Research Article

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An Evaluation and Comparison of Marginal Accuracy of Conventionally Cast Co-Cr Alloy Crowns with Laser Sintered Co-Cr Alloy Crowns: An In Vitro Study

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ABSTRACT

Background: The purpose of the study is to assess the marginal accuracy of the copings fabricated by computer-aided milling and direct metal laser sintering (DMLS) systems in comparison to casting method and to evaluate if the fabrication technique can produce prosthesis that is within the standards of clinical acceptance of marginal discrepancy.

Materials and Methods: 20 metal copings each (n=40) were fabricated by laser sintering & traditional casting method. Marginal gap at the buccal, lingual, mesial, and distal areas was measured. Evaluation was done using silicone replica technique. To measure the marginal discrepancy between the working die and the copings, stereomicroscope microscope were used. Statistical analysis was done using t-test using Open-epi calculator software.

Results: The results showed significant difference in the marginal accuracy of Co-Cr metal copings fabricated using the two different techniques. The values indicated that the marginal gap was less for the copings fabricated using Co-Cr alloy crowns fabricated with direct metal laser sintered technique than Co-Cr alloy crowns fabricated with conventional casting technique.

Keywords: Direct metal laser sintering, Conventional casting, Marginal fit, Marginal accuracy.

INTRODUCTION

Computer-aided design and computer-aided manufacturing (CAD/CAM) dentistry has evolved dramatically in the past few decades. Most recently, numerous CAD/CAM systems with broad capabilities that range from fabrication of fixed restorations, cast partial dentures and orthodontic appliances have become widely available for clinicians and dental 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] Amongst all the factors, marginal accuracy plays an important role in influencing the fit of cast restoration. The purpose of this study was to evaluate and compare the marginal accuracy of the conventionally cast Co-Cr alloy crowns with laser-sintered Co-Cr alloy crowns using stereomicroscope

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microscope and to assess the efficacy of these techniques to fabricate the crowns for fixed restorations.

MATERIALS & METHOD

For the study a customized stainless steel master diewith cervical diameter of 8 mm, 1.5mm cervical margin, 6 degree of uniform taper and height of 10 mm was made with two anti-rotational grooves. (1mm depth) (Fig 1 a)

Fig. 1(a): Customized Master Die.

A total of 40 specimens were prepared. The specimens were divided into two categories as follows:

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)

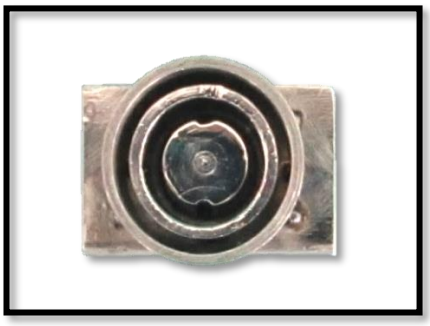


Fig. 1 (b):Master Die with Impression Sleeve and Pattern Sleeve.

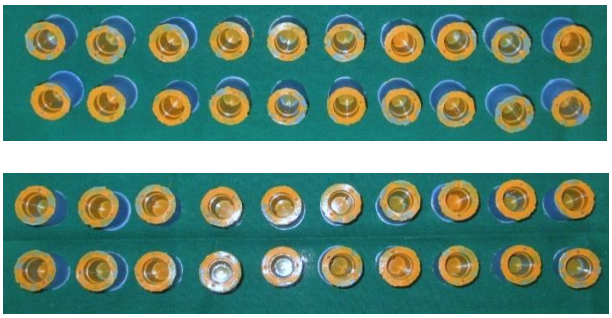


Fig. 2a,2b: Impressions of Stainless Steel Master Die in Elastomeric Impression Material.

The impressions were poured in high strength dental stone (Type IV) to obtain working models. Group I (20 specimens) were obtained using conventional casting technique while for Group II(20 specimens) 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 additive technique (Selective Laser Sintering), where each layer of 20 µ Co-Cr powder (Bego) was used to build the crowns. (Fig 3)

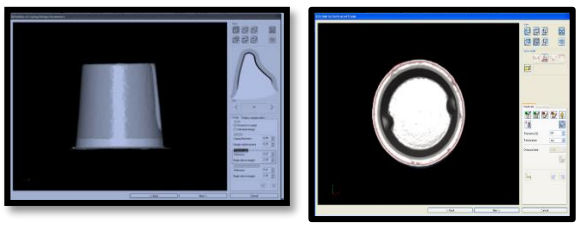


Fig 3: Co-Cr crowns fabricated using addition technique (Selective Laser Sintering). (3M Lava Scan ST)

To measure the marginal discrepancy each Co-Cr crown obtained from conventional casting procedure as well as metal laser sintering procedure were seated on its respective working stone die and subjected to constant load of 2 kgs for 10 min. The marginal discrepancy between the working die and the copings were then measured with Stereomicroscope (LEICA DMLM with Watec WAT 2020 Digital Camera, Japan)at magnification of 40 X. Four pre-marked points A, B, C and D on working die were taken for measurement of marginal discrepancy. Measurements were done with the help of the software. Marginal discrepancy as per the definitions provided by Holmes et al [2] is the marginal gap i.e. perpendicular gap from external surface of the casting to the outer wall of the preparation. This study measured a

perpendicular gap at 90 degrees representing the marginal gap.

RESULTS

Figure 4 & Figure 5 show stereomicroscopic images of the marginal discrepancy of Group I and Group II samples respectively.

