Comparison of Marginal and Internal Fit of Metal Copings Fabricated by Cad/Cam Milling, Cad/Cam Wax and Conventional Lost Wax Technique

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Abstract

Background: In dentistry, metal ceramic prostheses are still frequently used despite the advent of metal-free prostheses. Because the marginal and internal fit of metal copings milled directly by CAD/CAM and cast from wax patterns created by CAD/CAM and conventional lost wax process are critical to the clinical outcome of a restoration, this study aimed to assess and compare these parameters.

Materials and Methods: PFM crown preparation with chamfer margin was performed on a maxillary first molar typodont tooth. The impression material used for the master models impression was elastomeric material. .30 dies were obtained and randomly divided into three group of 10 dies for each group(n = 10). GroupA Copings fabricated by Conventional lost wax pattern, Group B Copings fabricated by CAD/CAM milling and Group C Copings fabricated by CAD/CAM wax pattern milling and conventional casting.. Along with longitudinal sectioning, each coping was cemented onto its corresponding die. A 100x optical microscope was used to measure the internal and marginal gaps at seven different places.

Results Data analysis was done using a one-way ANOVA with Tukey HSD pair-wise comparisons. Groups A, B, and C had mean overall gaps of 168.53±37.26 µm, 109.62±24.96 µm, and 47.49±14.99 µm, respectively. Group B and Group C had the next greatest internal and marginal gaps, respectively. Group A displayed the largest gaps. The groups differed in both internal and marginal fit in a statistically significant way.

Conclusion: In comparison to CAD/CAM and traditional lost wax technique, metal copings made from wax patterns created using CAD/CAM and conventional casting technique had smaller marginal and internal gap.

Keyword: Marginal fit, Internal fit, PFM, FPD, CAD/CAM , STLfile

INTRODUCTION

The main objective of fixed prosthodontics treatment is the replacement and restoration of teeth using artificial substitutes. This might encompass anything from the rehabilitation of a full occlusion to the repair of a single tooth.[1] Materials used to fabricate prostheses in modern fixed prosthodontics include all metal, porcelain fused to metal, and all ceramic.[2] Because of its exceptional mechanical qualities, acceptable aesthetics, affordable price, and simple cementation process, porcelain fused to metal prostheses remain one of the most popular materials for the fabrication of fixed partial dentures. A metal framework or coping is covered in multiple layers of sintered porcelain material is used to create a porcelain fused to metal prosthesis.

Metal coping can be made using the conventional lost wax process, CAD/CAM milling, and CAD/CAM wax pattern followed by traditional casting.[3] The lost wax technique, which was developed by Taggart in the early 1900s, makes it possible to fabricate crowns, inlays, onlays, and FPDs.[4] Wax and waxing tools were used to create wax pattern fabrication in the past. Wax is used to create the patterns because it is easily worked, can be moulded exactly, and can be heated to remove it entirely from the mould.[4] The crucial and labour-intensive phase in creating the porcelain fused-metal coping is making the wax pattern. Computer-aided design/computer-aided manufacturing (CAD/CAM) technologies have been established in an attempt to solve the drawbacks of the traditional lost-wax process.[5]When it comes to flow characteristics, shrinkage, and expansion during heating and cooling, CAD/CAM wax differs from Inlay wax.

CAD/CAM wax which is made from a polymerisation reaction, is a solid synthetic wax that is less susceptible to temperature changes.[6] Nowadays CAD/CAM technology, which has turned into a significant revolution, being able to create incredibly exact designs and high-quality restorations makes it an advancement over conventional dentistry. Unfortunately, the expense and duration of the process are also limited by scanning systems' finite resolution, which may lead to somewhat rounded edges; other limitation include equipment's wear and tear. [7]

The biological, physical, and aesthetic criteria of restorations must be fully satisfied by precise marginal seating and internal fit of cast restorations. The precision and fine detail of the wax pattern will play a major role in the casting's fit and quality.[8] Inadequate coping internal adaption can lead to increased cement thickness and water sorption, which degrades cements hydrolytically and lowers their elastic modulus, which in turn lowers the mechanical durability of dental restorations. A too thick layer of cementitious material can lead to periodontal inflammation, cavities, and ultimately the restoration's loss.

