Implant Impression Techniques for the Edentulous Jaw: A Summary of Three Studies

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Abstract

Purpose: Precise implant-supported restorations require accurate impressions. Transfer, pick-up, and splinted pick-up are commonly used techniques. Several in vitro studies have compared these impression techniques; however, all studies used mechanical evaluation methods. The purpose of this study was to compare the discrepancies of these impression techniques digitally in vitro and in vivo.

Materials and Methods: Four dental implants were inserted in ten polymer mandibular models bilaterally in the regions of the first molars and canines. Three different impressions were made of each model and the models (original and stone casts) were scanned and digitized. Clinically, four implants were inserted in ten edentulous jaws; transfer and splinted pick-up impressions were made. With inspection software, discrepancies between the different impressions were calculated.

Results: The mean discrepancies in the in vitro study of the original polymer model to stone casts were 124 ± 34 μm for the transfer type, 116 ± 46 μm for the pick-up type, and 80 ± 25 μm for the splinted pick-up type, resulting in a mean discrepancy between the transfer and splinted pick-up type of 44 μm (124 – 80 μm). Clinically, the mean discrepancy between these two impression techniques was 280 μm.

Conclusions: The differing results between the transfer and splinted pick-up techniques of in vitro and in vivo data showed the need for clinical data; however, splinted pick-up impressions seemed to produce the most precise results.

To date, three different implant impression techniques are available: transfer technique with impression posts that remain in place after the impression with closed regular impression trays; pick-up technique with screw-retained impression posts that remain in the impression after removal of the impression from the mouth and individual open impression trays; splinted pick-up technique, which is similar to the previous technique except that the impression copings are rigidly splinted together with acrylic resin (Fig 1). This technique requires a previous impression and fabrication of a stone cast. In the laboratory, screw-retained impression posts are placed into the respective analogs and splinted with acrylic resin. The bars are then sectioned into individual segments and reconnected using acrylic resin in the mouth.1

Various studies have been carried out in relation to this topic.2-17 A review by Lee et al in 2008 summarized many studies and came to following conclusion.18 For the impression of at most three implants, there was no difference in accuracy between the different impression techniques; for more than three implants or when implants were placed with severe angulations relative to each other,3,19,20 the splinted pick-up technique demonstrated the highest accuracy. Some studies mentioned in Lee et al’s review measured linear discrepancy at the connection level of the implants between the experimental model and the cast. The range of discrepancy was from 0.6 to 136 μm.21-28 Semper et al described a horizontal misfit of up to 127 μm by an implant angulation of 20°.29

CAD/CAM (computer aided design/computer assisted manufacturing) fabricated restorations became popular in the last decade.30 Direct data capture with intraoral scanning for multiple implant restorations is nearly impossible. Indirect data capture may accomplish this with improved accuracy.31 If there is a clinical misfit of a zirconia or titanium supra-reconstruction fabricated by CAD/CAM technology, separation, intraoral fixing with acrylic resin, and soldering in the laboratory, as formerly used by gold alloy restorations, are not possible.32 Therefore, another impression and fabrication of the supra-reconstruction would be necessary, which would be time-consuming and
costly. Thus CAD/CAM-fabricated restorations with indirect data capturing require precise casts, making precise impressions indispensable.1

Because of the importance of precise casts for CAD/CAM-fabricated implant supra-reconstructions done by indirect data capturing, the purpose of this study was to digitally evaluate the accuracy of scan-body fit and of three digital impression techniques. In all previous studies on this topic, the measurements were carried out mechanically with analogous tactile techniques. Scan-body fit has not been tested before.

Materials and methods

This study is a summary of three studies, published in Clinical Oral Investigations.1,3,3 The essence of these studies was carved out, and the main focus was concentrated on the single steps and the possibilities for transmission errors of the clinical situation into the dental laboratory. It should help clinicians in their daily practice to produce a better fit when delivering implant-supported fixed dental prostheses.

