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Evaluation and Comparison of Internal Fit of Cobalt-Chromium Copings Cast from Milled Wax and Milled PMMA Patterns Fabricated Using CAD/CAM Technology- an in Vitro Study.

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KEYWORDS

Milled Wax, Milled PMMA, Internal fit, Cobalt Chromium Copings, CAD/CAM Technology

ABSTRACT:

PURPOSE

This study aimed to evaluate and compare internal fit of Cobalt- Chromium copings cast from milled wax and milled PMMA patterns fabricated using CAD/CAM technology

MATERIALS AND METODS

After selection of 30 ivory teeth , they were prepared for the master model. A custom tray was fabricated to make impressions of prepared ivory teeth . One- step double- mix elastomeric impression technique was used for the impression then poured with a Type IV die stone. The procedure was repeated thirty times to obtain dies of same dimensions for milled wax and milled PMMA patterns. Then the metal copings were fabricated and seated onto the stone die and fixed with commercially available Glass Ionomer Cement. All the copings were sectioned longitudinally in buccolingual direction using diamond disc and seen using stereomicroscope in 40X.

RESULTS

On comparative statistics of internal gap/ discrepancy between Group A (Milled wax) and Group B (Milled PMMA) respectively, there was found to be highly statistical difference ($p<0.001$) between both groups, Milled PMMA had better internal fit as compared to Milled wax.

CONCLUSION

Since the results obtained in this study using Group A (copings casted from milled wax patterns) and Group B (copings casted from milled PMMA patterns) were comparable and within acceptable limits, all of these Cobalt-Chromium copings casted from milled wax patterns and milled PMMA patterns can be considered for further clinical evaluation.

Introduction

Fixed prosthodontics is the branch of prosthodontics concerned with the replacement and/or restoration of teeth by artificial substitutes that cannot be removed from the mouth by the patient.[1]The recent phase in restorative dentistry is mainly esthetic demanding. In fixed Prosthodontics, all-ceramic restorations are highly aesthetic restorations. However, this restoration has certain limitations like fragile nature, low tensile

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strength, technique sensitive laboratory procedures & cost.[2]

One of the most widely used fixed restorations are metal ceramic restorations. This is partly due to technological enhancements in the fabrication of restorations by the dental laboratories and in part from the growing number of demands for aesthetic with durable restorations. The metal-ceramic restorations combine the physical properties of metal i.e., rigidity and impact strength, with aesthetic qualities, abrasion and strain resistance of dental ceramic. The metal-ceramic restoration was called 'Ceramco Crown,' 'Porcelain veneer crown', 'as well as 'Porcelain fused to metal (PFM).[2]

Porcelain fused to metal is still the most widely used choice of treatment for fabricating complete coverage crowns and bridges in fixed partial prosthodontics.[3] Many restorations are still produced using the conventional lost-wax casting technique which was introduced in 1970 by Taggart.[4] Multiple steps are involved in lost wax casting technique. The primary production of a wax pattern of the required restoration is completed and then it is invested in a heatproof investment material. The invested pattern is then placed in a furnace and heated to a high temperature where all wax patterns are burnt out and a void is left in its place, which is later filled with the molten metal of choice. The production of good quality restorations starts from the production of good quality wax patterns. Production of a good quality wax patterns is dependent on a number of factors along with the skill of experienced technicians. During the manual production procedure, removing the wax pattern may lead to die distortion and because the wax is glossy, small defects can be difficult to identify. Many different factors can affect the success of dental copings, including the accuracy of the fit and seating of the copings.[5]

Recently, restorations are commonly produced by various Computer-Aided Design/Computer-Aided Manufacture (CAD/CAM) systems.[4] The fabrication of patterns with CAD/CAM technology has several advantages, with high production rate, quality control of resin copings, reduced labour and time to produce the patterns, and less finishing work needed on cast copings (due to the absence of irregularities in coping thickness) and control of dimensional accuracy.[6] The optimism is that the application of CAD/CAM technology for metal-ceramic restorations may result in restorations with improved adaptation.Coping is a thin covering or crown made of metal alloy or ceramic that is luted to an abutment supporting an overdenture, fixed partial denture, or fixed complete denture.[1]

The adaptation of a restoration can be defined in terms of misfit measured at the various points of the restoration and the tooth along with the internal surface, at the margin, or on the external surface of the casting. This misfit represents the available cement space. Several techniques such as die relief, internal acid etching, venting, and use of disclosing agents, cementation process, and preparation geometry were investigated to improve seating. [7]

