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Original Article

Comparative Evaluation of the Marginal Fit of Conventional and Direct Metal Laser Sintered Metal Crowns: An *In-vitro* Study

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Abstract

Introduction: The advent of computer aided designing/computer aided manufacturing and 3D printing has reduced human error and simplified the process of fabricating prosthesis by the conventional approach. However, the conventional technique of crown fabrication still remains in use due to the high cost of production of 3D printed crowns. Marginal integrity is an important factor that determines the longevity of the prosthesis. Hence, the aim of the present study was to compare the marginal gap formation in conventionally fabricated and 3D printed metal crowns.

Materials and Methods: Forty stone dies with standard dimensions were equally divided into two groups for fabrication of crowns using two different techniques. Group A consisted of crowns fabricated by the laser sintering technique and Group B consisted of crowns fabricated using the conventional lost wax technique. The fabricated crowns were seated onto the die and then dissected vertically in buccolingual direction followed by which the distance between the external marginal line and the most extended point of the crown was measured and noted as the marginal gap. Inter group comparison was done using the *t*-test.

Results: The marginal gap overserved in the conventionally fabricated crowns was significantly higher (105.95 μm) than the marginal gap observed in the laser metal sintered crowns (102.0 μm) ($P < 0.00$).

Conclusion: Within the limitations of the present study, it can be concluded that both the techniques give crowns with clinically acceptable marginal fit. However, crowns fabricated by metal laser sintering have a superior marginal adaptation than those fabricated using the conventional lost wax technique.

Key words: 3D printing, Direct metal laser sintering, Lost wax technique, Marginal gap

INTRODUCTION

It was Charles Hull, in 1986, who was the first to develop a 3D printer based on the technology of stereolithography.[1,2] Since then, 3D printers have gained significant popularity. Over a period of time, computer-aided-design (CAD)/computer-aided-manufacturing (CAM) systems and 3D printers have come to replace the traditional approach in prosthetic dentistry. The conventional approach of fabricating a metal substructure is the lost wax technique. With the advent of CAD/CAM, human errors decreased, processes were simplified, and production rates increased. The CAD/CAM approach is based on subtractive manufacturing technique which involves milling an object from a block or a disc based on the input design. However, the size of the milling tool and its applied angle limits the fabrication of more complex shapes. Further, the loss of material using the subtractive technique can reach up to 90%.[1,3] Every prosthesis is unique to that patient and its construction requires replication of convoluted geometry to a high level of precision. This is achieved by 3D printers which are based on additive technique where an object is formed by adding one layer at a time.[4] The object to be printed needs to be in an standard tessellation language file format. 3D printing requires either a virtually designed object on CAD software, volumetric data from cone beam computed tomography scans, or data from digital intraoral or laboratory surface scans.[4] In simple terms, the process

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can be described as follows: The dentist creates a digital dataset on the computer (CAD) and then designs a 3D object; the data of the 3D object are then transferred to the milling machine or a 3D printer, which creates a physical object from these data. In dentistry, 3D printing has been used for surgical planning, creating working models, fabrication of crowns, bridges, complete and partial dentures, manufacturing surgical implants, occlusal splints, surgical guides, and three-dimensional custom printed trays.[1,2] Fabricating dental prosthesis is a daily task for dentists. The key to a successful dental prosthesis is its dimensional accuracy and marginal fit as well as a smooth surface with good reproduction of the surface details. Due to the high cost of production of 3D printed dental prosthesis, the conventional technique still remains in use. Hence, the aim of the present study was to compare the marginal fit of conventional and direct metal laser sintered (DMLS) crowns.

MATERIALS AND METHODS

Standardization and Fabrication of Samples

To prepare the master model, a mandibular first right molar ivorine tooth was selected and it was mounted in acrylic resin cold cure. The tooth was prepared with an occlusal reduction of 1 mm and a chamfer finish line of 0.5 mm.

