; 28.3 and 163 µ on the second molar; 33.2 and 141 µon the third molar and 30.7 and 150 µ on the fourth molar. For Bio HPP analyzed with micro CT the average values were: 84.057 (M1), 91.469(M2), 87.597 (M3) and 68.061 (M4) and the standard deviations were: 35.538 (M1), 37.868(M2), 38.330(M3), 39.081(M4) (table 1).

Statistical analysis was carried out on 8 columns of values (in two sets of 4). The results for the 8 inlays on the 4 molars were compared with One -way ANOVA with Tukey's Multiple Comparison Test performed using 5.00 for Windows (GraphPad Prism 5.00 Software, San Diego, California USA). In the 10 multiple comparisons shown in figure 2 we obtained significant statistical values

	BioHPP MCT1	BioHPP SEM1	BioHPP MCT2	BioHPP SEM2	BioHPP MCT3	BioHPP SEM3	BioHPP MCT4	BioHPP SEM4
Number of values	51	249	57	375	67	347	65	320
Minimum	34.4	33.2	34.6	28.3	34.6	33.2	31	30.7
25% Percentile	55.4	54.9	62.3	58.1	48.4	51.3	36.9	51.1
Median	83	82.2	89.9	76.2	83	66.3	51	66.2
75% Percentile	111	116	124	100	118	84.4	100	109
Maximum	145	154	159	163	159	141	148	150
Mean	84.1	86.4	93	82	87.6	69.4	68.1	79.5
Std. Deviation	35.5	34.5	36.5	30.8	38.3	22.3	39.1	33.8
Std. Error	4.98	2.19	4.83	1.59	4.68	1.2	4.85	1.89
Lower 95% CI	74.1	82.1	83.3	78.9	78.2	67.1	58.4	75.8
Upper 95% CI	94.1	90.7	103	85.2	96.9	71.8	77.7	83.2

Table 1.Descriptive statistics for the measured gaps with SEM and micro CT for Bio Hpp inlays

Table Analyzed	Data 1				
One-way analysis of variance					
P value	P<0.0001				
P value summary	***				
Are means signif. different? (P < 0.05)	Yes				
Number of groups	8				
F	10.5				
R squared	0.0462				
Bartlett's test for equal variances					
Bartlett's statistic (corrected)	91.3				
P value	P<0.0001				
P value summary	***				
Do the variances differ signif. (P < 0.05)	Yes				
ANOVA Table	SS	df	MS		
Treatment (between columns)	73700	7	10500		
Residual (within columns)	1520000	1523	998		
Total	1590000	1530			
Tukey's Multiple Comparison Test	Mean Diff.	q	Signifi? P < 0.05?	Summary	95% CI of diff
BioHPP MCT1 vs BioHPP SEM3	14.6	4.36	Yes	*	0.132 to 29.1
BioHPP SEM1 vs BioHPP SEM3	17	9.14	Yes	***	8.93 to 25.0
BioHPP SEM1 vs BioHPP MCT4	18.3	5.89	Yes	**	4.87 to 31.8
BioHPP MCT2 vs BioHPP SEM3	23.5	7.37	Yes	***	9.71 to 37.3
BioHPP MCT2 vs BioHPP MCT4	24.9	6.14	Yes	***	7.36 to 42.4
BioHPP SEM2 vs BioHPP SEM3	12.6	7.58	Yes	***	5.41 to 19.8
BioHPP SEM2 vs BioHPP MCT4	14	4.66	Yes	*	1.00 to 27.0
BioHPP MCT3 vs BioHPP MCT4	19.5	5.02	Yes	*	2.71 to 36.4
BioHPP SEM3 vs BioHPP SEM4	-10.1	5.81	Yes	**	-17.6 to -2.58
BioHPP MCT1 vs BioHPP SEM1	-2.33	0.679	No	ns	-17.2 to 12.5
BioHPP MCT2 vs BioHPP SEM2	10.9	3.44	No	ns	-2.82 to 24.6
BioHPP MCT3 vs BioHPP SEM3	18.2	6.09	Yes	***	5.27 to 31.1
BioHPP MCT4 vs BioHPP SEM4	-11.4	3.76	No	ns	-24.6 to 1.71

