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Original Article

Reproducibility of different coping arrangements fabricated by dental micro-stereolithography: Evaluation of marginal and internal gaps in metal copings

Dong-Yeon Kim [a], Il-Do Jeong [a], Ji-Hwan Kim [a], Hae-Young Kim [b], Woong-Chul Kim [a*]

[a] *Department of Dental Laboratory Science and Engineering, College of Health Science, Korea University, Seoul, Republic of Korea*
[b] *Department of Public Health Science, Graduate School & BK21 + Program in Public Health Sciences, Korea University, Seoul, Republic of Korea*

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Abstract *Background/purpose:* To evaluate the reproducibility of the marginal and internal gaps of metal copings fabricated using dental micro-stereolithography (μ-SLA), which is an additive manufacturing system.
Materials and methods: A study cast of abutment tooth 46 was made from type-IV dental stone and was scanned to create a standard triangulation language file. Arrays of one (ORM), three (TRM), and six (SRM) resin copings were then fabricated on the μ-SLA build platform using investment, burnout, and casting ($n = 12$). The marginal and internal gaps of these metal copings were measured using a silicone-replica technique with a digital microscope (×160). The data obtained were analyzed using a non-parametric Kruskal–Wallis H test, a post-hoc Mann–Whitney U test, and a Bonferroni correction.
Results: The mean and standard deviation of the marginal gap for each group were measured and found to be 81.1 and 53.2 μm, 68.3 and 44.8 μm, and 90.3 and 57.7 μm for ORM, TRM, and SRM, respectively. There were no statistical differences in the marginal gaps of the three groups ($p > 0.05$).
Conclusion: The marginal and internal gap of ORM, TRM and SRM groups were considered clinically acceptable.

* Corresponding author. Department of Dental Laboratory Science and Engineering, College of Health Science, Korea University, 145, Anam-ro, Seongbuk-gu, Seoul 02841, Republic of Korea. Fax: +82 2 921 7361.
E-mail address: kuc2842@korea.ac.kr (W.-C. Kim).

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Introduction

Porcelain-fused-to-metal (PFM) crowns with substructures that consist primarily of a metal coping produced by the lost-wax technique are widely used in dentistry for fixed aesthetic restorations.[1–3] The process of making PFM crowns involves carving the shape of the entire lost tooth on a prepared abutment with an appropriate coping thickness of 0.3–0.5 mm, which is then followed by spruing, investing, burnout, and casting.[4–7] The disadvantages of this approach include the time requirements for carving the wax and the reliance on a skilled dental technician, which makes it difficult to maintain a consistent quality level.

The need for an automated manufacturing system prompted the introduction of dental computer-aided design/manufacturing (CAD/CAM) in the 1970s, which made the fabrication of a dental prosthesis much faster and more accurate.[8] These dental CAD/CAM systems can be classified as either subtractive manufacturing, in which a solid block is milled, or additive manufacturing, in which the material is built up layer by layer.[8] Subtractive manufacturing can be applied to different materials and, by using different milling tools, it is possible to maintain high accuracy and achieve a very smooth surface. However, it is difficult to form a complex model with this method, and a large amount of material is wasted.[8] In contrast, additive manufacturing allows complex shapes to be fabricated with less material wastage.[8–11]

A micro-stereolithography (μ-SLA) system, which is an additive manufacturing technology, can provide the micrometer-scale resolution required for dentistry; it allows prostheses to be manufactured more quickly.[12] This method is based on the use of an ultraviolet (UV) light source to cure a photopolymer resin in two dimensions and to control the shape in three dimensions, making it possible to manufacture various forms. Furthermore, by using a light-emitting diode as the UV source, light energy is transmitted to the target object more efficiently than it is with conventional digital light-processing systems used in the manufacturing of resin copings. In the case of dental μ-SLA, the process of fabricating a substructure for a PFM crown begins with the UV irradiation of a photopolymer to produce a resin coping, which is then used in place of a wax carving for metal casting. Park et al.[13] reported The multi-jet modeling system (MJM) had a molar marginal gap of 83.2 μm. The μ-SLA was 69.3 μm. The μ-SLA showed a marginal gap results are excellent. This is capable of fabricating one or more resin copings on a single build platform. To date, no guidelines have been issued regarding the effect on the marginal and internal gaps of manufacturing several copings simultaneously. However, the marginal gap is the most important element of any metal coping because it determines the marginal fit of that coping. Furthermore, an incorrect marginal gap can lead to leakage, retention of subgingival plaque, and distribution of microflora,[14–16] all of which can lead to the failure of the prosthesis as a result of hypersensitivity and secondary caries.[17,18] To date, there have been no studies on the accuracy of the μ-SLA technique in relation to the quantity of resin coping on the build platform.

The purpose of the present study is to evaluate the reproducibility of repeating one, three, and six metal copings fabricated using a μ-SLA system and to assess their clinical acceptability. The null hypothesis is that the marginal and internal gaps between the metal copings fabricated by a μ-SLA system are equivalent to each other.

Materials and methods

Master die

The master die selected for this study was a plastic mandibular right first molar (ANA-4; Frasaco GmbH, Tettnang, Germany) (Fig. 1), onto which an occlusal surface for an abutment was formed by uniformly removing 2 mm from the internal edges and 1.5–2 mm from the axial wall using a chamfer margin of 360° and an axis milling angle of 6° (Cruise 440; Silfradent, Sofia, Italy). This plastic master die was then replicated in silicone (Deguform; Degudent GmbH, Hanau-Wolfgang, Germany) and injected with molten wax (Geo Wax; Renfert GmbH, Hilzingen, Germany). The resulting wax die was then used to cast a nickel–chromium alloy (VeraBond 2V; Aalba Dent Inc., Fairfield, CA, USA) master die (Fig. 2).

Study die

By replicating the master die through a silicone impression (Aquasil Ultra XLV and Aquasil Ultra Rigid; Densply DeTrey GmbH, Konstanz, Germany), a study die was subsequently obtained by injecting plaster (Fujirock EP; GC Corp, Leuven, Belgium) that was mixed according to the manufacturer's recommended water/powder ratio.

Metal coping fabrication

The fabricated study die was scanned using a model scanner (Identica Blue; Medit, Seoul, Korea) to produce a

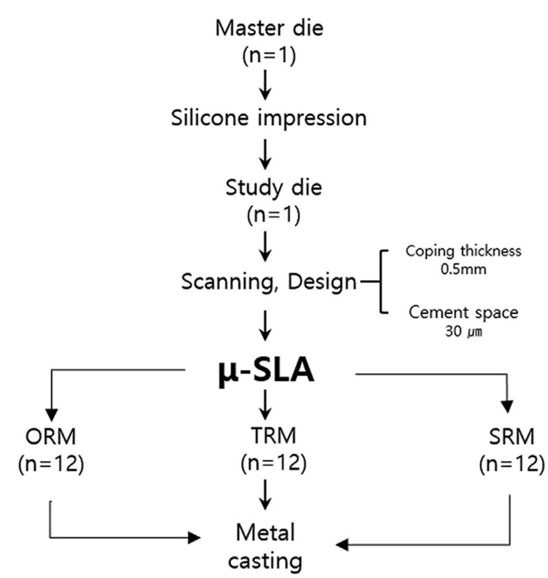

Figure 1 Study design.

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