An impression of the prepared tooth was made using the one step elastomeric technique which was then poured using die stone. This procedure was repeated 40 times to obtain forty stone dies with standard dimensions which were then equally divided into two groups for fabrication of crowns using two different techniques. Group A consisted of crowns fabricated by the laser sintering technique and Group B consisted of crowns fabricated using the conventional lost wax technique. To standardize the wax patterns for Group B, first a digital impression of the stone die was obtained and a wax pattern of thickness 0.5 mm was designed using CAD software (ExoCad) on a separate stone die which was poured from the impression of the master model. This was 3D printed in pattern resin over which a putty index was made and this index was used as a guide to standardize the wax pattern of Group B which were fabricated using inlay wax. The patterns were immediately invested to avoid any distortion and were casted in Cobalt-Chromium (Co-Cr) alloy. The CAD-designed data were used to fabricate 20 laser sintered crowns for group A. A film of Co-Cr alloy powder was laid down by the machine and was then sintered at 1500°C to a thickness of 20 micrometer. This process was continued layer by layer till the entire crown structure was fabricated from the occlusal surface to the margins.

Sectioning of Samples and Measurement of Marginal Gap

The fabricated crowns were seated on the die and then mounted onto the platform of a water jet cutter which sectioned the prepared tooth and crown buccolingually in a vertical direction. A stereo microscope was used to observe the marginal gap. The distance between the external marginal line and the most extended point of the crown was measured which was noted as the marginal gap.

Statistical Analysis

Data obtained were compiled on a MS Office Excel Sheet (v 2019, Microsoft Redmond Campus, Redmond, Washington, United States) and subjected to statistical analysis using Statistical Package for the Social Sciences (SPSS v 26.0, IBM). Mean and standard deviation were obtained for numerical data. Normality of numerical data was checked using Shapiro–Wilk test and was found that the data followed a normal curve; hence, parametric test was used for comparison. Intergroup comparison was done using the t test. For all the statistical tests, $P < 0.05$ was considered to be statistically significant, keeping α error at 5% and β error at 20%, thus giving a power to the study as 80%.

RESULTS

The mean marginal gap observed in metal laser sintered crowns was 102.0 μm which was significantly lower than the mean marginal gap observed in conventionally fabricated crowns which was 105.95 μm. *P*-value of *t*-test was <0.01 which signifies a statistically highly significant difference [Table 1].

DISCUSSION

The traditional technique for fabricating the metal crowns and copings is the lost-wax technique using various metal alloys for casting.[5] It is technique sensitive and time consuming. This technique faces problems with making impressions in the oral cavity which may cause discomfort for patients and contraction of the material resulting in an inaccurate marginal fit or irregularities in the cast

Table 1: Intergroup comparison of the marginal gap observed in conventionally fabricated crowns and crowns fabricated by 3D printing

Group	*n*	Mean	Std. Deviation	Std. Error Mean	*P*-value of *t*-test
DMLS Technique	20	102.20	1.673	0.374	0.000**
Conventional Technique	20	105.95	2.305	0.515	

**A highly statistically significant difference between the groups (*P*>0.05) metal.[6] The conventional lost wax technique is limited by the skills of the operator, the manual process of waxing, and use of spacer to obtain a 50 micrometer thickness as well as the thickness of the wax. These factors can lead to distortion.[7] In an effort to overcome these limitations, CAD/CAM systems and 3D printers have been introduced. The digitalization in dentistry has many advantages such as reduction of material wastage and fabrication time.[8] Since 2011, 3D printing has enjoyed a worldwide wave of popularity, especially selective laser melting metal printing technology. The newly developed DMLS system is an additive metal fabrication technology. Based on information received from three-dimensional (3D) CAD and using a data file, metal powder is shot selectively and fused with a laser to laminate approximately a 20–60 μm thick layer with each shooting to complete a metal structure.[7,9] With the rapid development and integration of software and hardware technologies, CAD/CAM design and 3D printing technology have been used to fabricate high-quality crowns with greater accuracy in addition to facilitating crown design by clinicians.