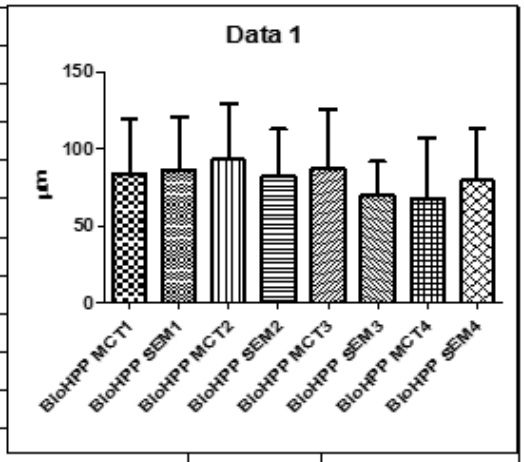

Fig. 2.Anova One-way Analysis of variance and statistical diagram for SEM and microCT on BioHPP inlays

comparing the marginal gap of the two used methods materials on each tooth.

Our results show that the material we used for the conservative reconstruction of the cavities, a heat pressed resin reinforced with ceramic particles, is a reliable material which provides good clinical results. These results are within the acceptable limits coted in the literature. As we already emphasized in our previous study [22,30], there are various possibilities to examine the marginal gap of fixed restorations: visual examination, radiographic techniques, score-based stereomicroscopic quantification, SEM measurements of light body silicone or epoxy replicas with or without sectioning of the sample. Sometimes there is the need of embedding and sectioning of the restorations, or thermocycling and immersing of the specimens in basic fuchsin previous to sectioning. Other studies use OCT which exhibits microstructural details that cannot be obtained with current imaging modalities. There is also the possibility of scanning the teeth with the help of efOCT or laser microspectral analysis. For fixed restorations there are several methods for measuring the marginal fit. MicroCT is a very sensitive, contactless technique but depends on the scanning parameters as: examined volume, distance to the scanned object, resolution, magnification. It also implies higher costs then other investigation methods. SEM on the other hand is not price prohibitive and if evaluation is made only before luting does not need neither sectioning nor repositioning of the samples.

The values we obtained with both examination methods were close four all four samples. Knowing that microCT is an investigation which does not need the direct input of the examiner, excepting the setting of the parameters, we can affirm that it is a more reliable method than SEM. This latter investigation method implies the positioning of the measuring cursor –tool from the limit of the preparation to the margin of the restoration, being thus a much more subjective investigation compared to microCT. Nevertheless, we can affirm by comparing the values, that SEM examination was carried out correctly, and if this condition is accomplished, it is a reliable method for investigating the marginal gap of fixed restorations.

We can conclude that microCT and SEM are easier methods than methods used by other researchers [3,4,8,10,14]. In a comparative research of 2 types of composites, the specimens were examined after cementation under a dental surgical microscope and were photographed with a digital camera to assess the external marginal gap at selected points. Then, each specimen was embedded in an acrylic resin block, and bucco-lingual and

mesio-distal sections were done to obtain 10 segments. Although this method is time consuming and more susceptible to human errors and therefore less precise, it allows measurements of the external gaps as well as of the internal one, and from this point of view more reliable by offering more data. The marginal and internal gaps of the two nano-composite CAD/CAM blocks differed according to the measuring points. Among the internal area of the two nano-composite CAD/CAM restorations, occlusal gap data were significantly larger than axial gap data.

Conclusions

Composite inlays are an alternative with superior results offering good esthetic results and longevity compared to fillings. One of their main advantage besides the lower costs, depending on the used material (eg. bioactive glass) is that they can poses antimicrobial and remineralization properties that can prolong the survival of dental composites in the oral environment. Marginal gap is formed because of polymerization shrinkage, specific phenomenon of all materials polymerized by free-radical activation, causing microleakage of bacteria and oral fluids toward the pulp of the tooth.

BioHPP, is a high performance polymer which provides very good clinical results due to of the structure but also due to of the polymerization method, namely heat pressing. The partially crystalline thermoplastic resin reinforced with ceramic particles to withstand extreme stress, it has *no* abrasive effect on the remaining teeth, it has white color suitable for fully anatomical use, and it insures no ion exchange in the mouth, no discoloration along with excellent stability and optimal polishable properties.

References

1.ANTONIAC I. (Ed.) Handbook of Bioceramics and Biocomposites, Publisher Springer International Publishing Switzerland, NY, 2016, pp.223.

2.CRACIUNESCU E., SINESCU C., NEGRUTIU M.L. et al., J Adhes Sci Technol., 30(6), 2016, p. 666-676.

3.MICULESCU F., BOJIN D., CIOCAN L.T. et al., JOAM, 9(11), 2007, p.3303-3306.