Therefore, the current study was taken to assess and compare the marginal and internal fit of metal coping milled directly by CAD/CAM and cast from wax pattern fabricated by CAD/CAM and conventional lost wax technique.[9]

MATERIAL AND METHODS

This invitro study was carried out in Department of Prosthodontics and Crown & Bridge and Oral Implantology Rajasthan Dental College & Hospital, Jaipur, Rajasthan.

Methodology:

Fabrication of Master Model

To replicate full coverage PFM crown preparation, a maxillary first molar typodont tooth was prepared with a chamfer margin around the entire circumference, occlusal clearance of 1.5

mm for nonfunctional cusp, 2 mm for functional cusp, and 1.5 mm for axial reduction. The preparation features a 0.7 mm chamfer width and a 6-degree convergence angle.

Fabrication of Die Specimens

Custom fabricated, self-cure acrylic resin impression trays were made in order to take impressions of the master model. Using a single-stage method, impressions of the master model were made using C-silicone impression material (orikam). To create the die stone models, 30 impressions were taken and type IV die stone (kalabhai kalrock) was poured. (Figure 1)

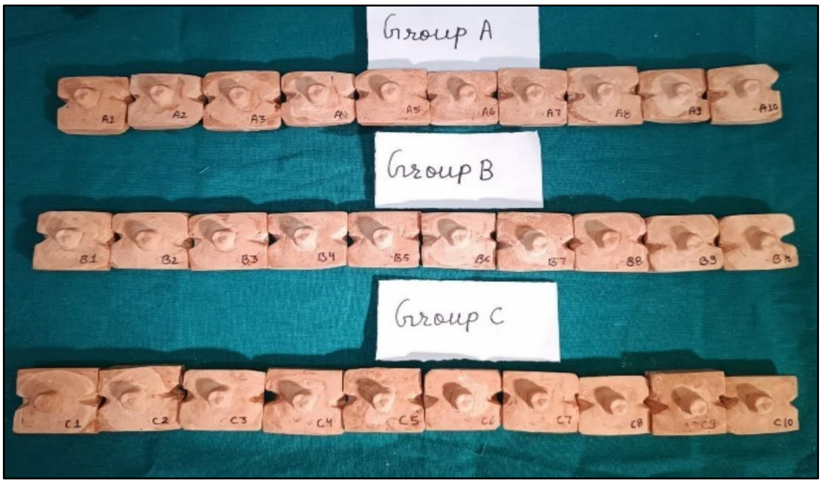


Fig 1 Dies prepared and randomly allotted to three groups

30 dies were obtained and randomly divided into three groups of 10 dies for each group (n=10)

- **Group A**: Copings fabricated by conventional lost wax pattern.
- **Group B**: Copings fabricated by CAD/CAM milling.
- **Group C**: Copings fabricated by CAD/CAM wax pattern milling and conventional casting.

Fabrication of Group A Specimens (conventional lost wax pattern)

A coat of die spacer was applied 1mm away from the margin, each layer of die spacer (DFS india) has a thickness of 20µm. After drying, a thin layer of separating medium (Renfert) was applied to the dies to remove the wax pattern easily. Wax pattern was fabricated by addition wax technique by type 2 inlay wax (JK industries). Wax was added and shaped by PKT instruments to form and follow the emergence profile of die. The thickness of the copings was confirmed with a thickness gauge to be 0.6mm. Finally, to readaptation of the margin was done. Prefabricated Wax sprues were attached, and all wax patterns were invested in a phosphate bonded investment (Begosol). After heating to 950˚C for wax elimination the copings were cast in Ni- Cr Alloy(Agkem Impex)using a casting machine(Bego Fornax T). The castings A1 to A10 according to their wax pattern code were removed from the investment and cleaned with aluminium oxide particles. The casting sprues were removed by using a polisher and grinder machine with a separating disc, after finishing and polishing 10 metal coping were fabricated. (Fig 2)

Fig 2: Group A metal copings

Fabrication of Group B Specimens (CAD/CAM Milling)

For the fabrication of CAD/CAM milled copings, ten dies were used. A 3D scanner (Lianoning Upcera) was utilised to scan the dies.The CAD program (CAD Design software) received the scanned data and used it to create patterns with a thickness of 0.6 mm and a cement space of 20 um for the axial and occlusal surfaces and no cement space at the border. An STL file, or standard tessellation language, was the product of this . The milling machine received the design and used it to construct frameworks out of the metal blank.Following coping milling, it was separated from the remaining disc. (Fig3)