The main goal of any prosthodontic treatment is to provide the patient with precisely fitting restorations or prostheses. In case of fixed prosthodontics, marginal gap and internal gap are the crucial factors which define the long-term success of the prosthesis. Distortion of wax pattern-like shrinkage due to relaxation of internal stress contributes to detrimental effects on cast restoration. Resins always overcome the shortcomings of wax as pattern-forming material. Resins offer strength, rigidity, and dimensional stability.[8]

Increased internal discrepancy of a crown favors the rate of cement dissolution and microleakage. Microleakage from the oral cavity can cause inflammation of the vital pulp. Poor marginal adaptation of crowns increases plaque retention and changes the composition of the sub-gingival microflora indicating the onset of periodontal disease.[6]Nickel chromium alloys have been the most popular base metal alloys for metal-ceramic restorations. In response to concerns about the toxicity of nickel and beryllium, cobalt-chromium (Co-Cr) alloys for use in metal-ceramic restorations were developed.[6]

Cobalt-chromium alloys are corrosion resistant and stable in biologic environment and as novel alternatives because of their high mechanical strength, corrosion resistance, biocompatibility, and cost efficiency.[9] Hand waxing produces a high proportion of crowns demonstrating excellent margin fit and optimal occlusion but is labour intensive. Milling technology was introduced over 20 years ago as an alternative to hand waxed restorations. Milling technology has increased the speed and volume of production and decreased operational costs: a stone cast does not have to be trimmed or duplicated, and a restoration pattern can be made in 7 minutes, allowing for higher production

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volume and shorter turnaround time.[10] Very limited information is available in dental literature regarding the internal fit of Cobalt-Chromium copings cast milled wax patterns and milled PMMA using CAD / CAM technology This study aimed to evaluate and compare internal fit of Cobalt- Chromium copings cast from milled wax and milled PMMA patterns fabricated using CAD/CAM technology

Materials And Methods

Ethical committee approval and study design-

This Study was carried out in the Department of Prosthodontics in 2022-2023. The sample size was calculated using the references of related articles, studies, reviews and sample size formula. The power of the study is less thus the sample size was taken as 30. The sample was divided into two groups namely Group A (Milled wax) and Group B (Milled PMMA) respectively. Each Group was assigned 15 samples each

Fabrication of Samples-

Samples were made with Milled PMMA and Milled wax patterns using CAD/CAM technology to compare the internal adaptation.

Copings casted from Milled wax Patterns material- 15 samples

Copings casted from Milled PMMA Patterns material- 15 samples

1. Preparation for master model:

An ivory tooth (mandibular right first molar 46, Columbia, Long Island, NY, USA) was selected for the preparation of the master model. (It will be mounted on a custom-made block of self-polymerizing resin [DPI RR cold cure]). Before the preparation will begin, putty index of ivory tooth selected will be made. The tooth is then prepared with a shoulder finish line of 1.5mm on the buccal aspect, a chamfer finish line of 0.5mm on the lingual aspect and an occlusal reduction of 2mm. Two vertical extensions will be made on the buccal and lingual sides, respectively extending from margins downwards. This will be done to guide the copings and assure their proper fit while measurement.

TOOTH PREPARATION

2. Preparation of samples:

A custom tray would then be fabricated with perforations to make the impressions of the prepared ivorine tooth by one-step double-mix elastomeric impression technique. The impression will then be poured into a Type IV gypsum product (die stone). The procedure will be repeated, and thirty impressions would be made to obtain thirty stone dies of the same dimensions. 15 will be used for Group A and Group B, respectively.

3. Designing the coping:

The prepared ivory tooth would be scanned with a dental scanner . Then that image will get transferred to the computer and the Standard Tesselation Language (STL) file will be generated which is used to design the patterns of uniform thickness (0.5mm) and cement space (50 μm) with the help of exocad software.