A precise marginal fit is an important factor that determines the longevity and function of the restored tooth. A crown with poor marginal fit will lead to micro leakage and eventually failure of the restoration. The clinically accepted marginal gap distance varies among different studies. A marginal gap is said to be clinically acceptable for longevity if its mean values are in the range of 50–120 microns.[10] According to Fransson *et al.*, a marginal gap of <150 microns after cementation is clinically acceptable.[11]

The fit of the crowns prepared from both the techniques in the present study was in the clinically acceptable range. However, laser sintered crowns had a superior marginal fit compared to conventionally fabricated crowns. Previously, studies have compared the internal fit of copings and crowns fabricated using the conventional technique and 3D printed technique. Ucar *et al.* have previously reported an insignificant difference between the marginal gap of direct metal sintered systems and the conventional method.[12] In another study, Kim *et al.* observed the marginal fit of the DMLS system to be significantly inferior to that of the conventional lost-wax technique and slightly larger than the acceptable range.[13] Örtorp *et al.* have reported superior fit of the DMLS system compared to the conventional method.[7] However, the findings of the study should be interpreted in light of the possible study limitations. In the present study, the patterns were manufactured under ideal circumstances and controlled conditions which does not represent an actual clinical scenario.

CONCLUSION

Within the limitations of the present study, crowns fabricated by metal laser sintering have a superior marginal adaptation to those fabricated using the conventional lost wax technique. However, both the techniques gave crowns which had clinically acceptable marginal fit. Although 3D printing saves time and material, it is expensive and requires training. Thus, where 3D printing is not easily accessible and affordable, the conventional technique can continue to be the preferred choice of crown fabrication technique.

REFERENCES

1. Tian Y, Chen C, Xu X, Wang J, Hou X, Li K, *et al*. A review of 3D printing in dentistry: Technologies, affecting factors, and applications. Scanning 2021;2021:9950131.
2. Prasad S, Kader NA, Sujatha G, Raj T, Patil S. 3D printing in dentistry. J 3D Print Med 2018;2:89-91.
3. Recent trends of 3-D printing in dentistry a review. Ann Prosthod Restor Dent 2016;2:101-4.
4. Dawood A, Marti BM, Sauret-Jackson V, Darwood A. 3D printing in dentistry. Br Dent J 2015;219:521-9.
5. Hunt LB. The long history of lost wax casting. Gold Bull 1980;13:63-79.
6. Ullattuthodi S, Cherian K, Anandkumar R, Nambiar S. Marginal and internal fit of cobalt-chromium copings fabricated using the conventional and the direct metal laser sintering techniques: A comparative *in vitro* study. J Indian Prosthod Soc 2017;17:373.
7. Örtorp A, Jönsson D, Mouhsen A, Vult von Steyern P. The fit of cobalt-chromium three-unit fixed dental prostheses fabricated with four different techniques: A comparative *in vitro* study. Dent Mater 2011;27:356-63.
8. Miyazaki T, Hotta Y, Kunii J, Kuriyama S, Tamaki Y. A review of dental CAD/CAM: Current status and future perspectives from 20 years of experience. Dent Mater J 2009;28:44-56.
9. Barazanchi A, Li KC, Al-Amleh B, Lyons K, Waddell JN. Additive technology: Update on current materials and applications in dentistry. J Prosthod 2017;26:156-63.
10. Euán R, Figueras-Álvarez O, Cabratosa-Termes J, Brufau-de Barberà M, Gomes-Azevedo S. Comparison of the marginal adaptation of zirconium dioxide crowns in preparations with two different finish lines. J Prosthodont 2012;21:291-5.
11. Fransson B, Oilo G, Gjeitanger R. The fit of metal-ceramic crowns, a clinical study. Dent Mater 1985;1:197-9.
12. Ucar Y, Akova T, Akyil MS, Brantley WA. Internal fit evaluation of crowns prepared using a new dental crown fabrication technique: Laser-sintered Co-Cr crowns. J Prosthet Dent 2009;102:253-9.
13. Kim KB, Kim WC, Kim HY, Kim JH. An evaluation of marginal fit of three-unit fixed dental prostheses fabricated by direct metal laser sintering system. Dent Mater 2013;29:e91-6.

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