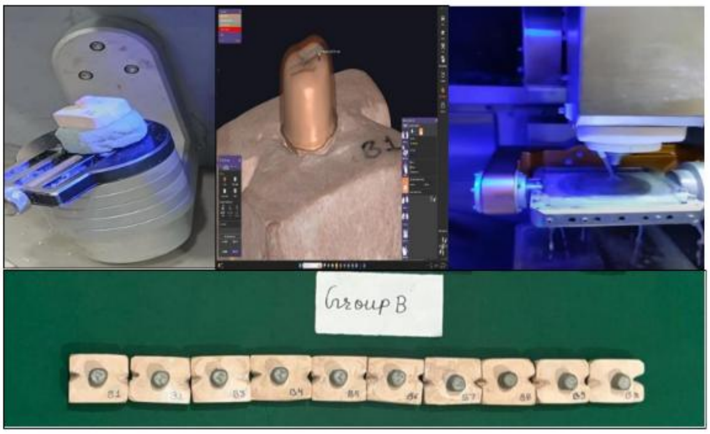


Fig 3: Group B metal copings

Fabrication of Group C Specimens (CAD /CAM Wax Pattern Fabrication and Conventional Casting)

10 Dies were used to fabricate the CAD/CAM wax pattern.Dies were scanned by using a scanner (Lianoning Upcera). The scanning data were transferred to the CAD software (CAD Design software), in which the thickness of the patterns was set at 0.6 mm, and a cement space of 20 um was considered for the occlusal and axial surfaces, with no cement space at the margin. The output of this design was a standard tessellation language (STL) file. The design was sent to the milling machine (Cradle Medical) and frameworks were fabricated from the wax blank(Tuskerdent) with milling machine. After the milling of wax pattern was done it was separated from the remaining of the disc. Prefabricated Wax sprues were attached, and all wax patterns were invested in a phosphate-bonded investment. After heating to 950˚C for wax elimination the copings, were casted in Ni- Cr Alloy using a casting machine. The castings C1 to C10 according to their wax pattern were removed from the investment and cleaned. The casting sprues were removed after finishing and polishing of metal copings was done. (Fig 4).

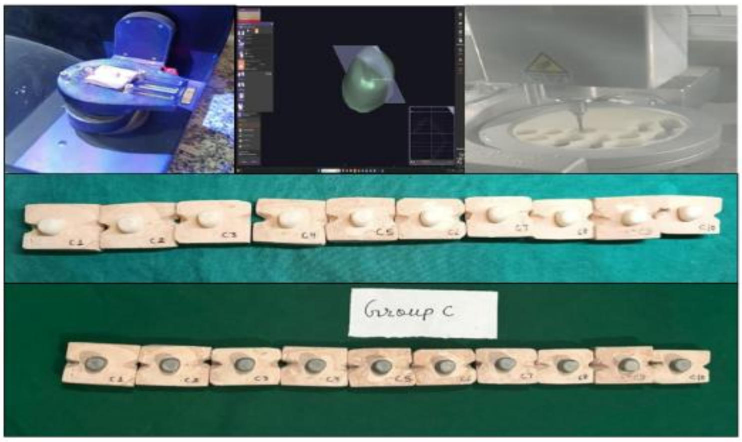


Fig 4 : Group C metal copings

Cementation of Test Specimen

Glass-ionomer cement was used to firmly cement ,copings to their corresponding die specimens. A suitable mixture of powder and liquid was prepared for GIC (Shofu Inc., Tokyo). A gauze pad was used to remove the extra cement. The finger-pressured seating force is used to mimic a clinical situations. (Fig 5)

