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Evaluation of Accuracy of Marginal Fit of Metal Crowns Fabricated By Conventional Casting Technique and CAD/CAM Milling –A Stereomicroscopic Study

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Abstract

Statement of problem: The recent application of direct metal milling for metallic crowns has not been compared and evaluated for margin discrepancy (margin fit) with restorations fabricated using milled wax pattern followed by conventional casting and hand-wax pattern followed by conventional casting.

Purpose: The purpose of this in vitro study was to evaluate and compare margin discrepancy of metal crowns fabricated from hand wax pattern, milled wax pattern, and direct metal milling from Co-Cr block.

Material and methods: Thirty crown were produced by each of 3 different methods: Direct metal milling from Co-Cr block via CAD/CAM, milled wax pattern via CAD/CAM followed by casting and hand waxed, then invested and cast into metal crowns. Each crown was evaluated at 6 positions around the margin on the corresponding Type Ⅳ die stone models under ×50 light microscopy to determine the mean and maximum margin discrepancy.

Results: Milled wax patterns and direct metal milling crowns were not statistically different from each other (P>.05), while crowns from hand wax patterns produced significantly higher mean and maximum margin discrepancy than milled wax patterns and direct metal milling. (P<.05).

Conclusions: Relative to margin discrepancy, Milled wax patterns and direct metal milling crowns were not significantly different from each other. The crowns from hand wax patterns were significantly different from milled wax patterns and direct metal milling crowns, with an overall poorer result. Fabricating metal crowns from CAD/CAM technology has proven to lesser marginal discrepancy as compared to manual methods.

Introduction

The accuracy of marginal fit of prosthetic restorations is valued as one of the most important criteria for the clinical quality and success of prosthetic restorations.. The overall acceptability of a cast restoration is best determined by the marginal adaptation as it is considered to be the most

important factor in prevention of secondary caries.[1] An absolutely closed margin cannot be obtained clinically, but it is practical to minimize the margin discrepancy to minimize leakage.[2] A 120µm margin discrepancy has been reported to be the limit for a clinically acceptable crown margin.[3]Any discrepancies in the marginal fit tend to expose the luting material to the oral environment, thus leading to cement dissolution and further microleakage [4] affecting the vitality of the pulp.

Metal crowns, although are not the preferred choice of restoration because of esthetic reasons but there are a lot of clinical situations like patients with bruxism, deep bite, lack of interocclusal space, last molars where the occlusal forces are heavy, teeth that exhibit extensive coronal destruction by caries or trauma where metal crowns are preferred over other restorations. [5]

The traditional technique for fabricating the metallic crown is the lost-wax technique and using various metal alloys for casting . However, the disadvantages associated with waxes are the highest coefficient of thermal expansion, and a tendency to warp or distort upon standing. To avoid distortion of wax, ideally wax patterns must be invested immediately after removal from the preparation. [6]

Dental interest in Co-Cr has increased due to its low price and different fabrication methods. [7] Two fabrication methods are primarily used with this new digitized technique, either by milling the frameworks from a block of Co-Cr or by using direct laser metal sintering.[8, 9]

Milling technique was introduced over 20 years ago as an alternative to hand waxed restorations.[10] Milling technology has increased the speed and volume of production and decreased operational costs. [11] Another advantage is the potential to enhance accuracy as they omit several fabrication steps used as waxing, investing and casting.[12] CAD/CAM features also provide the option of automatic margin detection and restoration design compared to manual waxing, making it the most sensible option to resort to wherever possible .

Metal milling is relatively new to dentistry. There have not been sufficient studies on the accuracy of the vertical marginal fit of milled metal Co-Cr crowns considering its indications in certain clinical situations. Therefore, in the present study the vertical marginal fit of milled metal Co-Cr crowns will be compared to the Co-Cr crowns fabricated by conventional casting technique using free hand wax pattern and milled wax pattern. The null hypothesis was that the marginal discrepancies of the metal crowns fabricated from hand wax patterns, milled wax patterns and milled metal blocks would not be statistically different.

