Received: 18 August 2020 | Revised: 10 January 2021 | Accepted: 13 January 2021
DOI: 10.1111/clr.13715

ORIGINAL RESEARCH

CLINICAL ORAL IMPLANTS RESEARCH WILEY

A comparative clinical study on the transfer accuracy of conventional and digital implant impressions using a new reference key-based method

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Abstract

Objectives: The objective of this study was to systematically compare the transfer accuracy of conventional and digital implant impressions in patients using a new reference key-based method.

Material and methods: Thirty-nine cases were included in the study (upper jaw 22 edentulous, 8 partially edentulous, average distance between implants 30.15 ± 11.18 mm; lower jaw 6 cases edentulous, 3 cases partially edentulous, average distance between implants 33.19 ± 14.85 mm). Individual reference keys were manufactured and reversibly fixed on implants. A conventional (CVI) and a digital (DI) implant impression was made. The implant positions (center points) of conventional and digital models were measured (coordinate-measuring machine/three-dimensional analysis software) and superimposed with the positions of the reference keys to compare the deviations of the conventional and digital models. For statistical analysis, ANOVA with MIXED procedure was applied ($p < .05$).

Results: Mean deviation ranged from 0.040±0.029 mm (DI/upper jaw) to 0.079 ± 0.050 mm (DI/lower jaw). There were significant differences between the CVI and DI impressions in the lower jaw ($p < .05$). No significant differences in transfer accuracy were found between partially and completely edentulous patients for the impression methods.

Conclusions: Within the limits of the present study, it can be concluded that full-arch digital implant impressions of the upper jaw in partially or completely edentulous patients showed comparable results to conventional implant impressions. However, with regard to the implant position transfer accuracy, there are still limitations for digital impression in the lower jaw.

KEYWORDS

clinical study, dental implants, dental impression technique, digital dentistry, dimensional measurement accuracy, intraoral scanner

1 | INTRODUCTION

In recent years, implant-supported prosthodontic restorations have significantly increased (Patzelt et al., 2014). Their survival time is supposed to be influenced by several factors such as oral hygiene, systemic diseases, and smoking behavior (Howe et al., 2019; Moraschini et al., 2015). However, from a prosthetic point of view the passive fit—the accuracy of fit of the restoration—may be as well influential. To achieve an appropriate passive fit, an accurate three-dimensional transfer of the intraoral implant position to the model cast is indispensable (Abduo et al., 2010; Katsoulis et al., 2017). This is often challenging, as in contrast to natural teeth, implants have an inherent mobility of only 8–15 μm (Chang et al., 2012), which decreases with ongoing osseointegration (Winter, Klein, & Karl, 2013a, 2013b). Thus, the transfer accuracy of implant positions must be as accurate as possible so that the remaining discrepancies can be compensated by summation of the elasticity of the bone between the implants, the residual mobility of the implants, and the manufacturing tolerances of the abutments (Franca et al., 2015; Mangano et al., 2017). However, the remaining discrepancies resulting from conventional implant impressions are often higher, particularly for full-arch restorations. Furthermore, process-related errors resulting from disinfecting impressions to model casting may also reduce the transfer accuracy of the conventional implant impression (Wulfman et al., 2019). In addition, non-parallel implant abutments are widespread, owing to the often seen limited bone supply. Moreover, while impression making, compression of the impression material may lead to a three-dimensional displacement and incorrect transfer of the implant position to the model cast (Schmidt et al., 2018). Hence, intraorally bonded tertiary structures are currently required to compensate for the three-dimensional transfer discrepancies in order to achieve a tension-free, passive fit of the implant-supported prosthodontic restoration (Weigel et al., 1994).

In recent years, digital impression making has become more popular. In contrast to previous findings, which reported a significantly lower accuracy for digital full-arch impressions with intraoral scanners (IOSs) compared with conventional impressions (Güth et al., 2016; Kuhr et al., 2016), the current clinical study did not reveal a significant difference between the latest generations of IOS and conventional polyether impressions regarding the accuracy of full-arch impressions (Schmidt et al., 2020). Thus, digital implant impressions may have a decisive advantage over conventional impression techniques because the described limitations, such as process-related errors, are omitted. However, the three-dimensional scan data set of IOS is composed of single images. If this "matching process" is flawed, a three-dimensional shift may also occur, resulting in transfer errors of the implant position to the model (Güth et al., 2016; Keul & Güth, 2020; Kuhr et al., 2016; Park et al., 2015; Schmidt, Klussmann, et al., 2020). As overall clinical data are sparse, there is an urgent need for valid clinical data on conventional and digital implant impressions as described by Papaspyridakos et al. (Papaspyridakos et al., 2020), and to the best of our knowledge, there is no clinical study describing implant impressions using reference keys.