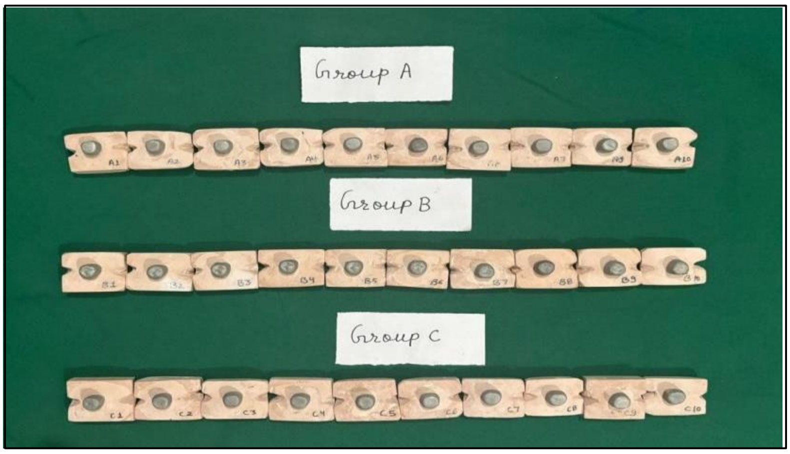


Fig 5: Cementation of test specimens

Sectioning Of Specimens

Using a carborundum disc in a die cutting machine(Unident), the specimens were sectioned. After being fixed, each specimen was sectioned into two halves. Specimens were fine-finished and cleaned to get rid of any debris. (Fig 6)

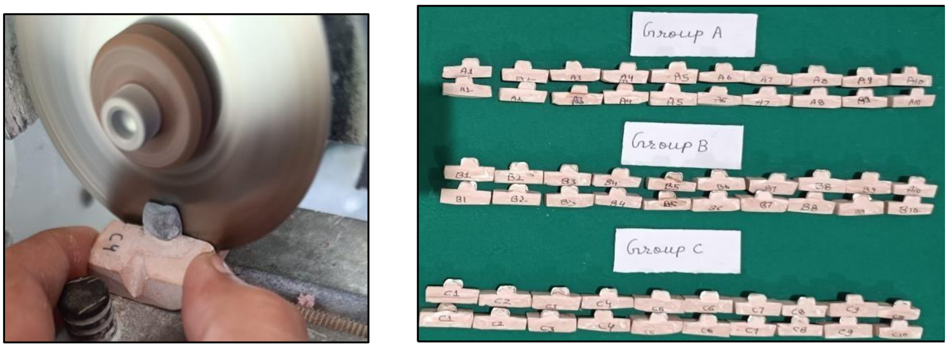


Fig 6: Sectioning of test specimens

Measurements of Marginal & Internal Fit

Following the completion of the longitudinal sectioning to determine the internal and marginal gaps. The marginal and internal fits of the metal coping were determined at seven different sites. Every measurement was taken with a Zeiss optical microscope. Digital photos were captured at a 100x magnification and examined using a measurement tool. (Fig 7) (Fig 8)

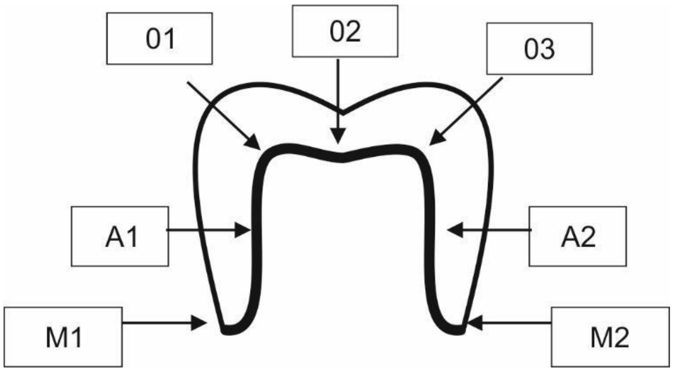


Fig 7: Schematic line diagram of measurement locations (M1, M2, A1, A2 and O1, O2, O3)

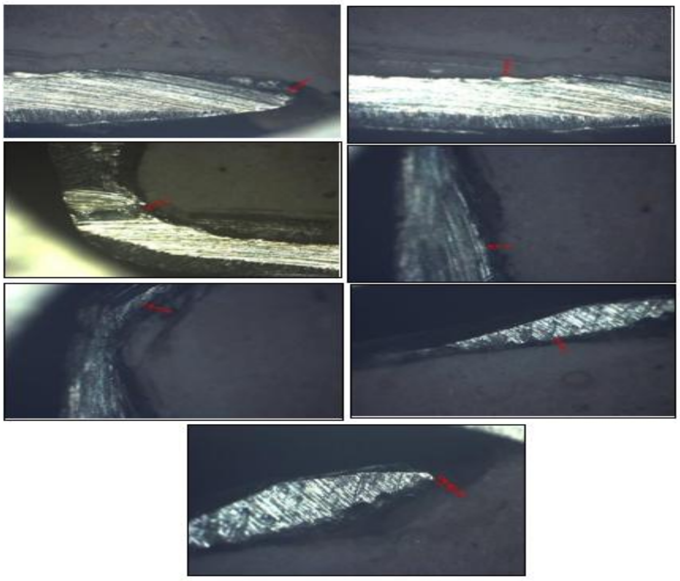


Fig 8: Measurement of marginal and internal gap of specimen's Statistical analysis