In vitro testing of the scan-body fit

For digitalization of implant positions, hexed scan-bodies are required (Fig 2). Prior to digital evaluation of the different impression techniques, the fit of the scan-bodies in the original implant and lab analogs was tested, as their fit has a high impact on the accuracy of digital data capturing. The original model (B-3 NM J UK; Frasaco, Tettnang, Germany) with original implants (Screwline Promote ø4.3/13 mm; Camlog Biotechnologies, Wimsheim, Germany) in regions #19, #22, #27, and #30 and a respective stone cast, fabricated by an impression made of the original model, with lab analogs (Camlog Biotechnologies) in regions #19, #22, #27, and #30 were each provided with four scan-bodies (Camlog Biotechnologies). Both the original model and the stone cast were placed in a white-light scanner (Everest Scan Pro; KaVo, Biberach, Germany) to digitize the entire mandibular arch including the four implants with the help of the hexed scan-bodies. After the first scan was completed, the scan-bodies were detached from the implants one by one and then reattached on the same implants. Once all four scan-bodies were relocated, another scan was obtained. This was repeated nine times; data of the ten scans of the original model with implants and the stone casts with lab analogs with the same scan-bodies in the same regions were available. The first scan of the original model and the cast were each used as reference (control) and compared with the remaining nine digital models (target). The data of these scans of the original model and also of the cast were superimposed with inspection software (COMETInspect® plus 4.5; Steinbichler Optotechnik, Neubeuern, Germany), and deviations of the scan-bodies were determined three dimensionally for each: the original model with the original implants and the cast with the lab analogs. For optimal superimposing of the control and the target models (best fit) a 3-run iterative approach (search radius 1, 0.5, and 0.1 mm; 5° search angle) was used.

In vitro testing of the different impression techniques

For the evaluation of the accuracy of the different impression techniques, four implants (Screwline Promote ø4.3/13 mm) were inserted in ten mandibular models (B-3 NM J UK) bilaterally in the regions of the first molars and cuspsids. Three impression techniques were performed for each of the 10 original models, and 30 stone casts were produced. All impressions were made with regular-body polyether impression material (Impregum; 3M-ESPE, Seefeld, Germany); the stone casts were fabricated from class IV gypsum (Rocky Mountain Sahara; Klasse IV Dental GmbH, Augsburg, Germany). All 10 original models and 30 stone casts (3 stone casts of each original model) were scanned with a white-light scanner (Everest Scan Pro). To avoid interchange of the scan-bodies, each scan-body was detached from the implants of the original model and reattached exactly into the same region on the lab analogs of the stone cast. Evaluating the positions of the scan-bodies and accordingly of the implants, all data were imported and processed with inspection software for data comparison (COMETInspect® plus 4.5; Steinbichler Optotechnik, Neubeuern, Germany). The scan of the original model was used as the reference and compared with the three stone casts produced by the different impression techniques. To avoid errors caused by the jaw and the gingiva, all parts of the jaw were faded out, and only the scan-bodies were...
consulted for superimposition of the three digital cast models. The scan-body in the region of the first left molar (region #19) of the original model and the stone cast were superimposed (Fig 3), and the discrepancies of the scan-bodies at the positions of the cuspsids and the first right molar (regions #22, #27, and #30) were calculated by the software three dimensionally (Fig 4). The data were imported into a statistics program (SPSS 17.0; SPSS Inc., Chicago, IL) and compared by the ANOVA test and the Tamhane post-hoc test. The level of statistical significance was set at 5%.

In vivo accuracy comparison of transfer and splinted pick-up techniques

Transfer and splinted pick-up techniques were compared clinically. Ten patients received four two-piece dental implants (Screwline Promote Plus ø3.8 mm and/or ø4.3 mm) placed nearly bilaterally in the regions of the lateral incisors and the first bicuspids (regions #5, #7, #10, and #12) in their edentulous jaws. After osseointegration and second-stage surgery both impression techniques (transfer and splinted pick-up type) of each patient were performed to fabricate bar-retained overdentures. Both stone casts fabricated by the two impressions of patient number 1 were scanned with scan-bodies in place with a white-light scanner (Everest Scan Pro). Following this scan, the stone casts from patients number 2 to 10 were processed in the same manner. Hence, the STL (Standard Tessellation Language) data of 20 scans (patients #1 to 10 with two stone casts produced by means of both impression techniques) were available. When the best fit of scan-body number 1 (region #5) was found, the discrepancies of the three scan-bodies, number 2, number 3, and...
number 4 (regions #7, #10, and #12), were calculated by inspection software (COMETInspect® plus 4.5), so the deviation between the two stone casts produced by the two impression techniques was calculated three dimensionally. This procedure was done with all ten patients. Also the span between scan-bodies number 1 to 2, number 1 to 3, and number 1 to 4 were measured and compared with the discrepancies of the scan-bodies. The calculated discrepancies of the three scan-bodies, number 2, number 3, and number 4, for each patient were imported into a statistics program (SPSS 20.0, SPSS Inc.). The distribution of the data was tested by the Kolmogorov–Smirnov test. Data were compared by the ANOVA test. The level of statistical significance was set at 5%.

