Original Article

A Comparative Evaluation Of Marginal Fit In Copings Obtained By Three Techniques: An In-Vitro Study

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Abstract

Aim- The purpose of this study was to evaluate the amount of microleakage in the copings fabricated by three different techniques. **Materials and Methods-** Total of 60 premolar teeth specimens were collected. Individual teeth preparation was done. Impressions were recorded and dies were prepared. They were divided into different groups based on their technique of fabrication of prosthesis. In Group-A, thirty copings were fabricated using direct metal laser sintering (DMLS). In Group –B, other thirty copings were fabricated using milling technique (CAD-CAM). In Group C, the remaining thirty specimens received copings fabricated using conventional casting techniques. Type-1 of Glass ionomer cement was used to lute the prosthesis to the underlying tooth structure. The luted specimens were subjected to thermocycling, in order to simulate thermal stresses and ageing of the cemented crowns. They were immersed in bath of 2% methylene blue solution for 48 hours. Later the specimens were sectioned at the middle, microleakage was observed under stereomicroscope (SZM-45N Zoom Stereo Microscope) at 40X magnification. **Statistical Exam nation**- The data from all the groups were evaluated using Chi square test using SPSS software (SPSS 12.0;SPSS, INC,Chicago III). **Results-** in Group A, 70% of the samples has a score of 0 and 30% has a score of 1. In Group B, 30% of the samples has a score of 0, 50% has a score of 1 and 20% has a score of 2. In Group C, 5% of the samples has a score of 0, 20% has a score of 1, 30% has a score of 2, 20% has a score of 3 and 25% has a score of 4. **Conclusion-** The copings fabricated using direct metal laser sintering (DMLS, Group A) had shown improved marginal fit and reduced microleakage.

Keywords – Microleakage, Marginal fit, Metal coping, Conventional casting technique, CAD-CAM, Laser sintering.

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Introduction

Fixed prosthesis helps in replacing in the loss of tooth structure along with rehabilitation of lost function and esthetics. The factors that determine success of prosthesis are type of tooth preparation, technique of prosthesis fabrication, type of luting cement used, esthetics, marginal adaptation, microleakage etc.[1] The prosthesis can survive in the oral cavity only if the margins are closely adapted to the finish line.[2] It is weakest link in the prosthesis fabrication.

McLean and Fraunhofer has quoted 120 μm as the maximum value for marginal misfit in a designed prosthesis.[3] Internal fit ranging between 50 and 100 μm is considered acceptable.[4] Marginal misfit at tooth prosthesis junction causes dissolution of luting cement and microleakage. It further leads to plaque accumulation, entry of bacteria into the tooth causing hypersensitivity, secondary decay and periodontitis. Microleakage persists as one of the main biological causes for restoration failure.[5] Microleakage is defined as the penetration of oral fluids, bacteria into a gap that present between the prepared finish line and the prosthesis.[6]

One of the factors affecting marginal misfit in the base metal alloy prosthesis is the type of technique used in fabrication.

One of the most common techniques used is conventional casting technique (lost wax technique). It introduced by Taggart in 1907.[7] It has reported to have major setbacks like technique sensitivity, time consuming procedure, casting shrinkage, etc, In order to overcome the drawbacks of the conventional casting technique, CAD-CAM (Computer Aided Design-Computer Aided Manufacturing) technique was introduced. This involves use of CAD to scan and design the prosthesis. The CAM involves both milling and direct metal sintering (DMLS).[8] The milling technique involves subtractive manufacturing in which prosthesis is fabricated by milling from the solid block of the desired material. Another newly developed laser sintering is the additive prosthesis fabrication technique in which high fusing laser is fired at the fused alloy particles, creating layers of 0.020mm thick.[9]

Various studies[10,11,12] have stated the advantages of CAD-CAM milling and laser sintering technique over conventional casting for coping fabrication. But limited literature is available regarding the amount microleakage observed due to different technique of prosthesis fabrication.

Thus, the following study was undertaken to assess the amount of microleakage occurred to due to different coping fabrication techniques i.e., conventional lost wax technique, milling and laser sintering technique. The null hypothesis was formulated that type of coping fabrication technique doesn't affect the amount of microleakage observed at the tooth-coping junction. An additional hypothesis was formulated that the different coping fabrication techniques affect the marginal adaptation and microleakage at the coping-prosthesis junction.

Materials and Methods

Preparation of test specimen: Sixty extracted premolar teeth with intact occlusal morphology and no clinical or radiographic evidence of occlusal caries were collected. All were hand scaled and cleaned to remove debris. They were disinfected with 5.2% sodium hypochloride solution and stored in distilled water at room temperature until the further procedure. Autopolymerising acrylic resin (DPI, India) blocks were prepared by silicone putty (polyvinyl siloxane, Densply, USA) custom made mould. Each of the premolar specimens were mounted in the acrylic resin blocks such that its long axis was parallel to the axis of the acrylic resin block. The cemento-enamel junction was positioned 2mm coronal to the acrylic resin.

