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In vitro precision of fit of computer-aided design and computer-aided manufacturing titanium and zirconium dioxide bars

Joannis Katsoulis[a,b,*], *Regina Mericske-Stern*[a], *Douglas M. Yates*[c], *Naomi Izutani*[b], *Norbert Enkling*[a], *Markus B. Blatz*[b]

[a] *Department of Prosthodontics, School of Dental Medicine, University of Bern, Bern, Switzerland*
[b] *Department of Preventive and Restorative Sciences, University of Pennsylvania School of Dental Medicine, Philadelphia, USA*
[c] *PENN Regional Nanotechnology Facility, School of Engineering and Applied Science, University of Pennsylvania, Philadelphia, USA*

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ABSTRACT

Objectives. Optical scanners combined with computer-aided design and computer-aided manufacturing (CAD/CAM) technology provide high accuracy in the fabrication of titanium (TIT) and zirconium dioxide (ZrO) bars. The aim of this study was to compare the precision of fit of CAD/CAM TIT bars produced with a photogrammetric and a laser scanner.
Methods. Twenty rigid CAD/CAM bars were fabricated on one single edentulous master cast with 6 implants in the positions of the second premolars, canines and central incisors. A photogrammetric scanner (P) provided digitized data for TIT-P ($n = 5$) while a laser scanner (L) was used for TIT-L ($n = 5$). The control groups consisted of soldered gold bars (gold, $n = 5$) and ZrO-P with similar bar design. Median vertical distance between implant and bar platforms from non-tightened implants (one-screw test) was calculated from mesial, buccal and distal scanning electron microscope measurements.
Results. Vertical microgaps were not significantly different between TIT-P (median 16 μm; 95% CI 10–27 μm) and TIT-L (25 μm; 13–32 μm). Gold (49 μm; 12–69 μm) had higher values than TIT-P ($p = 0.001$) and TIT-L ($p = 0.008$), while ZrO-P (35 μm; 17–55 μm) exhibited higher values than TIT-P ($p = 0.023$). Misfit values increased in all groups from implant position 23 (3 units) to 15 (10 units), while in gold and TIT-P values decreased from implant 11 toward the most distal implant 15.
Significance. CAD/CAM titanium bars showed high precision of fit using photogrammetric and laser scanners. In comparison, the misfit of ZrO bars (CAM/CAM, photogrammetric scanner) and soldered gold bars was statistically higher but values were clinically acceptable.

* *Corresponding author at:* Department of Prosthodontics, School of Dental Medicine, University of Bern, Freiburgstrasse 7, 3010 Bern, Switzerland. Tel.: +41 31 632 25 39; fax: +41 31 632 49 33.
E-mail address: joannis.katsoulis@zmk.unibe.ch (J. Katsoulis).
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1. Introduction

Computer-aided design and computer-aided manufacturing (CAD/CAM) allows for the fabrication of cement- and screw-retained prostheses made from a single, homogenous block of titanium (TIT) and yttria-stabilized tetragonal zirconia polycrystal (ZrO) [1–3]. CAM uses industrial machines with Computerized Numerical Control (CNC) technology to mill the definitive framework based on the digital CAD information [4]. Therefore, the intraoral three-dimensional (3D) position of the implant needs to be digitized [5]. This can be done in two ways. One is to scan the implant position intraoral with specific scan abutments and an intraoral scanner [6]. However, only few systems allow for this direct method for digital impression taking on abutment level. The second (traditional) way is to scan the implants in the master cast produced with a conventional impression [7,8], with laboratory scan bodies and a laboratory scanner. The introduction of new scanners with laser and photogrammetric technology [9] and specialized milling centers allows for accurate and fast fabrication of CAD/CAM frameworks at a low price. Many companies provide a broad range of products including laboratory scanners and CAD software [3]. While scanning may be performed by local laboratories, some production centers prefer to scan the model in-house for standardizing their procedures and minimizing external manual errors in the initial phase of the digital chain.

