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Original article

Accuracy of various impression materials and methods for two implant systems: An effect size study

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ABSTRACT

Purpose: An accurate impression is required for implant treatment. The aim of this in-vitro study was to determine the effect size of the impression material/method, implant system and implant angulation on impression transfer precision.
Methods: An upper jaw model with three BEGO and three Straumann implants (angulations 0°, 15°, 20°) in the left and right maxilla was used as a reference model. One polyether (Impregum Penta) and two polyvinyl siloxanes (Flexitime Monophase/Aquasil Ultra Monophase) were examined with two impression techniques (open and closed tray). A total of 60 impressions were made. A coordinate measurement machine was used to measure the target variables for 3D-shift, implant axis inclination and implant axis rotation. All the data were subjected to a four-way ANOVA. The effect size (partial eta-squared [η^2_P]) was reported.
Results: The impression material had a significant influence on the 3D shift and the implant axis inclination deviation (p-values = .000), and both factors had very large effect sizes (3D-shift [η^2_P] = .599; implant axis inclination [η^2_P] = .298). Impressions made with polyvinyl siloxane exhibited the highest transfer precision. When the angulation of the implants was larger, more deviations occurred for the implant axis rotational deviation. The implant systems and impression methods showed partially significant variations (p-values = .001–.639) but only very small effect sizes (η^2_P = .001–.031).
Conclusions: The impression material had the greatest effect size on accuracy in terms of the 3D shift and the implant axis inclination. For multiunit restorations with disparallel implants, polyvinyl siloxane materials should be considered. In addition, the effect size of a multivariate investigation should be reported.

1. Introduction

An accurate impression is the most important step in transferring the intraoral situation to a plaster model to manufacture an appropriate prosthetic restoration. For implant treatment in particular, a high accuracy is essential. The influences of different implant angulations, impression materials and impression methods on impression accuracy have been investigated in several studies. However, most of those investigations employed a univariate approach. Several investigators compared impression techniques (open and closed tray) using different impression materials, such as polyvinyl siloxane and polyether [1,2]. Other studies targeted the influence of the implant angulation [3,4]. Overall, the results are variable and even contradictory [5–8]. In general, there is a wide scattering of the data, and some authors only reported significance levels. These varying reports could be due to the range of variations and different results. Thus, all variables studied appear to influence the transfer accuracy [2–5,9,10]; however, to our knowledge, no publication analyzed the effect sizes of the stated variables using a multivariate methodology.

Therefore, the aim of the present study was to investigate the influence of the clinically relevant variables impression material (a), impression method (b), implant system (c) and implant angulation (d) on the transfer accuracy using a multivariate approach. Moreover, the effect size of the influencing factors was calculated and analyzed to determine which parameter has the strongest influence on the transfer accuracy. We performed this

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analysis because only the effect size can show the actual impact of a certain parameter on the outcome.

Although there are a few studies with different model setups, we could only identify one study that analyzed the implant system itself as a variable in a PubMed search [11]. Based on the clinical perspective, we included two different implant systems from different manufacturers (*BEGO Ri-line* bone-level implants [12] and *Straumann Standard Plus* soft tissue-level implants [13]) in this study.

The model setup intends to represent the clinical situation as closely as possible. Therefore, the study was performed using the most common clinical framework conditions in a multivariate approach. The following null hypothesis was tested: neither (a) the impression material, (b) the impression method, (c) the implant angulation nor (d) the implant system influences the linear displacement (3D shift), the implant axis inclination or the rotational deviation caused by impression transfer.

2. Materials and methods

A partial edentulous upper jaw model served as a master model. It was composed of a stainless steel baseplate (10 × 10 cm). For implant placement, six steel tubes were mounted on the baseplate as follows: two tubes were placed in the position of the third molar with a 20° anterior angulation and two tubes in the position of the first molar, which were placed in a straight position of 0° and parallel to each other. The last two tubes were positioned in the region of the first premolar, with a 15° angulation in a buccal direction (Fig. 1). Three BEGO Semados TiPure Plus bone-level implants (RI 4.5 × 15 mm LOT003657 BEGO, Bremen, Germany), were luted into three tubes (4.5 mm inner diameter, 1 mm below gingiva level) in the right maxilla. Three Standard Plus soft tissue-level implants for trans-, semi- or subgingival ingrowth (RN 4.8 × 14 mm LOT CF617 Straumann, Basel, Switzerland), were applied into the three tubes (4.8 mm inner diameter, 1 mm above gingiva level) in the left maxilla. Galvano AGC-Cem adhesive (Wieland Dental, Würzburg, Germany) was used as the luting material. A perpendicularly placed cuboid acted as a reference point in the center of the palate. This setup was integrated into a model of a partial edentulous upper jaw model made of Acryl Ortho acrylic resin (Henry Schein, Langen, Germany). (For construction a model was doubled and filled with wax. The wax pattern was fit on the stainless steel base and the hollows were filled up with wax. A second double impression was taken from the model, the wax was removed and the impression was filled up with the acrylic resin. After polymerization and hardening, the acrylic resin model was fixed on the steel base to receive the finished master model (Fig. 2)).