Tooth Preparation: To standardize teeth preparation technique among all the teeth, each specimen was oriented on the Will's surveyor. Straight handpiece was clamped to the surveying arm for tooth preparation. Each tooth was prepared for metal coping of following dimension- 1mm chamfer margin using taper round ended diamond, 2mm occlusal reduction, 1.5mm axial reduction, 12 degrees axial walls convergence angle. All teeth were prepared by single operator to eliminate bias.

Preparation of Co-Cr metal copings: Sectional tray was used to record impression of the prepared tooth. Dual impression technique was performed using polyvinyl siloxane putty (Densply, USA) and light body polyvinyl siloxane (Densply, USA). Impressions were poured using Type IV die stone (Kalabhai Ultra Rock Die-Brown). Total sixty dies were divided into three groups based on the method of Co-Cr metal coping fabrication:

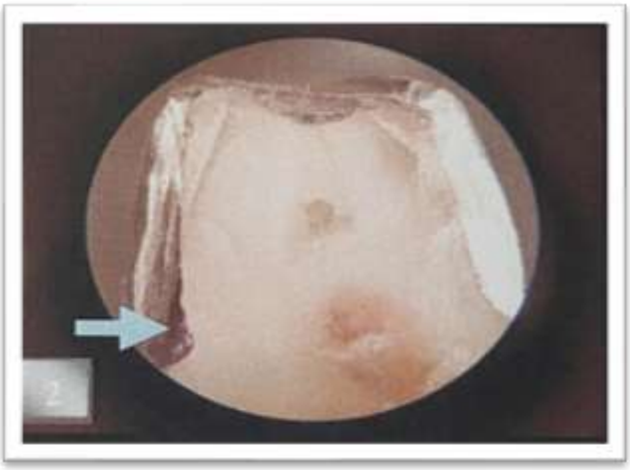

Fig.1- Sectioned premolar specimen **Fig.2- Die penetration- microleakage upto 1/3rd of axial wall**

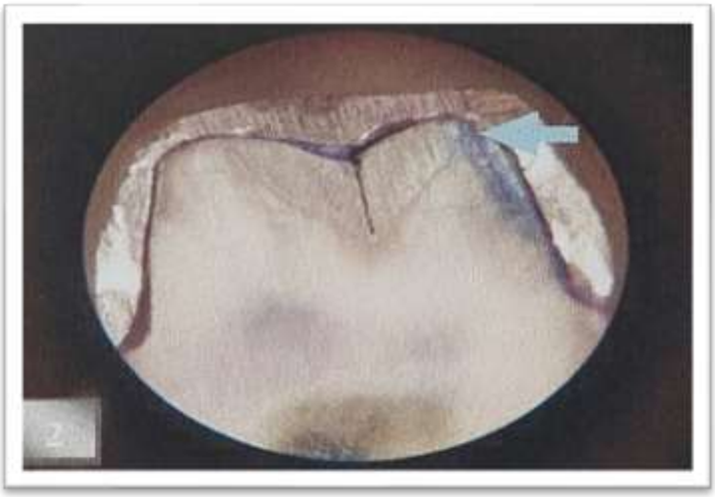

Fig.3- Die penetration- microleakage upto 2/3rd of axial wall

Group A- Copings fabricated using laser metal sintering technique: Twenty individual dies were scanned (ESPE Lava scan ST scanner). With the help of CAD software (Lave design software, 3M ESPE), internal relief of 30 µm and coping design of 1mm thickness was designed as an STL data. This data was transferred to CAM machine (EOSINT M 270). High powered laser (Yb-fibre laser, 200 W) was used to sinter the Co-Cr alloy (EOS Cobalt-Chrome SP2 alloy) particles. They were added in vertical increment layer of 20–60 µm thick to fabricate the designed coping.

Group B- Copings fabricated using milling technique: For fabrication of twenty Co-Cr metal copings by CAD-CAM (Dental CAD) system, the individual dies were digitized by scanning. Coping design of 1mm was designed with 30 µm of die spacer was designed. This data was electronically transmitted to the CAM where the blocks cobalt chromium alloy was sectioned into the designed coping of 1mm thick was fabricated.

Group C- Copings fabricated using conventional casting technique: Twenty stone dies were coated with two coats of die spacer to get about 30 µm thickness, followed by application of wax separator (Sigmadent, India). Standardized wax patters were made for all the samples. After the pattern wax completely solidified, they all were carved to attain a uniform thickness of 1mm. Wax patters were invested (Bego Bellasun and Bego Sol, Germany) individually following the manufacturer's instructions using ringless casting technique.[13] Co-Cr (Wirobond, BEGO, Germany) alloy was used to fabricate the copings. Final finishing and polishing of all the sixty metal copings were done.

