Research Article

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Comparative Evaluation of Internal Fit of Co-Cr Metal Copings Fabricated Using Traditional Casting Techniques and Metal Laser Sintering: An In Vitro Study

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ABSTRACT

Background: The purpose of the study is to determine the amount of internal fit produced by Co-Cr copings fabricated using two different fabrication methods i.e. traditional casting & direct metal laser sintering and compare the values obtained between each fabrication technique and to evaluate if the fabrication technique can produce prosthesis that is within the standards of clinical acceptance of internal fit.

Materials and Methods: 20 metal copings each were fabricated by laser sintering & traditional casting method. The crowns obtained were then cemented on their dedicated working dies using Glass ionomer cement. Internal fit at the buccal, lingual, mesial, and distal areas was measured after the crowns were sectioned longitudinally. Optical microscope was used to measure the internal fit between the working die and the copings. Statistical analysis was done using t-test using Open-epi calculator software.

Results: The values indicate that the marginal gap was less for the copings fabricated using Co-Cr alloy crowns that were fabricated with direct metal laser sintered technique than Co-Cr alloy crowns fabricated with conventional casting technique.

Conclusion: The internal fit of Co-Cr alloy crowns fabricated with laser sintered technique was better than Co-Cr alloy crowns fabricated with conventional casting technique

Keywords: Direct metal laser sintering, conventional casting, internal fit.

INTRODUCTION

In the recent times, restorative dentistry has witnessed a sea of change which may be attributed to the advances in biomaterial science and technology. Fabrication techniques, that have been developed recently like computer aided milling and selective laser sintering, are also gaining popularity amongst commercial laboratories. However, in spite of these technological advances, the lost wax technique still remains the most widely used technique for fabrication of metal castings. The accuracy of fit of the casting is dependent on multiple factors starting from impression procedures till the final finishing of the prosthesis.[1,2] Amongst all the factors, marginal accuracy and

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internal fit of pattern plays an important role in influencing the fit of cast restoration. The purpose of this study is to evaluate and compare the internal fit of the conventionally cast Co-Cr alloy crowns with laser-sintered Co-Cr alloy crowns using Stereomicroscope and Optical Microscope and to assess the efficacy of these techniques to fabricate the crowns for fixed restorations.

MATERIALS & METHOD

For the study a standardized stainless steel die with cervical diameter of 13mm, 1.5mm cervical margin, 5 degree of uniform taper and height of 12mm was made with two retentive grooves (1mm depth) extending 2mm short of finish line. (Fig 1 a)

Fig 1(a): Master Die.

A total of 40 specimens were prepared. The specimens were divided into two categories as follows: (n=20)

Group I- 20 Co-Cr crown specimens fabricated by conventional casting technique.

Group II- 20 Co-Cr crown specimens fabricated by direct metal laser sintering technique.

A metal impression tube with inner diameter of 19 mm and 6 mm relief over the master die was fabricated for making impressions of the master die with polyvinyl siloxane impression material with a two step putty wash technique. (Fig. 1b)

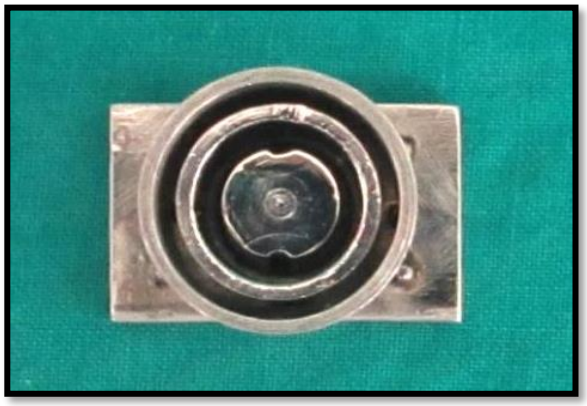


Fig 1 (b): Master Die with Impression Sleeve and Pattern Sleeve.

Fig 2: Impressions of Stainless Steel Master Die in Elastomeric Impression Material

The impressions were poured in high strength dental stone (Type IV). Group I specimens were obtained using conventional casting technique while for Group II the dies were scanned using optical scanner (3M Lava scan ST) to obtain a 3D model of the die on the computer. The machine then built units by addition technique (Selective Laser Sintering), where each layer of 20 µ Co-Cr powder (Bego) was used to build the crowns.