**Results**

**In vitro testing of the scan-body fit**

The mean discrepancy of the reproducible scan-body fit in the original implant was 13 ± 2.6 µm, and the mean discrepancy of the scan-body fit in the lab analog was 5 ± 2.0 µm (these results are reported in Stimmelmayr et al).\(^3\)

**In vitro testing of the different impression techniques**

The overall in vitro discrepancy for the transfer technique was 124 ± 34 µm, 116 ± 46 µm for the pick-up technique, and 80 ± 25 µm for the splinted pick-up technique.\(^1\) The in vitro discrepancy between the transfer and the splinted pick-up techniques was 44 µm (124 – 80 µm).

**In vivo accuracy comparison of transfer and splinted pick-up techniques**

The overall clinical discrepancy between the transfer and the splinted pick-up techniques was 280 µm. The discrepancies of the scan-bodies increased from scan-body number 2 (192 ± 96 µm), to number 3 (282 ± 97 µm), and number 4 (366 ± 114 µm). Also the distances between scan-bodies number 1 increased to scan-bodies number 2, number 3, and number 4. Therefore, a regression line was drawn from the discrepancies relating to the distances. There was almost a linear correlation (Fig 5).\(^34\)

**Discussion**

No study has previously measured the reproducibility of implant scan-body fit. Because of the better scan-body fit in the lab analogs (5 µm discrepancy) compared to the fit in the original implants (13 µm discrepancy), it was concluded that improvement of the fit of scan-bodies on original dental implants offers the potential to enhance the accuracy of implant impressions. The most accurate impression method was the splinted pick-up technique. The un-splinted pick-up technique was more precise than the transfer technique; however, statistically significant differences could be found only between the splinted pick-up technique and transfer techniques.

Practitioners should consider that these results specifically refer to the Camlog implant system. Further implant systems might lead to different results and inaccuracies. Therefore, a comparison of transfer registrations of various systems would be interesting to verify the data of this manuscript and to provide reliable data for other systems; however, the presented results are in line with results found in current literature. Several studies that evaluated the accuracy of the transfer in comparison to the pick-up technique can be found.\(^2,5,9,12,15,17,20,21,26\) Within these studies, two showed a higher accuracy of transfer impressions, and five showed better results with the pick-up technique. Seven of the studies found no difference between the two techniques. Also, when the splinted and non-splinted pick-up techniques are compared, some authors prefer to use non-splinted impression posts,\(^10,16\) whereas others showed that impressions using splinted posts lead to better results.\(^2,7,8,17,20,24,25\) However, this is a controversial issue, as various studies found neither of the two techniques to be superior.\(^5,9,11,14,15,22,23\)

In a literature review, Lee et al referred to similar results with pick-up or transfer technique in situations of up to three implants. For more than three implants, the technique using splinted impression posts and open trays was reported to be the most accurate technique to transfer the clinical implant position to a plaster cast.\(^16\) In addition to the absolute number of implants, the angulation of the implants under each other also influences the transfer accuracy of intraoral implants.\(^3,19,20,29\) The implants in the in vitro part of this study were not placed parallel due to the anatomic conditions of the edentulous lower jaws. This means the ten original models were not identical; however, the study design of this in vitro study was very close to clinical reality. That said, when comparing the data (transfer and splinted pick-up) from the in vitro study (44 µm) to the in vivo study (280 µm), a huge difference of 236 µm was found. This fact demonstrates that in vitro results under predefined conditions might not often reflect the clinical reality, because they do not consider clinical conditions. The relation between the transfer accuracy and the distance of the implants leads to the conclusion that the greater the span between implants, the greater the inaccuracy of the transfer.

On the other hand, a small discrepancy in the superimposition of scan-body number 1 would lead to a large “shift-effect” on the positions of the other scan-bodies (2 to 4), especially on the scan-body furthest away. Therefore, short-span implant rehabilitations might be advantageous in daily practice, as they are probably more precise.

**Conclusions**

The results of these three studies demonstrated the following:

1. Impression technique influences accuracy of implant transfers.
2. The splinted pick-up technique demonstrated the greatest accuracy, and the authors believe it should be used for impressions of four or more implants in edentulous jaws.
3. Long-span prosthodontic rehabilitations have higher misfits when compared to short-span rehabilitations.
4. Discrepancies between transfer and splinted pick-up techniques in the in vivo study (280 µm) were six times higher than the results reported in the in vitro study (44 µm).
References