Clinical Implications : Metal crowns fabricated from direct Co-Cr blocks have margin accuracy comparable with those fabricated from milled wax patterns, therefore metal crown fabrication from direct metal milling can replace the fabrication methods of hand wax patterns and milled wax patterns.

Materials And Methodology

A cobalt-chromium master die was fabricated by CAD/CAM to simulate a tooth prepared for full metal crown from a prototype of prepared tooth on a typhodont. The prepared tooth had taper of 6 degrees and a heavy chamfer finish line with occlusal reduction of 1.5 mm and axial reduction of 1 mm.

A stainless steel sectional custom impression tray was fabricated with two vertical stops on the adjacent teeth of prepared tooth maintaining a space of 2 – 2.5mm thickness for uniform thickness of impression making. Vinyl polysiloxane impression material was used and a single step dual mix technique was preferred. Thirty such type IV stone dies were prepared from 30 impressions. 10 models were used for hand wax pattern and conventional

casting. 10 models were used for milled wax pattern and conventional casting. 10 models were used for direct metal milling from Co-Cr block. The 30 models were divided into **Group 1 (hand wax pattern and conventional casting), Group 2 (milled wax pattern and conventional casting) and Group 3 (milled metal from Co-Cr)**

Figure 1 : Stainless Steel Master Die

An optical scanner captured the 10 working dies and then digitized the image to obtain the wax pattern for single unit crowns. Computer assisted designing (CAD) was done using STL(Stereolithography) format. The CAD/CAM wax patterns were produced with a milling machine using a laser scanner to digitize the dies. The data was transmitted to a software (EXOCAD) program in which the wax pattern were designed. The investing and casting technique were done similarly as for Conventional Casting Group, using the same investment material and casting alloy. Similarly, 10 working dies were scanned and designed followed by milling of Co-Cr alloy blocks for fabrication of metal crowns.

The specimens were evaluated under the Stereomicroscope (Olympus SZX7, Tokyo, Japan) at (X50) for the marginal fit between the crown and the finish line of each working die, at six reference points (Mesio-buccal, mid-buccal, disto-buccal, mesio-lingual, mid- lingual and disto-lingual). Two marks were made on the stainless steel master die at the mid buccal and mid lingual points to standardize the measuring points. The results from each reference point were recorded and tabulated. The average of six surfaces was calculated for each specimen. Finally, an overall average marginal fit was calculated for each test group. The collected data was then statistically analysed.

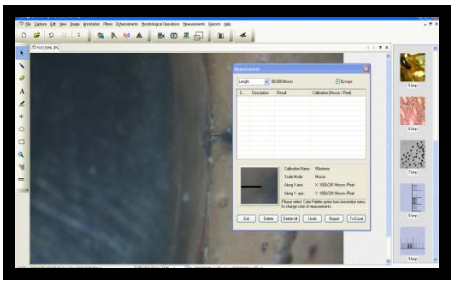


Figure 2 : evaluation of marginal fit of metal crowns by milled co-cr disc by stereomicroscope

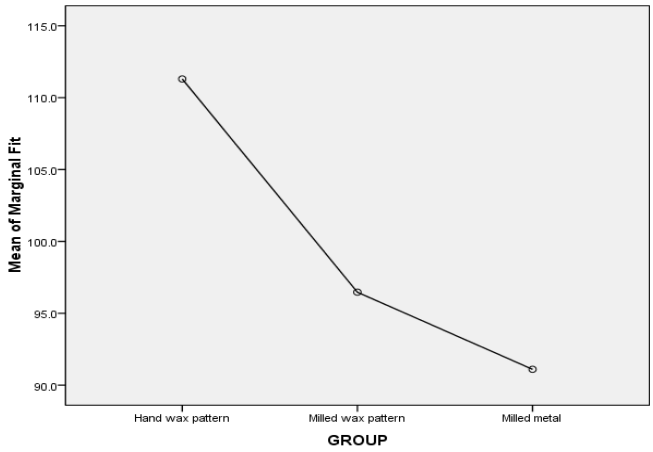
Result

Data was entered in the data collection form and entered into the computer software excel 2010 and analysed by using SPSS Statistical Software Version 16.0. Descriptive data that included mean, standard deviation was calculated for each group. The normality of the data was tested by Shapiro Wilks test and found normally distributed. The significance difference of marginal fit between the groups was tested by one way ANOVA, followed by Tukey HSD test. The level of significance and confidence interval were 5% and 95% respectively.