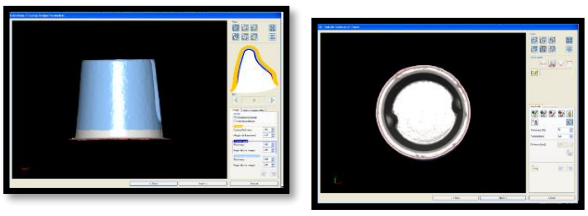


Fig 3: Measurements were calculated using Software.

To measure the internal fit each Co-Cr crown obtained from conventional casting procedure as well as metal laser sintering procedure was seated on its respective working stone die cemented with

GIC and subjected to constant load of 2 kgs for 10 min.(Fig. 4) The dies were then embedded in autopolymerising acrylic resin for sectioning. The embedded crowns were then sectioned longitudinally using a slow speed diamond cutting saw with a coolant to prevent distortion of metal during sectioning. (Fig. 5)

Fig 4: Crown Cemented on Die.

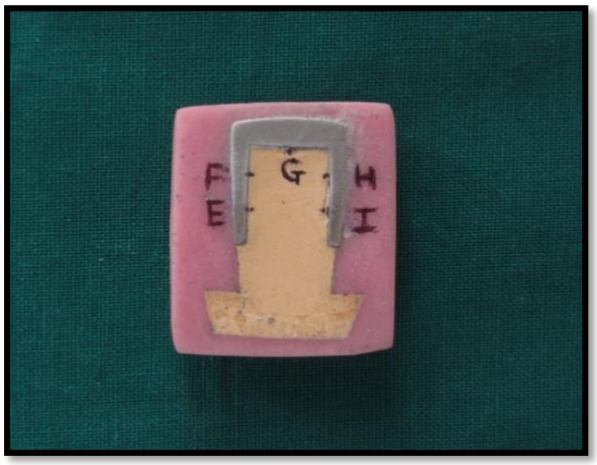


Fig 5: Sectioned Die.

The discrepancy between the crowns and the die was measured in microns at 5 different locations E, F, G, H and I along the entire surface. The mean was calculated. Measurements were done with the help of the software (Fig.3).

RESULTS

Figure 6 & Figure 7 shows optical microscopic images of the internal fit of Group I and Group II samples respectively.

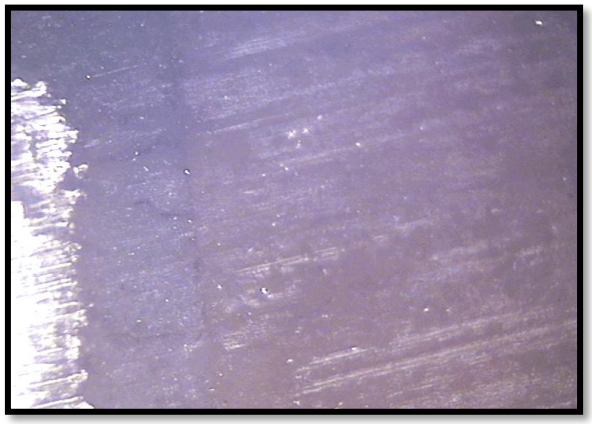


Fig 6: Optical microscopic image of Group I crown.

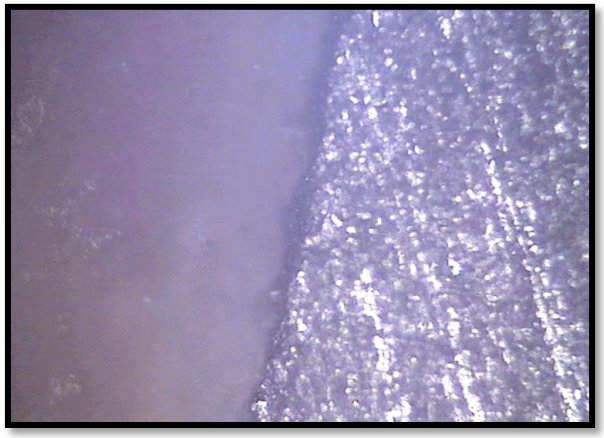
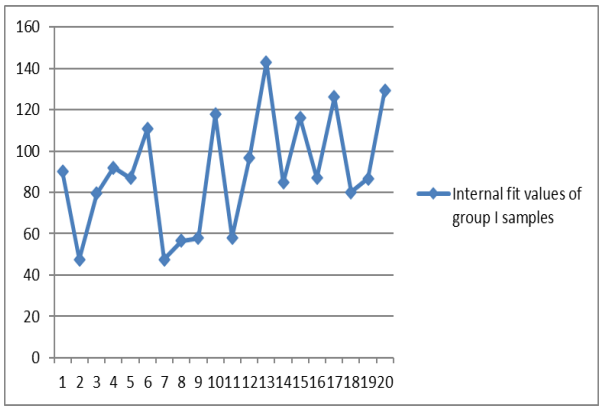
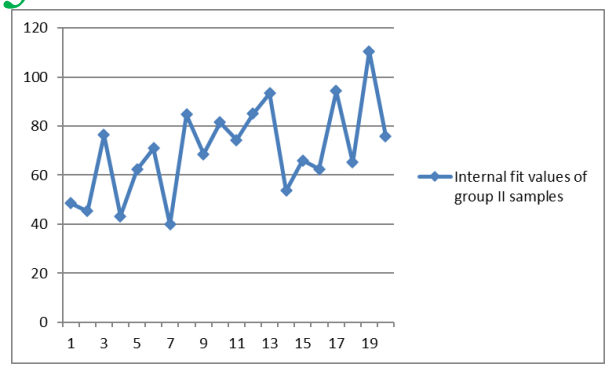