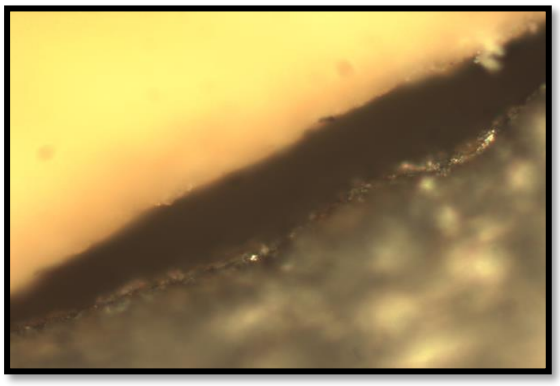


Fig 4: Stereomicroscopic image of Group I crown.

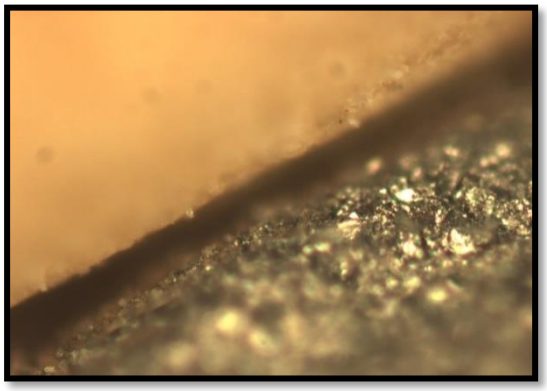
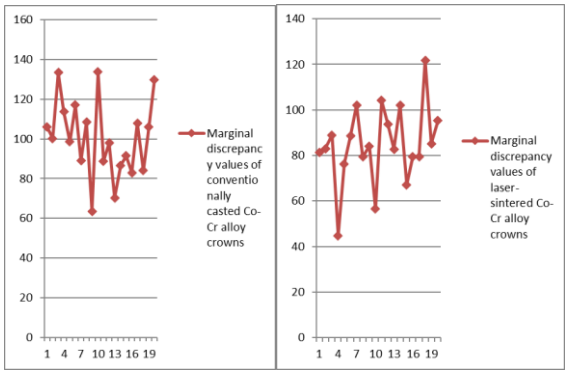


Fig 5: Stereomicroscopic image of Group II crown.

Graph 1 and Graph 2: Show the marginal discrepancy values (in µm) of Group I and Group II samples respectively in quadrant A, B, C and D.



The differences in the mean of marginal gap values of two groups were analysed by t-test using Open-epi calculator software.P value of less than 0.05 was considered as statistically significant. The mean marginal discrepancy of Group I was found to be 100.46 µm with a standard deviation of 19 while that of Group II was found to be 84.82 µm with a standard deviation of 16.94. 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 Co-Cr alloy crowns fabricated with laser sintering technique (Group II) had less mean marginal discrepancy as compared to the Co-Cr alloy crowns fabricated with conventional casting technique (Group I), which indicates that the marginal accuracy of Co-Cr alloy crowns fabricated with laser sintering technique (Group II) was significantly higher than Co-Cr alloy crowns fabricated with conventional casting technique (Group I).

DISCUSSION

To achieve a clinically acceptable result for fixed dental prostheses (FDPs), accurate fit of the construction is one important requisite for a good long-term prognosis. The use of the conventional method of crown fabrication has been used for decades with proven long-term results for both longevity and survival. Careful selection of materials and meticulous fabrication procedures are necessary to compensate for expansions and contractions of the different materials involved to create an accurately fitting crown. However, the impossibility of controlling all the variables, combined with a propensity for human error, can result in poor marginal fit and even misfit. [4,5]Margin inaccuracy could lead to the accumulation of dental plaque, the dissolution of luting material, and/or the inflammation of the periodontium. The marginal fit of cemented restorations ranges from 25 to 40 mm, with some researchers suggesting that a marginal opening of 120 mm is clinically acceptable.[2,3]A study performed by Foster[6] on 142 failed FDPs concluded thatone important reason for this technical complication was anunacceptable fit. An unacceptable marginal gap could resultin cement washout with subsequent biological complications such as secondary caries, periodontal problems and pulpitis.[7]Many studies have been done to improve the fit of the cast restoration. Multiple protocols to minimize errors and yield best

marginal fit of the cast restoration also had been suggested.

Laurent et al. [8] showed that in vitro studies present better quality of fit in a controlled laboratory environment with optimal circumstances, than in a clinical setting. However, the production procedures for dental restorations in the dental laboratory do affect the fit of the restoration. The main clinical and laboratory variables are impression making, master cast fabrication, die spacing, fitting procedures and cementation. Accordingly, future CAD/CAM techniques could minimise some of these risk factors proven in the DLMS group were few critical manual steps are present.

The mean marginal discrepancy of conventionally casted Co-Cr alloy crowns (Group I) was found to be 100.46 µm, and for Iaser sintered Co-Cr alloy crowns (Group II) was found to be 84.82 µm. There was statistically significant difference between group I and group II ($p< 0.05$). In other words, the marginal accuracy of the castings obtained from laser sintering technique was significantly higher as compared with those obtained from conventional casting technique.

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. These advancements and the rapid development of digitalization in dentistry will continue, making this computerised technique more cost effective and flexible with better accuracy and precision. Initially a new technique is often costly, which is a potential limitation. More research is needed to develop the digitised technique and improve its efficiency, usefulness and application in day-to-day practise.[9]

CONCLUSION

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

1. The mean marginal discrepancy of Co-Cr alloy crowns fabricated with conventional casting technique was found to be 100.46 µm.
2. The mean marginal discrepancy of Co-Cr alloy crowns fabricated with laser sintered technique was found to be 84.82 µm.
3. The marginal accuracy of Co-Cr alloy crowns fabricated with laser sintered technique was significantly higher 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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