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Misfit and microleakage of implant-supported crown copings obtained by laser sintering and casting techniques, luted with glass-ionomer, resin cements and acrylic/urethane-based agents

Raquel Castillo-Oyagüe [a,*], *Christopher D. Lynch* [b], *Andrés S. Turrión* [a], *José F. López-Lozano* [a], *Daniel Torres-Lagares* [c], *María-Jesús Suárez-García* [a]

[a] *Department of Buccofacial Prostheses, Faculty of Odontology, Complutense University of Madrid (UCM), Pza. Ramón y Cajal, n° 3, 28040, Madrid, Spain*

[b] *Tissue Engineering and Reparative Dentistry, School of Dentistry, Cardiff, UK*

[c] *Department of Stomatology, Faculty of Odontology, University of Seville (US), C/Avicena, s/n, 41009, Seville, Spain*

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ABSTRACT

Objectives: This study evaluated the marginal misfit and microleakage of cement-retained implant-supported crown copings.

Methods: Single crown structures were constructed with: (1) laser-sintered Co–Cr (LS); (2) vacuum-cast Co–Cr (CC) and (3) vacuum-cast Ni–Cr–Ti (CN). Samples of each alloy group were randomly luted in standard fashion onto machined titanium abutments using: (1) GC Fuji PLUS (FP); (2) Clearfil Esthetic Cement (CEC); (3) RelyX Unicem 2 Automix (RXU) and (4) DentoTemp (DT) ($n = 15$ each). After 60 days of water ageing, vertical discrepancy was SEM-measured and cement microleakage was scored using a digital microscope. Misfit data were subjected to two-way ANOVA and Student–Newman–Keuls multiple comparisons tests. Kruskal–Wallis and Dunn's tests were run for microleakage analysis ($\alpha = 0.05$).

Results: Regardless of the cement type, LS samples exhibited the best fit, whilst CC and CN performed equally well. Despite the framework alloy and manufacturing technique, FP and DT provide comparably better fit and greater microleakage scores than did CEC and RXU, which showed no differences.

Conclusions: DMLS of Co–Cr may be a reliable alternative to the casting of base metal alloys to obtain well-fitted implant-supported crowns, although all the groups tested were within the clinically acceptable range of vertical discrepancy. No strong correlations were found between misfit and microleakage. Notwithstanding the framework alloy, definitive resin-modified glass-ionomer (FP) and temporary acrylic/urethane-based (DT) cements demonstrated comparably better marginal fit and greater microleakage scores than did 10-methacryloxydecyl-dihydrogen phosphate-based (CEC) and self-adhesive (RXU) dual-cure resin agents.

* *Corresponding author at*: Department of Buccofacial Prostheses, Faculty of Odontology, Complutense University of Madrid (UCM), Pza. Ramón y Cajal, s/n, 28040 Madrid, Spain. Tel.: +34 607367903; fax: +34 913942029.

E-mail addresses: raquel.castillo@odon.ucm.es (R. Castillo-Oyagüe), lynchCD@cardiff.ac.uk (C.D. Lynch), jflozano@odon.ucm.es (J.F. López-Lozano), danieltl@us.es (D. Torres-Lagares), mjsuarez@odon.ucm.es (M.-J. Suárez-García).

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1. Introduction

The construction of metallic structures with a passive adaptation on their respective abutments is regarded as a prerequisite for the long-term success of implant-based restorations.[1,2] A wide range of materials and techniques have been developed to improve the quality of the frameworks.[3] However, despite their excellent mechanical properties[4] and lower associated costs,[5] which make them the preferred choice for a growing range of applications, base metals are difficult to cast and some inaccuracies may occur.[5–7]

The potential distortions inherent in casting of dental alloys such as Co–Cr may be overcome through the use of direct metal laser sintering (DMLS) technologies.[6,8] Laser-sintered structures are built up in layers by means of a high-energy-focused laser beam that fuses metal–alloy powder following a sliced 3D computer-aided design (CAD) file obtained from the abutments' digitisation.[9] As very few studies focus on the use of DMLS in the field of dentistry,[5,6,10–12] further research is required before its widespread clinical use can be recommended.