Fig 7: Opticalmicroscopic image of Group II Crown.

Graph 1 and Graph 2 shows internal gap values (in µm) of Group I and Group II samples respectively at points E, F, G, H and I.



Graph 1: Internal gap values of Conventionally Casted Co-Cr alloy crowns (Group I) (in µm).



Graph 2: Internal gap values of Laser-Sintered Co-Cr alloy crowns (Group II) (in µm).

The differences in the mean of marginal gap values of two groups were analysed by t-test using Open-epi calculator software.[3] P value of less than 0.05 was considered as statistically significant. The mean internal gap value of Group I was found to be 89.71 µm with a standard deviation of 27.76 while that of Group II was found to be 70.12 µm with a standard deviation of 18.59. The statistical comparison of marginal discrepancy of Group I and Group II showed statistically significant difference. ($p<0.05$).

The result of the study showed that the Co-Cr alloy crowns fabricated with laser sintering technique (Group II) showed less mean internal gap value of 70.12 µm as compared to the Co-Cr alloy crowns fabricated with conventional casting technique (Group I) which showed mean internal gap value of 89.71 µm, which indicates that the laser sintered crowns showed better fit as compared to conventionally casted crowns.

DISCUSSION

To achieve a clinically acceptable result for fixed dental prostheses (FDPs) the fit of the construction is one important requisite for a good long-term prognosis. An improperly adapted margin of the metal casting causes plaque retention leading to periodontal diseases and secondary caries.[4] A study performed by Foster[5] on 142 failed FDPs concluded that one important reason for this technical complication was an unacceptable fit. An unacceptable gap could result in cement washout with subsequent biological complications such as secondary caries, periodontal problems and pulpitis.[6] Many studies have been done to improve the fit of the cast restoration. Multiple protocols to minimize errors and yield best internal and marginal fit of the cast restoration also had been suggested.[7-14]

The mean value of internal gap of conventionally casted Co-Cr alloy crowns (Group I) was found to be 89.71 µm, and for laser sintered Co-Cr alloy crowns (Group II) was found to be 70.12 µm. There was statistically significant difference between group I and group II ($p< 0.05$), which means that, the internal fit of the castings obtained from laser sintering technique was superior as compared with those obtained from conventional casting technique.

The reduced number of steps of DMLS may contribute to explaining those findings.[15-16] Although the superiority of metal laser sintering technique over conventional is very clear from above, still it is worth discussing the potential limitations of this study. Firstly, the stone dies were prepared using polyvinyl siloxane impression material and a die stone by two step putty wash technique. Therefore, the resultant marginal discrepancy and fit is also due to polymerization shrinkage of the impression material and setting expansion of the die stone. Secondly, incorporation of errors during scanning of the die cannot be overlooked. More detailed analysis with larger sample size needs to be done. Lastly the results of this study are based on an in vitro evaluation and hence further clinical studies are required to substantiate the results.

CONCLUSION

Within the limitations of this study, the following conclusions were drawn:

1. The mean internal gap value of Co-Cr alloy crowns fabricated with conventional casting technique was found to be 89.71 µm.
2. The mean internal gap value of Co-Cr alloy crowns fabricated with laser sintered technique was found to be 70.12 µm.
3. The internal fit of Co-Cr alloy crowns fabricated with laser sintered technique was better than Co-Cr alloy crowns fabricated with conventional casting technique.

CONFLICTS OF INTEREST

The authors declare they have no potential conflict of interests regarding this article.

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