The mean marginal fit discrepancies of the crowns fabricated by hand wax pattern and conventional casting (Group 1) were 111.30±12.318 µm , crowns fabricated by milled wax pattern conventional casting (Group 2) were 96.47± 6.481 µm and crowns by milled metal from Co-Cr disc (Group 3) were 91.100± 3.897 µm respectively.

Graph 1 : Represents the plot between the Mean of marginal fit discrepancy of three groups viz hand wax pattern and conventional casting, milled wax pattern and conventional casting and milled metal from Co-Cr disc

which reveals **Group 3 showed the best fit followed by Group 2 and Group 1.**



Multiple comparison of Mean of Marginal fit discrepancy between the three groups of hand wax pattern and conventional casting, milled wax pattern and conventional casting and milled metal crowns from Co-Cr disc. (Inter group comparison) by Tukey HSD test revealed Group 2 (milled wax patterns) has a better marginal fit as compared to Group 1 (Hand wax pattern). However, the results revealed there was not much of a difference of marginal fit in the crowns fabricated from Group 2 (milling of wax pattern followed by conventional casting) and Group 3 (direct milling from Co-Cr block) whereas between Group 1 and Group 3 the samples showed a drastic difference of marginal fit proving Group 3 to be the most superior method of fabrication.

Discussion

The mean and maximum margin discrepancy for different techniques of fabrication of metal crowns were compared as to gain a perspective of which fabrication method has to be used in future. Here a significant difference was found between the crowns fabricated from hand wax pattern and milled wax patterns whereas a highly significant difference was found between the hand wax patterns and milled Co-Cr. Therefore, the null hypothesis was rejected.

Regarding the finish line of the preparation, Keyf concluded that there was no significant difference in the fit of crowns when either shoulder or chamfer finish lines were prepared.[13] Therefore, a heavy chamfer finish line was chosen for master die preparation in this study.

With the advancement in technology many authors worldwide were tempted to conduct comparative studies of marginal fit of copings and crowns between the conventional procedures and the CAD/CAM systems. The various studies had showed mixed results with few studies proving the newer technology of CAD/CAM to be superior over conventional methods in terms of marginal fit [14, 15, 16] whereas few studies proved the opposite [17,18,19]

The present study revealed the mean vertical marginal discrepancy of Group 1 : Free Hand Wax Pattern (111.30 ± 12.31µm) , Group 2 : Milled Wax Pattern (96.46 ± 6.48µm) and Group 3: Milled Co-Cr disc (91 ± 8.04µm).

The mean vertical marginal discrepancy between the Group 2 (Milled Wax Pattern) and Group 3 (Milled Co-Cr disc) were found to be non significant revealing that fabrications of metal crowns by milled wax pattern and conventional casting can be considered as an option for considering the relatively high cost of metal milling. However, the crowns fabricated by hand wax pattern and conventional casting showed significant difference in the mean vertical marginal discrepancy proving that the metal crowns fabricated from the CAD/CAM system yielded better results than the conventional method of crown fabrication using free hand wax patterrn

S Gunsoy et al [20] conducted a similar study comparing the marginal fit discrepancy of metal crowns following different fabrication techniques namely, Conventional lost wax method(CLW), milled wax with lost-wax method (MWLW), direct laser metal sintering (DLMS), and milled Co-Cr (MCo-Cr). Their results showed DLMS had the lowest value followed by MCoCr, MWLW, and CLW.