Statistical analysis

To do a multiple comparison between the three groups, one way analysis of variance (ANOVA) post Hoc Tukey HSD was utilised to tabulate and statistically analyse the findings for marginal and internal fit. A significant threshold of $P \leq 0.05$ was applied.

RESULT

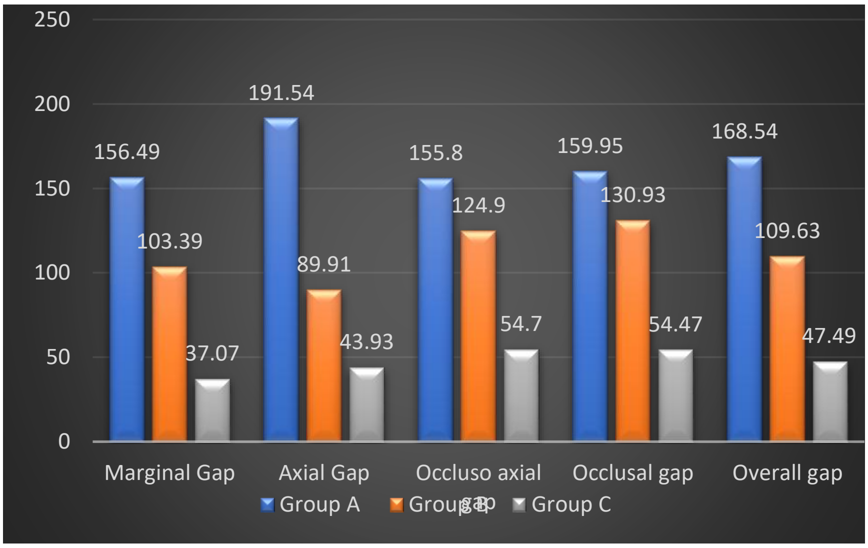
On statistical analysis it was found that there was statistically significant difference between mean marginal and internal gap among all test groups. (Table 1) (Graph 1)

Table 1: Shows mean marginal and internal gaps of specimens of all groups

Group	Mean Marginal Gap (in um)	Mean Axial gap (in um)	Mean Occluso axial gap(in um)	Mean Occlusal Gap(in um)	Mean overall Gap(in um)
Group A	156.49±42.66^{a}	191.53±90.93^{a}	155.83±53.91^{a}	159.94±67.72^{a}	168.53±37.26
Group B	103±27.99^{b}	89.90±27.23^{b}	124.90±41.12^{b}	130.96±44.21^{b}	109.62±24.96
Group C	37.07±11.95^{c}	43.92±17.63^{c}	54.78±17.65^{c}	54.47±29.47^{c}	47.49±14.99

Same lowercase superscript letters denote values not significantly different among same column

Graph 1: Shows mean marginal and internal gaps of specimens of all groups



DISCUSSION

Methods for fabricating metal copings include the conventional lost wax process, CAD/CAM metal coping fabrication, and CAD/CAM wax pattern fabrication followed by traditional casting. This study was conducted to compare the marginal and internal fit of metal copings milled directly by CAD/CAM and cast from wax pattern fabrication by CAD/CAM and conventional lost wax technique.

Marginal errors may cause plaque to be retained, which can result in gingival recession, marginal gingival irritation, and the formation of secondary caries behind the crown edges. One possible reason for the failure could be marginal inaccuracy.