For exact determination and comparison of the transfer accuracy of different impression methods, a reference data set or structure is inevitable (Güth et al., 2016; Keul & Güth, 2020; Kuhr et al., 2016; Park et al., 2015; Schmidt, Klussmann, et al., 2020). This can be easily implemented in laboratory studies, by taking a precise initial image of a jaw model in the micro-CT or by attaching measuring bodies to create a reference data set (Schmidt et al., 2020). However, there is no natural reference structure available in patients (Güth et al., 2016; Keul & Güth, 2020; Schmidt, Billig, et al., 2020). Therefore, Nedelcu et al. used a high-precision extraoral industrial scanner intraorally to create a reference data set. However, this method is limited only to anterior areas due to anatomical restrictions (Nedelcu et al., 2018).

To overcome these limitations, reference keys were developed and successfully applied in previous clinical studies to investigate the transfer accuracy of full-arch impressions in patients (Güth et al., 2016; Keul & Güth, 2020; Kuhr et al., 2016; Schmidt, Klussmann, et al., 2020). However, to date, these reference keys are only suitable for the examination of fully dentulous jaws and not for the examination of implant impressions, especially in partially or completely edentulous jaws. Therefore, Schmidt et al. (Schmidt, Billig, et al., 2020) developed a new method for intraoral registration of the three-dimensional implant position with an implant reference key, suitable to transfer the correct implant position with significantly higher accuracy (<10 μm) compared with conventional or digital methods. Additionally, a proof of principle was shown (Schmidt, Billig, et al., 2020).

Therefore, the aim of this study was to compare the transfer accuracy of conventional and digital implant impressions using this new implant reference key-based method.

The following null hypothesis was investigated: In terms of transfer accuracy, there is no significant difference between conventional and digital implant impressions in patients. Furthermore, the number of remaining teeth was also investigated as a covariate.

2 | MATERIAL AND METHODS

The clinical study included 20 patients who received at least three implants in each jaw in two different quadrants in the last six months. In addition, implants had to be arranged in a triangular geometry (Figure 1); this was based on a known method from a previous study (Schmidt, Billig, et al., 2020).

Because some patients had more than three implants per jaw, different triangle-geometry implant configurations could be examined. Thus, data from 39 cases were collected. From the first impression to the final analysis, each case was handled separately. Table 1 shows the distribution of cases with the number of remaining teeth. A sample size (power calculation) was performed before the clinical trial was conducted ($\alpha = 0.05$, $\beta = 0.20$, power= 0.80, number of cases needed = 20).

A total of 86 implants from two manufacturers were used in the study: 18 ProActive Straight (Neoss, Cologne, Germany), 48 Narrow

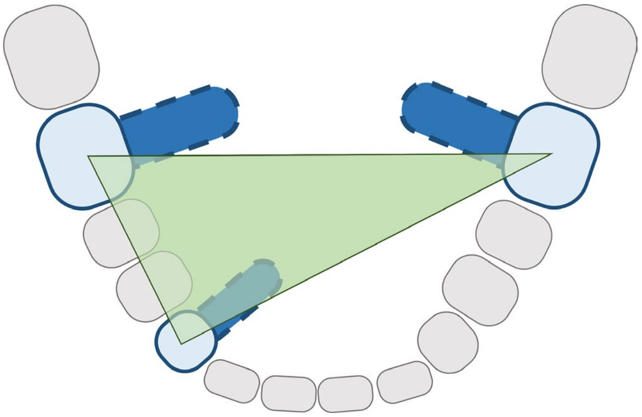


FIGURE 1 Schematic drawing of an example of a feasible implant configuration for inclusion in the study: Three implants in two quadrants per jaw arranged in a triangular geometry (green triangle)

Crossfit(NC), and 20 Regular Crossfit(RC) Bone Level (Straumann, Freiburg, Germany) in 20 patients. Patients with severe systemic diseases or multimorbid conditions were excluded from the study. Only implants with a maximum inclination of 15 degrees were included in the study (Ozan & Hamis, 2019; Schmidt et al., 2018).

The present study was conducted in accordance with the guidelines of World Medical Association Declaration of Helsinki and approved by the local Ethics Committee of the Justus Liebig University Giessen (Ref. no. 163/15). Furthermore, the study was registered in the German Register of Clinical Trials (DRKS00014948) (CONSORT Checklist). To standardize the experimental procedure, all impressions were made by one dentist (P.E.R.) experienced in conventional and digital impression making.

2.1 | Data acquisition

At the first appointment, an alginate impression with a stock tray was made of the respective jaw in dental practice and plaster models were cast with type IV dental plaster (Implant-rock, Picodent, Wipperfürth, Germany) in a dental laboratory for each patient. Subsequently, an individual reference key made of a cobalt–chromium–molybdenum alloy (Co-Cr-Mo) was fabricated according to the methodology described by Schmidt et al. (Schmidt, Billig, et al., 2020). This reference key comprised of three tubes, which were rigidly connected to each other via metal bars (diameter 4 mm). A circular distance of 1 mm ensured sufficient space for subsequent intraoral impression posts' fixation of the implant position with reference keys (Figure 2a).

Furthermore, an individual resin tray (Palatray XL, Kulzer, Hanau, Germany) was fabricated.