The values for MWLW, MCo-Cr, and DLMS were under the 100 µm which can be acceptable for a good marginal fit. Our results are consistent with their results as CAD/CAM milling (milled Co-Cr disc and milled wax pattern) yielded better marginal fit then conventional hand wax pattern..**Nesse et al** [21] in an study comparing the marginal and internal fit of Cobalt-Chromium fixed dental prosthesis by 3 fabrication techniques namely, conventional casting, CAD/CAM Milling and Selective laser melting concluded that the prosthesis fabricated with CAD/CAM Milling showed lowest marginal discrepancy followed by conventional casting and Selective laser melting which was in accordance with our study.

Recently, **Örtorp et al**[15] also conducted a similar study. They figured out the DLMS(Direct laser metal sintering) had the lowest mean value below 100 µm followed by MWLW(Milled wax lost wax), CLW(Conventional lost wax), and MCo-Cr(Milled Co-Cr) which was inconsistent with this study **Vojdani et al**[17] in an invitro study concluded that the marginal fit of CAD/CAM group was poorer as compared to conventional group. The values for conventional group were mere 69.54±15.60 as compared to 157±20.63. **Hao-Sheng Chang et al**[22] evaluated the marginal adaptation of Co-Cr-Mo metal crowns fabricated by traditional method and computer aided technologies. The mean marginal gap between the metal crowns of Group A(Conventional ,lost wax technique) ,B(Selective laser sintering method) , C (CAD/CAM Tcehnology) were 76±61µm , 116±92µm , and 121±98µm respectively. Thus, this study concluded that the conventional lost wax technique and conventional casting method had better marginal fit as compared to SLS and CAD/CAM technology.

The Milled Wax Pattern combines both old and new techniques. The larger distortion in Hand Wax Patterns could be attributed to the difficulty in standardizing the spacer as a result distortion is seen when the wax is removed from the cast. [23] In the Free hand wax pattern there are 5 positive negative transformations from the tooth to the crown in the form of impression making, the die, the wax pattern, the refractory investment mold and the metal cast.[17] Even with advanced techonology of CAD/CAM, there are chances of inaccuracies at the margins due to the transformation of the of the point clouds obtained in scanning area into a smooth, continuous surface. The reason for larger gaps are attributed to the fact that in structures smaller than the narrowest bur diameter, more internal substructure may be removed than necessary. Wear of the milling burs also have to be considered while milling Co-Cr blanks because using burs of reduced diameters due to wearing off could lead to marginal inaccuracies.[24]

The results in this in vitro study revealed that the newer technology i.e, CAD/CAM produced better metal crowns that had acceptable margins, and surpassed the fit of conventionally fabricated crowns.. The marginal fit also depends on the material used in fabrication of crowns so further studies can be done to check the marginal fit of zirconia crowns by the CAD/CAM.

This in- vitro study had some limitations namely**,**

- Since this was an in vitro study so the preparation used as a master die was ideal, with a smooth and well-defined finish line; which may not be the case in a clinical situation and could affect the margin discrepancy values of the metal crowns.
- Although the entire margin was surveyed, some areas (especially around the line angles) were difficult to see, and some large margin discrepancies may have been missed.
- Also in milled techniques, anatomic contours, and restoration design are dependent on the software

quality and on the operator's ability to use the program.

- This study only examined the vertical margial fit and internal fit was not measured.

Conclusion

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

1) Direct metal milling of Co-Cr disc showed a mean vertical marginal fit of 91 ± 8.04µm as compared to Milled Wax Pattern and conventional casting (96.46 ± 6.48µm) proving it to be a better alternative.
2) Direct metal milling of Co-Cr disc showed a mean vertical marginal fit of 91 ± 8.04µm as compared to hand wax pattern and conventional casting (111.30 ± 12.31µm) proving it to be much superior than the conventional technique.
3) Since, metal milling is a costlier mode of dental treatment , the use of CAD/CAM for fabricating crowns using milled wax pattern as compared to hand wax pattern have proved to be viable alternative.

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