This study uses tooth analogues made of acrylic resin to replicate a clinical situation. According to a study conducted by Hyun-Sook Han, Hong-So Yang, Hyun-Pil Lim, and Yeong-Joon Park, the coping in all three groups had to have a uniform thickness of.6mm for each wax design that was manufactured.[10] In order to replicate the clinical cementation of FPD, finger pressure was used to seat the crown on the die. The clinical scenarios were not simulated in this investigation using a standardised force, as in the study by Anders Ortorpa, David Jonsson, Alaa Mouhsen, and Per Vult von Steyern.[11] The CAD/CAM procedures were standardised by using the same scanner, and the casting technique was optimised for melting by using an induction casting machine. The lost wax process involves making manual wax patterns, which are sensitive to technique. In order to reduce these concerns, the waxing and casting were done by the same operator.[12] The longitudinal cross-sectional methodology was used in this study to verify the marginal and internal fit. This method requires the sacrifice of a sample, but the results are more precise since the measurement sites are more precise and consistent.[13]

The variation in the pattern of wax distortion between the CAD/CAM and manual wax could account for the disparity in adjustment interventions between the two groups (group A and group C). The hand-fabricated wax's flow characteristics, shrinkage, and expansion following uneven heating and cooling are the primary causes of these variations, whereas the solid synthetic wax utilised in CAD/CAM is made through a polymerisation reaction and is less temperature-sensitive.[14] When compared to the inlay wax utilised in the traditional lost wax method, the marginal gap of the crown manufactured using CAD/CAM wax was noticeably less. This outcome could be the result of minor flaws in the hand waxing process brought on by the glossy surface and colour of the wax pattern.Such outcomes are also influenced by the typical 35-um opening of the shoulder margin prior to investing that occurs during the process of extracting a wax pattern from a die.[15]

Result of this study showed all values for marginal and internal fit for Group B and Group C were found in the range of clinical acceptance, while for the conventional technique (Group A) were higher than the accepted value of 120 um and statistically significant result were obtained for Group A (copings fabricated by conventional wax pattern and casting), Group B (copings fabricated by CAD/CAM milling) and Group C (copings fabricated by CAD/CAM wax pattern milling and conventional casting). Group C showed better marginal and internal fit followed by Group B and Group A.

Group C is a combination of old and new techniques. In comparison with the traditional lost wax technique group A , it presented the less amount of measurement distortion values. However, the group A had higher value, one explanation for the larger distortion in the lost wax group could be that the spacer is difficult to standardize, and distortion could be set when the wax is removed from the model. The CAD/CAM technique contains fewer production steps compared to the lost technique. The group B had higher distortion values than group C this could be explained by wear of the milling burs when milling such a hard material as Ni–Cr . Therefore, the burs must be changed often to reduce the risk of using burs with decreased diameters. Vibrations in the milling device could also be a reason for the results in the group. There were some limitations in this study.

There were some limitations in this study.

- The force used to seat the restorations was not standardized. The use of a loading apparatus would provide a more uniform load on all the specimens.
- The marginal accuracy measures in this study were based on the simulation of tooth configurations ready to receive full crowns using stone dies. To simulate a clinical process, human teeth would be the best option.
- In this study the measurement area is restricted to the sectioned line so only provide a 2D information.
- Present study was done in vitro conditions result can vary in oral environment.
- Small specimen size.

CLINICAL CONSIDERATION

Metal coping created by CAD/CAM wax and conventional casting exhibited superior marginal fit and internal fit than CAD/CAM milling and conventional casting, thus it can be recommended for metal copping fabrication even though the CAD/CAM technique's values were within clinically acceptable bounds. Because of its improved marginal and internal fit, it influences the restoration's clinical outcome. Less plaque buildup, marginal gingival irritation, gingival recession, and cavities are all benefits of improved marginal fit.

SCOPE FOR FUTURE RESEARCH

- Effect of veneering ceramic application on the marginal and internal fit of metal coping.
- Measurement of mechanical properties and metal to ceramic bond strength and to assess the 3D volume between metal coping and dies.
- Study can be done in vivo to simulate the oral environment

CONCLUSION

With in the limitations of this study, the following conclusions could be derived as

➢ Metal copings fabricated by CAD/CAM wax showed better marginal and internal fit than manual wax.

Result for marginal and internal fit of this study was statistically significant and showed that mean marginal fit for Group C (metal copings fabricated from wax pattern fabricated by CAD/CAM and conventional casting technique) exhibited maximum marginal and internal fit followed by Group B(metal copings fabricated by CAD/CAM) and Group A (metal copings fabricated from conventional lost wax technique).

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