Cementation of the copings: Before cementation, all the prepared teeth were cleaned with pumice. Then thoroughly cleaned with water and dried with filtered compressed air. Each of the copings were cemented to the prepared teeth with Type -1 glass ionomer (Gold Label, GC) luting cement. The luting cement was mixed and loaded sufficiently in the intaglio surface of the coping and seated on the tooth with digital pressure. A sustained load of 5kg was applied with a loading device for 10 min continuously. Excess cement was removed with the explorer.

Thermocycling and storage of specimens: After cementation, the specimens were stored in 100% humidity at 37°C for 1 hour, thermo cycled 200 times between 5°C and 55°C with a dwell time of 10 seconds, then stored in 100% humidity T 37°C. This process was done to induce thermal stresses in order to simulate thermal stresses and resulting in ageing of the luted copings.

Dye penetration: Specimens were dried and immersed in bath of 2% methylene blue solution for 48 hours. Later they were removed from the solution, wiped clean and stored in distil water at 37°C for 1 week until the evaluation of microleakage was done.

Sectioning of the samples: Each of the specimens were sectioned at the centre of the bucco-lingual dimension, with a low speed metal cutting disc and water spray (Fig. 1).

Testing the specimens: Depth of maximum dye penetration through the margins and axial walls was evaluated under stereomicroscope (SZM-45N Zoom Stereo Microscope) at 40X magnification (Fig 2 & 3). For each tooth specimen, the most severe degree of dye penetration observed was recorded (Table-1).

Statistics

The data from all the groups were evaluated using Chi square test using SPSS software (SPSS 12.0;SPSS, INC,Chicago III).

Results:

It is showing that (Table. 3, Graph. 1) in Group A, 70% of the samples has a score of 0 and 30% has a score of 1. In Group B, 30% of the samples has a score of 0, 50% has a score of 1 and 20% has a score of 2. In Group C, 5% of the samples has a score of 0, 20% has a score of 1, 30% has a score of 2, 20% has a score of 3 and 25% has a score of 4. In total of 60 samples, 35% has a score of 0, 33.33% has a score of 1, 16.66% has a score of 3 and 8.33% has a score of 4. This implies that Group A has maximum value of 70% of score of 0. Group B has maximum value of 50% of score 1. Group C has maximum value of 30% of score 2. This shows that the result is statistically significant with the test value of 27.143 and p value of 0.00066789 (P<0.001).

Table.1- The scoring was done according to the following scale

Score	Criteria
0	No microleakage
1	Microleakage to 1/3rd of axial wall
2	Microleakage to 2/3rd of axial wall
3	Microleakage to full length of axial wall
4	Microleakage over the occlusal surface

Table 2- Shows the amount of microleakage through the margins to the axial walls of each tooth of all the groups

Specimen number	Group A	Group B	Group C
1	0	0	1
2	0	1	1
3	1	1	0
4	0	0	4
5	0	1	1
6	1	0	2
7	0	1	3
8	1	2	2
9	0	1	2
10	0	1	4
11	0	2	4
12	1	0	2
13	0	2	4
14	1	1	2
15	0	1	3
16	0	0	4
17	0	1	3
18	0	0	3
19	1	2	2
20	0	1	1

Graph. 1- Comparison between degree of dye penetration and number of teeth for the different groups

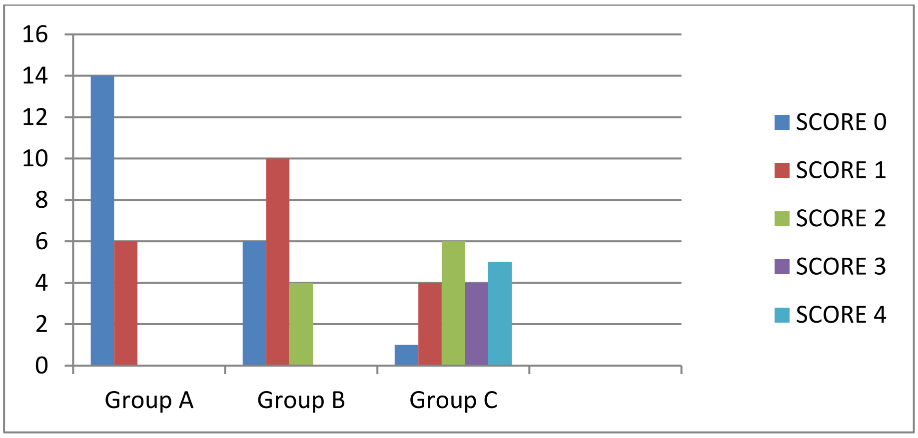

Table.3- Shows initial data using chi square test from comparison of degree of dye penetration of all the groups