4.EARAR, K., GRADINARU, S., PARIZA ,G. et al., Rev. Chim. (Bucharest), **68**, no. 8, 2017, p. 1868.

5.ANDREI B., NICULESCU M., POPESCU GH., International Orthopaedics, 40(2), 2016, p.393-397.

6.ANTONIAC I., NEGRUSOIU M., MARDARE M.; et al., Medicine. 96(19):e6687, 2017.

7.BOTEZ P., SIRBU P., SIMION L. et al., EJOST, 19(6), 2009, p.387-395.

8.ISTRATE,B.,MUNTEANU,C.,CRIMU, C.I.,IACOB, S.S.,MARCELIN,B., EARAR ,K., ,Indian Journal of Engineering and materials sciences, 23(6), 2016: 418-424

9.CIOATA, R.,BALAN,A., ANTOHE, M.E.,SAVIN,C., IGNAT,G., BASNO,A, Mat. Plast., **53**, no. 1, 2016, p. 147

10.ANTOHE,M.E., AGOP FORNA, D., ANDRONACHE, M., FEIER R., FORNA, N.C., Romanian Journal of Oral Rehabilitation, Vol. 8, No. 2, April - June 2016 , pp16-25

11.BRATILA, E., COMANDASU, D., MILEA ,C. et al., J Adhes Sci Technol., 31(18), 2017, p.2028-2043.

12.PARIZA, G., MAVRODIN, C.I., ANTONIAC, I., Mat. Plast., **52**, no. 4, 2015, p.484

13.NICULESCU ,M, ANTONIAC, I, VASILE, E. et al., Mat. Plast., **53**, no. 4, 2016, p.642

14.GRECU, D., ANTONIAC, I., TRANTE, O. et al., Mat. Plast., **53**, no. 4, 2016, p.776

15.ANTONIAC, I., BURCEA, M., IONESCU, R.D., BALTA, F., Mat. Plast., **52**, no. 1, 2015, p.109

16.CIRSTOIU, M., CIRSTOIU, C., ANTONIAC, I., MUNTEANU, O., Mat. Plast., **52**, no. 3, 2015, p.258

17.ISTRATE, B.,MARECI,D., MUNTEANU,C., STANCIU,S., CRIMU,C.I., TRINCA,L.C., EARAR, K., Environmental engineering and management journal,15(5),2016,:955-963

18.DOLOCA,A., TANCULESCU, O., TRANDAFIR, L., CIONGRADI I.,STOLERIU S., MOCANU, R, IFTENI.G., Mat. Plast., **53**, no. 3, 2016, p.370

19.BARBINTA ,C.A.,EARAR, K., CRIMU, C.I., Bioceramics, Vol25, Book series:Key Engineering Materials, Vol 587,2014,303

20.MARINESCU, R., ANTONIAC, I., LAPTOIU, D., ANTONIAC, A., GRECU, D., Mat. Plast., **52**, no. 3, 2015, p.340

21.CONSTANTINESCU, I., DINU, A.A., BOSCAIU, V., NICULESCU, M., Hepatitis Monthly, 14(10):e22072, 2014.

22.IOSIFESCU, A.G., MOLDOVAN, H., ILIESCU, V.A., J Heart Valve Dis., 23(2), 2014, p.149-157.

23.BACIU, S., BERECE, C., FLOREA, A., et. al., Rev. Chim. (Bucharest), **68**, no. 3, 2017, p.615

24.BACIU, S., BERECE, C., FLOREA ,A., et. al., Rev Chim. (Bucharest), **68**, no. 6, 2017, p.1414

25.MANOLE, M., BERECE, C., FLOREA, A. et. al., Rev Chim. (Bucharest), **68**, no. 8, 2017; p.1919

26.BACIU, S., FLOREA ,A., MANOLE, M. et. al., Mat. Plast., **52**, no. 3, 2015, p.393

27.GORDON J. CHRISTENSEN -Marginal Fit Of Gold Inlay Castings; The Journal of Prosthetic Dentistry, 1966

28.ASAFTEI, I.V., EARAR, K.,BIRSA, L.M., et al, Rev. Chim. (Bucharest), **66**, no. 7,2015, p. 963

29.BACIU, S., FLOREA, A., MANOLE, M. et. al., Mat. Plast. **52**, no. 2, 2015, p.214

30.BACIU S., BERECE C., BURDE A.V. et. al.; International Journal of Medical Dentistry; 7 (3), 2017; p.62-68

Manuscript received: 12.09.2017