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Original article

Marginal fit and microleakage of cast and metal laser sintered copings—An in vitro study

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ABSTRACT

Purpose: This study aimed to compare the marginal fit and microleakage of metal laser sintered Co–Cr alloy copings and conventional cast Ni–Cr alloy copings using a stereomicroscope.

Methods: Forty extracted maxillary premolars were randomly divided into two groups. One group was subjected to coping fabrication using conventional lost wax (LW) technique while the other group was subjected to coping fabrication using metal laser sintering (MLS) technology. The marginal fit of these copings were compared before and after ceramic addition using images obtained with a steromicroscope and an ImageJ analysis software. All the specimens were cemented using Type 1 glass ionomer cement and were subjected to thermocycling. The specimens were evaluated for microleakage using stereomicroscope and 2% methylene blue die used as a tracer. The data were subjected to statistical analysis using paired *t*-test, Mann–Whitney test and Chi-Square test.

Results: The mean marginal fit of copings before and after ceramic addition in Group B (MLS) was better than the copings in Group A (LW) and was statistically significant ($P < 0.05$). The influence of ceramic firing had a significant ($P < 0.05$) increase in mean marginal gap in Group A (LW) but not in Group B (MLS). And the difference in mean microleakage between the groups was not statistically significant ($P \geq 0.05$).

Conclusion: The copings fabricated using MLS technique had a better marginal fit and an observable decrease in microleakage when compared to the copings fabricated using the conventional lost wax (LW) technique.

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1. Introduction

Today a vast majority of restorative procedures in fixed prosthodontics are by metal ceramic restorations [1]. The greatest disadvantage of the metal ceramic restoration is indicated to be the marginal fit associated with metal casting and firing porcelain onto it. Deterioration of the initial fit of the metal coping has been observed after the porcelain firing cycle. Studies on marginal distortion have identified many factors, such as the mismatch of porcelain-metal thermal contraction, alloy type and margin design, as contributing to the distortion. Considerable controversy still exists with regards to the influence of ceramic firing on the marginal fit of metal ceramic crowns [2].

A paradigm shift in the procedure for fabricating the metal coping onto which the porcelain can be fired, has come into vogue with the introduction of metal laser sintering (MLS) technology. This metal laser-sintering (MLS) system is an additive metal fabrication technology, based on information received from three dimensional CAD, in which metal powder is shot selectively using a data file and fused with a laser to laminate approximately a 20–60 μm thick layer with each shooting to complete a metal structure. Advantages of the MLS system include the ease with which it can be fabricated and eliminating a major disadvantage of the lost wax technique, i.e., the casting shrinkage [3]. Other advantages include easy fabrication of complicated shapes, operation of an automatic system, and short working time due to elimination of the procedures of fabricating a wax pattern, investing, burning, and casting works. While an essential condition for a successful dental prosthesis is good marginal fit and least microleakage [4], there is little data on the marginal fit and microleakage of fixed dental prostheses (FDPs) fabricated by the MLS system as compared to the conventional casting procedures [5]. Hence the purpose of this study was to compare the marginal fit and microleakage between the copings fabricated using conventional lost wax technique and metal laser sintering technology.

2. Materials and methods

2.1. Specimen preparation and die fabrication

Forty extracted, non-carious permanent maxillary premolars were randomly divided into two groups Group A and Group B. All the premolar specimens were prepared to receive a full coverage metal–ceramic restoration with 1.5 mm functional cusp reduction, 1 mm non-functional cusp reduction, 1.2 mm overall axial wall reduction and 1 mm heavy chamfer finish line.

All the specimens were mounted in dental plaster in the shape of a horse-shoe, mimicking a dental arch with ten samples in each arch. Four such arches were obtained to facilitate making impressions similar to an intra-oral impression. Each of these arches was pressed with a 1 mm thick soft vacuum formed sheet which provided the space for the light body consistency addition silicone (Aquasil ultra). The pressed vacuum formed sheet was cut to confine only the arch. Four stops were cut in between the samples and the vacuum formed sheet acted as a spacer for making a two stage putty wash impression. A definitive impression was carried out using a two stage putty wash impression technique [6]. The impression was casted with Type 4 die stone (Kalrock, Kalabhai) and the dies were fabricated. Potable water [7] was used as the storage media for the specimens during the period of study.

2.2. Fabrication of copings

The dies of Group A specimens were coated with two layers of die spacer (DVA Diespacer blue) corresponding to 30 μm [8]. A layer of vaseline was applied over the die models and pattern resin (GC America) was used to fabricate patterns for copings. The thicknesses of the patterns were randomly checked at multiple points using a metal gauge and were kept at a uniform thickness of 0.4 mm The finished resin patterns of the copings of Group A were invested and casted using conventional lost wax (LW) technique with Ni–Cr alloy pellets.

The copings for Group B specimens were fabricated using metal laser sintering (MLS) technology (EOS M270). EOS has developed a biocompatible cobalt chrome alloy especially for dental prostheses. It is a cobalt chrome molybdenum-based superalloy designed specifically for porcelain fused to metal (PFM) restorations. The material is available in powder form and has a coefficient of thermal expansion of $14.0–14.5 \times 10^{-6}$ m/m °C and thus provides optimum adhesion of commercial ceramics. The metal laser sintered copings were fabricated using this Co–Cr alloy with the thickness of the coping kept a constant of 0.4 mm with an internal relief of 30 μm, a space for the luting cement. All these necessary data were fed to the software (EOS RP tools) for selective laser sintering. Once the parameters were set a constant, all the die specimens were scanned using the 3D scanner (Scanner 3Shape) and the CAD design of the coping was obtained as an STL data. This data was then used in EOS RP tools software for fabrication of copings using laser sintering technology by vertical stacking of the alloy powder with each increment of layer 20–60 μm thick.

2.3. Assessment of marginal fit

The obtained copings of the specimens in Groups A and B were transferred onto their respective tooth specimen and analyzed for marginal fit using pictures obtained from a Nikon digital camera mounted to a stereomicroscope [9] (Olympus CHi20) set at 40× magnification and the measurements were calculated (in μm) using ImageJ analysis software. Four images were captured for each specimen which includes four sides of the specimen namely buccal, lingual, mesial and distal.

The ImageJ analysis software was first calibrated (Fig. 1) to micrometer scale and the obtained images were analyzed for the marginal fit by marking the distance from the tooth margin to the coping margin. Each sample had four values one from each side of the specimen namely, mid-buccal, mid-lingual, mid-mesial and mid-distal [10]. The values were recorded at the near mid-point of the specimen on each side. This was standardized as the image magnification was same, grids were