Precision of fit of CAD/CAM frameworks has been shown to be more accurate than conventional techniques [10–13]. Although controversially discussed, misfit of a rigid framework may enhance the risk for technical and biological complications [14,15]. To a certain degree, the gap between the components seems to be unavoidable and causes bacterial invasion into the implant-abutment interface [16,17]. This may result in peri-implant infection with deep pockets and crestal bone loss [18,19].

While fixed implant-supported restorations can be cemented or screw-retained, the bar of implant-overdentures has to be screw-retained. Tightening of the occlusal screws in implants with divergent axes will increase the tension within the bar [20] and transfer strains in the implant–bone complex, independent of the bar material [21–24].

However, no studies are available that compare CAD/CAM titanium bars using the latest scanners with different technologies. Thus, the aim of this study was to analyze the precision of fit of CAD/CAM TIT bars fabricated with the latest photogrammetric and laser scanners in comparison with ZrO bars (photogrammetry, CAD/CAM) and conventionally soldered gold bars. The null-hypothesis was that there is no difference in the mean vertical microgap at the implant-bar interface independent from the scanner, the CAD/CAM system and the material used.

2. Materials and methods

2.1. Master cast

A controlled laboratory study was performed as described by Katsoulis et al. [10]. In short, an edentulous maxillary jaw model was made from polyester resin (EFCO Produkte GmbH,

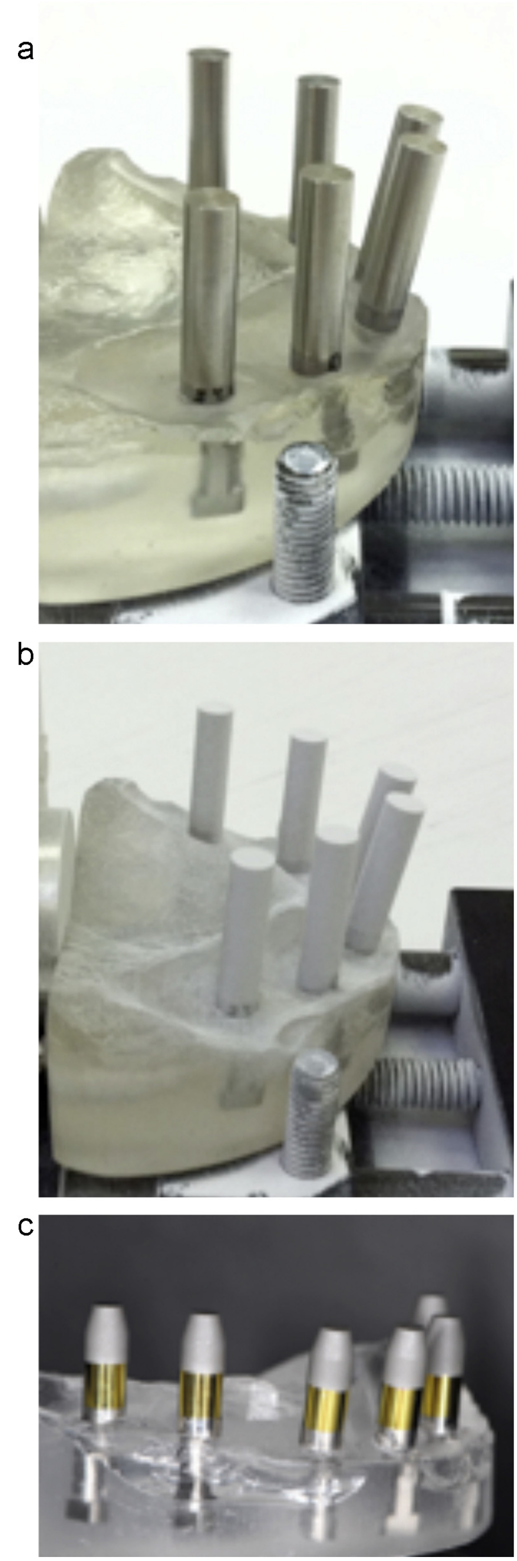

Fig. 1 – Master model with specific screw-retained scan-bodies (a) before and (b) after spray application to improve photogrammetric scanning. Laser scanning (c) was performed with screw-retained scan-bodies of the specific system without spray-application.