Cement selection is one of the most important factors for guaranteeing a suitable fit and marginal seal of implant-based prostheses.[12] In this regard, along with different resin and glass-ionomer definitive cements, acrylic/urethane-based materials have recently been marketed as semi-permanent luting agents for implant restorations. However, deeper product evaluation is necessary, as no previous study has tested some of their critical properties, such as load resistance or microleakage.

The aim of this paper is to evaluate the vertical fit and marginal microleakage of laser-sintered and vacuum-cast implant-supported crown structures that have been cemented with different luting materials. The null hypotheses stated that (a) neither the alloy composition and fabrication technique nor the cement type influences the vertical fit of implant-supported structures and that (b) there are no differences in the microleakage scores amongst the four cements analysed when either type of framework was used.

2. Materials and methods

2.1. *Fabrication of structures*

Three series of single structures for mandibular cement-retained implant-supported premolar crowns were prepared by using different dental alloys suitable for ceramic veneering (wall-thickness: 0.8 mm). Titanium prefabricated implant abutments (height = 6 mm) were utilised (ref. PCM7013, Implant Microdent System, Barcelona, Spain). The composition of the dental alloys is presented in Table 1.

Group 1 (LS) was obtained by means of direct metal laser sintering (DMLS) of a Co–Cr powdered alloy. Each abutment was directly scanned by using an optical laser (Cercon Eye, Dentsply, Konstanz, Germany) that works on the principle of light-sectioning. The system's application software (Cercon Art, Dentsply) allows the frameworks to be designed by computer after the abutments have been digitised. The structures were constructed using a DMLS device (PM 100 Dental, Phenix Systems™, Clermont-Ferrand, France). The information from the generated CAD-file was used by sintering 20-μm increments of alloy powders from the occlusal surface to the margins at 1650 °C in an argon atmosphere. Once sintered, the structures were cooled to the ambient temperature (decreasing at the rate of 9 °C per min) inside the furnace.

Groups 2 and 3 were vacuum cast. Group 2 (CC) used a cobalt–chromium alloy (Co–Cr) and Group 3 (CN) used a nickel–chromium–titanium alloy (Ni–Cr–Ti). Patterns for both groups were waxed-up over burnout casting copings (Classic modelling wax-blue, Renfert GmbH, Hilzingen, Germany) and ringless invested in phosphate-based plaster (IPS Press Vest Speed, Ivoclar–Vivadent AG, Schäan, Liechtenstein). An induction centrifugal casting machine (MIE-200C/R, Ordenta, Arganda del Rey, Madrid) was utilised under vacuum pressure (580 mmHg). The casting temperatures were 1450 °C for Group 2 and 1330 °C for Group 3. The structures were then retrieved and cleaned with sandblasting using 50-μm-aluminium-oxide particles for 10 s at a working distance of 5 mm and a pressure of 50 ± 3.5 N/cm^2. Copings were neither retouched nor polished so as to avoid external variations.

Table 1 – Chemical composition of the alloys selected for the study (weight %).

Manufacturing technique and alloy type	Dental alloy composition (weight %)									
	Co	Cr	Mo	Mn	Si	W	C	Ni	Ti	Al
Laser-sintered Co–Cr (LS) (ST2724G, Sint-Tech, Clermont-Ferrand, France) Batch no.: 10d0209	65	27	7	0.5	0.5	–	–	–	–	–
Vacuum-cast Co–Cr (CC) (Gemium-cn, American GMG Inc., Union City, CA, USA) Batch no.: 0711/20cn	63.2	26.3	6.4	0.6	0.9	2.4	0.2	–	–	–
Vacuum-cast Ni–Cr–Ti (CT) (Tilite, Talladium Inc., CA, USA) Batch no.: 112907	0.28	12.20	5	–	–	–	–	75.8	4.57	2.15