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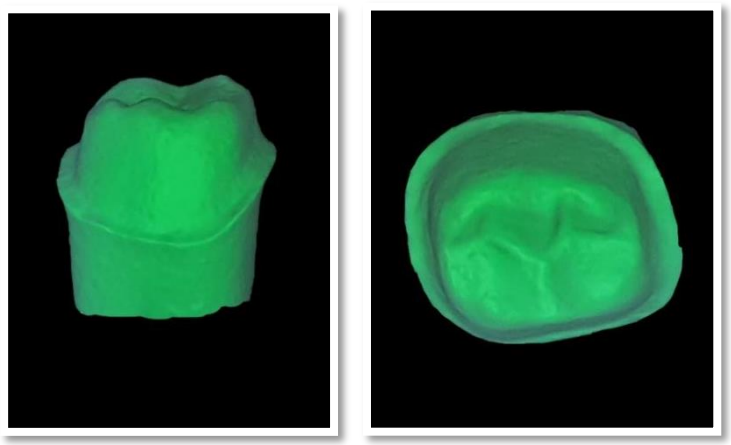
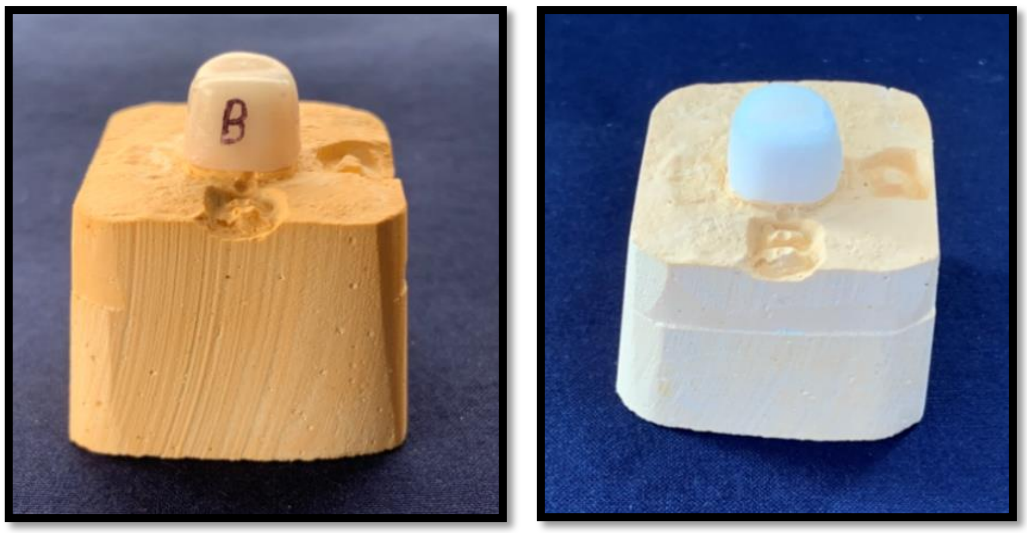


SCANNING

4. The procedure of investment and casting of the patterns:

Three rings would then be invested in phosphate bonded investment material. In each ring 10 patterns, five with milled wax patterns and five with milled PMMA patterns will be sprued to ensure that each group would pass through the same investment and casting procedure. The casting of the three rings will be performed by using a Cobalt-Chromium base metal alloy with an induction casting machine. After casting all the copings would be recovered and then minimally trimmed and adjusted to get proper fitting on the master model. After checking fit all will be sandblasted (125-micron sand) and cemented with Glass Ionomer Cement on respective master dies.



FABRICATION OF MILLED PMMA AND MILLED WAX COPING

5. Sectioning of samples:

The metal copings will then be checked for initial fitting and then cemented commercially available Glass Ionomer Cement under 50N load with UTM for 10 minutes on respective dies. All the copings would be sectioned longitudinally in a buccolingual direction using a circular saw.

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MILLED WAX COPING MILLED PMMA COPING

Results

On comparative statistics of internal gap / discrepancy between Group A (Milled wax) and Group B (Milled PMMA) respectively, there was found to be statistical significant difference ($p<0.001$) between both groups where Group B (Milled PMMA) had better internal fit as compared to Group A (Milled Wax)

Table 1: Descriptive statistics of internal discrepancy in both groups

Internal discrepancy (µm)	Mean	SD	SE	Minimum	Maximum
Group I (Copings casted from milled wax patterns)	90.32	4.77	0.55	80.6	99.7
Group II (Copings casted from milled resin patterns)	88.7	22.48	2.59	54.8	128.3