Groups		**Degree of dye penetration**					**Total**
		0	**1**	**2**	**3**	**4**	
Group A	**Count**	**14**	**6**	**0**	**0**	**0**	**20**
	% within Group	**70**	**30**	**0**	**0**	**0**	**100**
Group B	**Count**	**6**	**10**	**4**	**0**	**0**	**20**
	% within Group	**30**	**50**	**20**	**0**	**0**	**100**
Group C	**Count**	**1**	**4**	**6**	**4**	**5**	**25**
	% within Group	**5**	**20**	**30**	**20**	**25**	**100**

Total	**Count**	**21**	**20**	**10**	**4**	**5**	**60**
	% within Group	**35**	**33.33**	**16.66**	**6.66**	**8.33**	**100**

Discussion-

Marginal misfit and microleakage are important causes of prosthesis failure.[14] Microleakage is affected by many factors such as poor marginal misfit, contraction of restorative or luting cement during setting, improper seating of the prosthesis to the underlying tooth, deformation under load and temperature induced volume changes.[15] McLean and Fraunhofer has quoted 120 μm as the maximum value for marginal misfit in a designed prosthesis.[3] Internal fit ranging between 50 and 100 μm is considered acceptable.[4] Microleakage leads to accumulation of oral microflora at the gaps, tooth hypersensitivity, secondary decay, periodontitis and eventual failure of the prosthesis. Thus fabrication of accurate prosthesis fabrication technique is a vital step in reducing the error in marginal misfit and occurrence of microleakage.

Thus the following study was undertaken to evaluate the amount of microleakage in the prosthesis fabricated using different techniques i.e., conventional casting (lost wax technique), milling (CAD-CAM) and direct metal laser sintering (DMLS). Here, Co-Cr alloy was used in coping fabrication. Advantages of Co-Cr alloy over Ni-Cr have been documented. They have better strength, corrosion resistance, less frequently associated with allergic reactions as compared to Ni-Cr alloys.[16,17]

Ringless casting technique was employed in this study. As compared to the conventional casting technique, it has proved to produce better fitting and ensured uniform expansion of the refractory mould by uniform setting and thermal expansion.[13]

Total of sixty copings were fabricated using three different techniques. Copings were cemented to the prepared teeth with Type -1 glass ionomer (Gold Label, GC) luting cement. The coping was seated on the tooth with digital pressure. Later a sustained load of 5kg was applied with a loading device for 10 min continuously. Applying only finger pressure for cementation might cause variability; therefore loading device was used for uniform pressure application.[18]

Various techniques have been proposed to assess the microleakage.[15] They are air pressure method, dye penetration, fluid conduction studies, electronic methods, microscopic examination. In the present study, the specimens were stored in immersed in bath of 2% methylene blue solution for 48 hours. The sectioned specimens were observed under stereomicroscope (SZM-45N Zoom Stereo Microscope) at 40X magnification. The results were statistically significant ($P<0.001$).

The copings fabricated using conventional casting technique (Group C) showed maximum microleakage. The reasons of less marginal accuracy in casting technique in this study might be due to many steps involved the coping fabrication leading to increased variables; which in turn causes discrepancies in the final prosthesis. Error can be produced at any phase like impression recording, cast preparation, wax pattern phase, casting phase.

Among Group B, in which copings were fabricated using CAD-CAM techniques, majority of specimens (50%) exhibited score of 1 and 20% exhibited score of 2. CAD-CAM technology eliminates the chances of errors by reducing number of steps in prosthesis fabrication. The CAD scanners have precision upto 20 μm. During the CAD process of the framework, drill compensation is activated routinely. Milling burs require to be changed periodically as they are cutting hard alloys like Co-Cr.[19]

Group A in which copings fabricated using laser sintering technique showed least amount of microleakage with 70% specimens exhibiting the score of 1. This group specimen had shown least amount microleakage. The results were in correlation with the study done by Curie Colaco et al.[20] The recent technological advances have come up with much promising results. Direct metal laser sintering is one such example. It has proved to fabricate accurate prosthesis, its ease of use, and has improved electromechanical characteristics. Many studies[12,20] also has mentioned improved marginal adaptation when prosthesis were fabricated using this technique. Thus, the rapid development of digitised processes needs to be continued, making this computerised technique more cost effective and flexible with better accuracy and precision.

Conclusion:

Within the limitations of study, following conclusions were made.

1. The different crown fabrication techniques have a significant difference ($P<0.001$) between the amount of microleakage.

2. The copings fabricated using laser metal sintering (Group A) shown least amount of microleakage.
3. The copings fabricated using CAD-CAM (group B) exhibited less microleakage when compared to conventional casting technique (GroupB) but more than the copings fabricated by laser metal sintering.
4. The copings fabricated using conventional casting technique showed highest amount of microleakage.

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