Investigation of the deviation during the information transfer from the prosthetic field to the laboratory scanners

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Abstract. The aim of this work is to investigate the deviations during the first stage of the information transfer from the prosthetic field to the dental laboratory scanners for CAD/CAM technology. The first upper left molar on an artificial acrylic resin dental model was prepared for full metal-ceramic crown according to the standard guidelines for step cut. The prepared prosthetic field was scanned by a high-precision industrial scanner with a 1-mm ruby ball stylus and a digital copy was made. With a standard tray, a two-phase two-stage silicon (A-silicone Zhermack hydrorise putty and light body) impression from the acrylic model was taken following the technology recommended by the manufacturer. The impression was powdered with dental stone type IV and a stone model was created 1 h after impression, the time delay taking place ordinarily in dental practice. Using the same measurement methods, the stone model’s surfaces were digitized. Both digital models were compared using the acrylic resin dental model as a reference. The results on the deviation during the transfer of information between the prosthetic field and the stone model represent the first level of inaccuracy in the CAD/CAM processing technology. The difference in the alteration of each dimension according to the reference and the stone model is not more than 20 μm in shrinkage or expansion direction. Thus, the widely used approach for information transfer using stone models from the prosthetic field to laboratory scanner for CAD/CAM technology could be considered as relevant with an accuracy of about ±10 μm. If the silicon impression is performed carefully, the stone models are sufficiently accurate representations of the prosthetic field and their digitalization in the dental laboratory is a reliable starting point for the CAD/CAM technology.

1. Introduction

Creating a precise prosthetic construction requires a correct and accurate reproduction of the prosthetic field in the dental laboratory. Taking a correct impression and casting a suitable stone model is a guarantee that the future construction will fit well.

Among the conditions that the impression must meet is avoiding any volumetric changes and reproducing in detail the prosthetic field [1]. Usually, the impression is powdered with gypsum to create a master model. However, gypsum has some expansion that must be taken into account when choosing an impression material [2].

CAD/CAM systems have been increasingly used for a number of reasons, such as being very precise and saving time for both patients and doctors [3]. Various possibilities exist of transferring the information from the prosthetic field to the laboratory. Scanning the dentition by an intraoral scanner or scanning physical plaster models by a desktop optical scanner are some of them [4]. According to
Nisa Gül Amuk and al., a digital model could be an alternative to the plaster model [5]. A study conducted by Jin-Hun Jeon and al. showed that there is a significant difference between the accuracy achieved by the scanning impression and the stone model [6]. Some authors, as Jan-Frederik Güth and al., found that the digital impressions obtained by scanning a plaster model are less accurate that those obtained by impression scanning or direct scanning of the prosthetic field [7]. However, the correct information transfer is very important in view of the accuracy of the final construction. This is why the deviation during this transfer should be thoroughly investigated.

2. Method and material
For the purpose of this study, the plastic upper jaw model (SpofaDental) shown on fig. 1 was employed as a prosthetic field. Using a standard full-arch tray and additional silicon (Zhermack hydorise putty and light body), a two layer impression was taken from the plastic model (fig. 2).

Figure 1. Upper jaw plastic model

Figure 2. Impression from the plastic model

One hour later, the same impression was powdered with Gypsum class 4 (Elite rock), mixed according to the manufacturer’s instructions (fig. 3).

Figure 3. Stone model from the impression

Figure 4. CMM machine
The plastic and the stone models were scanned by a coordinate measuring machine (Optiv Performance 664, Hexagon Metrology). This device combines optical and tactile sensors; we made use of a six-way touch-trigger probe with a 1-mm diameter ruby-ball stylus with an accuracy according to calibration of ±1.00 μm. Two clouds of points using the same strategy were obtained. The differences between them represent the deviation during the information transfer from the prosthetic field to the laboratory scanner.

3. Results
From each model, 1786 points were measured. Based on them, two 3D mesh models were produced from the cloud of points using the 3D Reshaper software, as shown in fig. 5. Then, the two digital models were superimposed and the difference between them were detected using Geomagic Control X software with the plastic one as a reference, fig. 6.

The comparative analysis showed that about 87.3% of measured points differ within ±100 μm, and 12.2% deviate by about ±10 μm and less. The deviation directions show that the stone model is uniformly shrunken compared with the reference model.

4. Discussion
The result achieved of the comparative analysis leads to several important conclusions. The first is that an error was made in the process of creating the stone model or in the measurements. But the process of creating the impression and the stone model was performed according to the manufacturer's recommendations and no deviations were visually observed before the measurements. The second is that the comparisons are based on a small number of measured points compared to the published in the literature comparative analyses made with non-contact measuring devices. This effect is avoided by comparing 3D mesh models and high measurement accuracy unattainable for contactless scanners. The third possibility is that in some cases this is the achievable accuracy of the process and the good fit is ensured by adjusting the stone model by a dental technician and then by the dentist.

5. Conclusions
The comparative study was performed based on 1786 points measured with high accuracy from reference acrylic and stone models.

The comparative analysis showed that the stone model is smaller by about ± 0.1 mm. This is a relatively large deviation and leads to contradictory conclusions. One of them is that the results are relevant to some cases where the stone model as a transfer of information in the initial stage of CAD/CAM technology will compromise the subsequent work of dental technicians. Such a deviation in the transfer of information could not be detected at an early stage by either the dentist or the dental technician. Further investigation will be conducted with the aim of clarifying the possible reasons of these results.
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