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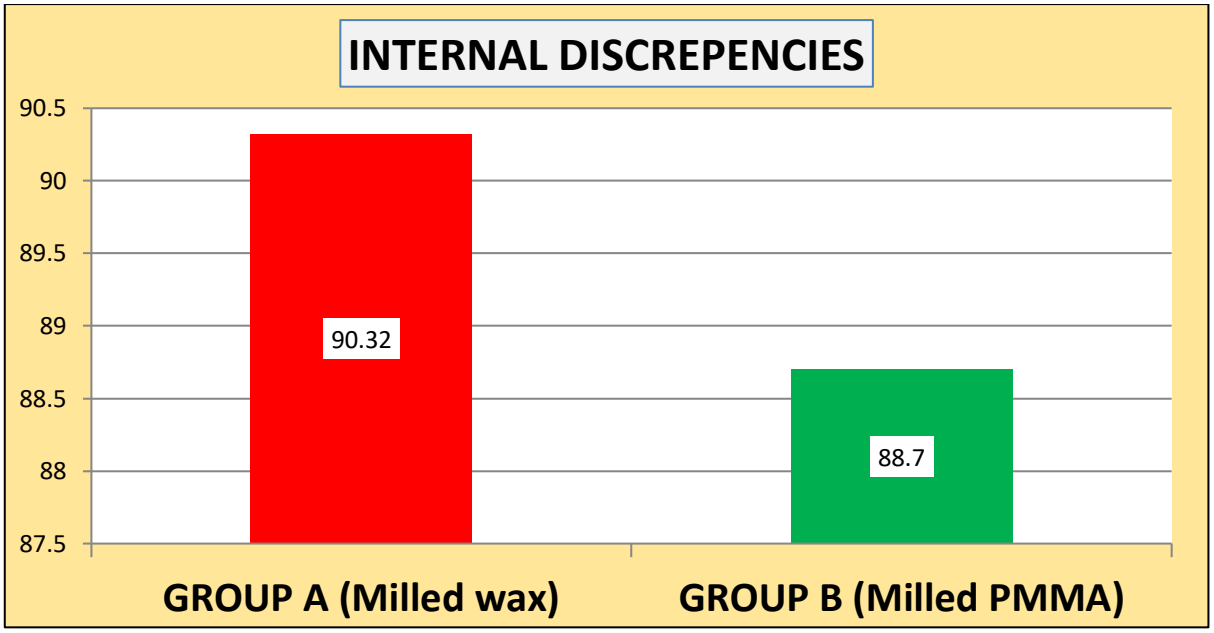
Graph 1: Comparative statistics of internal discrepancy in both groups



Discussion

There have been numerous and diverse factors that determine the FPD success. One element that determine the durability of final prosthesis in oral cavity is internal fit. Internal fit influences durability and clinical acceptability of restorations. .Ideally, cemented crown margins meet prepared tooth margins in perfect non-detectable junctions. In actuality clinical perfection is equally difficult to achieve and difficult to verify. The term marginal gap and internal gap do not have single definition. Holmes et al., who established several gap definitions according to contour difference between the crown and tooth margin, states that ‘‘the perpendicular measurement from inner surface of casting to the axial wall of preparation is called internal gap, and the same measurement at the margin is called marginal gap’’. Increase in internal space thickness will lead to compromised retention

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 . However very few studies have reported about obtaining metal copings directly using CAD/ CAM technique using Co–Cr alloys which has no nickel in its composition which has greater sensitization potential . Studies comparing discrepancies of the copings made using Co–Cr alloy using conventional casting and Milling is also lacking.

The CAD/CAM process of producing copings by milling technique using automated scanning process and powerful CAD software offers many advantages such as complete control over the framework and coping designing, margin placement, cement space maintenance, coping thickness and pontic designs as well as elimination of casting procedures.In this investigation the maximum clinically acceptable internal discrepancy was set at- 20-40 µm. The amount of internal discrepancy in both groups were within the clinicaaly acceptable range.

Internal discrepancy for the study groups i.e-

Group A- Copings casted from milled wax patterns

Group B – Copings casted from milled PMMA patterns was 90.32 µm and 88.7 µm respectively in which Group B (Copings casted from Milled PMMA patterns) showed better internal fit than Group A (Copings casted from Milled Wax patterns).

Certain limitations of this study are as follows-

1. This study was invitro so it does not simulate the oral conditions. The internal fit was evaluated by sectioning of casted copings.
2. In this study the internal gap was measured 2 dimensionally , actually 3 dimensional of this gap

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would have yielded more accurate resuts regarding the space occupied by the luting agents.

Conclusion

Within the limits of this study, the following conclusions can be drawn:

As Group B (Copings casted from Milled PMMA patterns) showed better internal fit (lower internal discrepancy) than Group A (Copings casted from Milled Wax patterns). Since the results obtained in this study using Group A (Copings casted from Milled Wax patterns) and Group B (Copings casted from Milled PMMA patterns) were comparable and within acceptable limits, all of this Co-Cr copings casted from Milled Wax patterns and Milled PMMA patterns using CAD/CAM technology can be considered for further clinical evaluation.

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