One polyether (Impregum Penta IP) and two polyvinylsiloxane (Flexitime Monophase FM/Aquasil Ultra Monophase AU) based materials were used as impression materials. For all materials, the manufacturer's instructions were meticulously observed. With all materials a closed tray impression as a well as an open tray technique with custom trays with a thickness of 3 mm and a tubular similar design around the impression copings was carried out (Table 1). For the open tray technique impression copings (BEGO: Sub-Dent open impression, length 12 mm/Straumann: SynOcta RN, length 11.5 mm) were screwed into the implants (Fig. 3). For the closed tray impression plastic transfer caps (BEGO: Sub-Dent closed impression/Straumann: SynOcta RN) were placed on the implants and the impression was taken with conventional stock trays (IP: Algilock/FM, AU: Ehricke) (Fig. 4). The impression was allowed to set 10 min (to compensate for the temperature in the lab). Thereafter the post screws were subsequently loosened (in the open tray technique only) and the impressions removed from the master model. A total of 60 impressions were made, with ten impressions per material and ten impressions per technique. Laboratory analogues were exactly repositioned in the hexagon (BEGO) or octagon (Straumann) and carefully tightened.

Plaster casts were made with Fujirock EP (GC Cor., Tokyo, Japan) and stored under laboratory conditions (23 ± 1 °C, 50 ± 10% relative humidity) for 8 days.

For the measuring procedure, angled abutments with different angulations (0°, 15°, 20°) were placed on the respective angled implants. Stainless steel cuboids (edge length 10 mm) were used as measuring posts and to replace the abutments of the implant (Fig. 5). The measurement posts were cemented perpendicularly on the abutments, with an angulation of 0°, 15° and 20° and appropriate to the diverting angulations of the implants. The measurement posts were luted onto abutments (Zirconioum Cem, GDF, Rosbach, Germany) with parallel alignment, developed to an abutment cuboid.

A Rapid (Thome Präzision, Messel, Germany) coordinate measurement machine with a measurement precision of 2.2 μm was used to measure the target variables with respect to accuracy for the 3D shift, the implant axis inclination and rotation. The machine assessed the difference between the master model and every plaster cast based on the resulting vectors in the x-, y- and z-directions of the reference point to each abutment cuboid. Reference planes were defined to measure the differences in inclination and rotation of the implant axis. All experimental procedures were performed by the same examiner (T.H.).

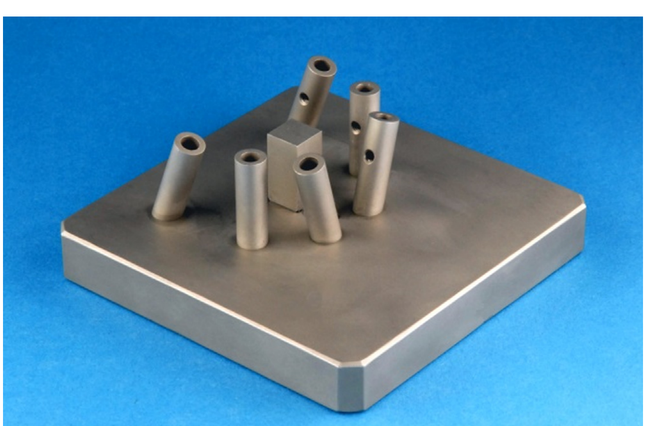

Fig. 1. Steel baseplate and steel tubes.

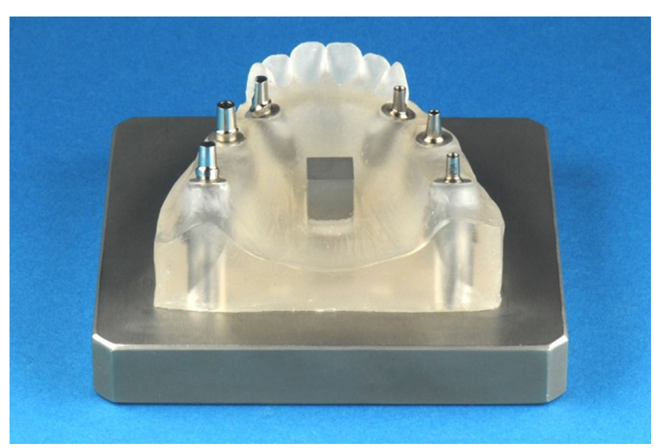

Fig. 2. Master model with six implants, including abutments (BEGO right side and Straumann left side) and the cuboid in the middle of the palate.