At second appointment, for determination of the exact implant position, implant system-specific impression posts with hexagonal connecting structure were screwed into the implants (torque of 10 Ncm) and the reference key was inserted in the mouth. For fixation, an impression material (Impregum Penta, 3M, Seefeld, Germany) was applied between the tubes and the impression post. After a setting time of six min, the impression posts fixed in the reference key were unscrewed and removed from the patient's mouth.

Subsequently, new implant system-specific impression posts with hexagonal connecting structure were screwed into the implants (torque of 10 Ncm) and a conventional open implant impression (pick-up technique) with the custom resin tray was made. Polyether (Impregum Penta) was used as the impression material. All impressions were taken at the implant level. After a setting time of

TABLE 1 Distribution of cases regarding jaw and tooth status

		Partially edentulous [*n*] (distance between the implants mean ± standard deviation [mm])		
	Edentulous [*n*] (distance between the implants mean ± standard deviation [mm])	< 5 remaining teeth	5–10 remaining teeth	> 10 remaining teeth
Upper jaw	22 (30.26 ± 9.75)	3 (27.03 ± 12.17)	5 (31.53 ± 15.33)	0
Lower jaw	6 (31.11 ± 11.61)	0	3 (37.34 ± 19.12)	0

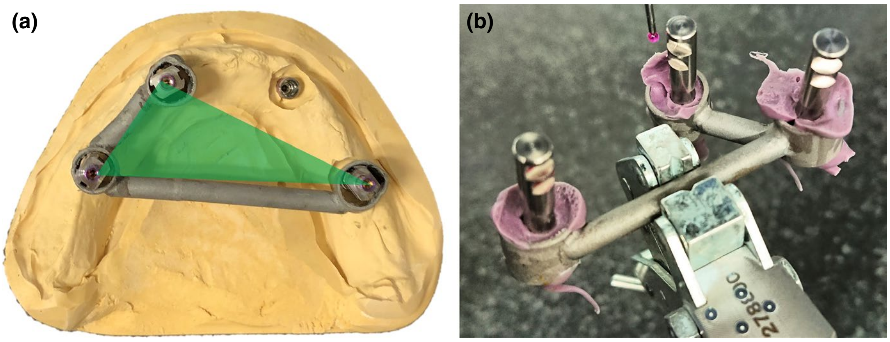


FIGURE 2 (a-b) Example of an individual reference key with three tubes (FDI #33, #36, and #46) rigidly connected to each other via two metal bars (green triangle displays triangle geometry of implants; a). Individual reference key during measurement within the coordinate measurement machine (red sphere = tactile sensor; b)

six minutes, the impression posts were unscrewed, and the impression with inherent impression posts was removed from the patient's mouth.

Finally, a digital implant impression was made with the intraoral scanner Trios 3 Pod (IOS, version 1.9.1.2, normal scanning speed mode, 3Shape). Prior to each scan, TRIOS 3 pod was calibrated with the respective calibration tip provided by the manufacturer. To transfer the implant position, implant system-specific scan bodies from NT Trading (Karlsruhe)*** were screwed into the implants (torque 10 Ncm). To reduce saliva, Dry Tips (Microbrush International, Grafton, USA) and OptraGate lip and cheek retractor (Ivoclar Vivadent, Schaan, Lichtenstein) were used. To scan the IOS-specific, scanning path recommended by Müller et al. (Müller et al., 2016) was applied, beginning with the occlusal surfaces, followed by the lingual or palatal surfaces and turning back on the vestibular surfaces. In the upper jaw, scans were started in the first quadrant and in the lower jaw, the fourth quadrant. All scan data sets were exported in Standard Tessellation Language (STL) format for analysis.

Figure 3 shows a schematic overview of the clinical examination and analysis.

2.2 | Data evaluation

The analysis of the reference keys and conventional and digital implant impressions was conducted at a standardized room temperature of 23°C ± 1°C and a constant humidity (50% ± 10%).

In accordance with the measurement method described by Schmidt et al. (Schmidt, Billig, et al., 2020), manufacturer-specific laboratory analogs were first screwed (10 Ncm) into the impression posts in the reference key, which were previously measured in a coordinate-measuring machine (CMM, Thome Rapid, Messel, Germany, accuracy < 3 µm). The reference key was then rigidly fixed in the CMM for tactile measurement of the center points of the implant position (Figure 2b). Prior to the examination, the roundness (<3.5 µm) of the ruby head (SP25M, Renishaw, Pliezhausen, Germany; diameter 1.502 mm) was evaluated. The measurement was repeated three times and recorded by the computer software Metrolog X10 (Metrologic Group, Meylan, France), and the average value was calculated. According to VDI 2,617, the measurement uncertainty was 3 ± (L/300) µm for three-dimensional length measurements. The three-dimensional coordinates of the measured center points were imported in Initial Graphics Exchange Specification (IGES) format into the measurement software GOM Inspect 2019 (Braunschweig, Germany).

To evaluate the conventional implant impression, the laboratory analogs specified by the manufacturer were screwed into impression posts (torque 10 Ncm) and the impressions were poured with type IV plaster (Implant-rock golden brown, Picodent, Wipperfürth, Germany). In order to ensure that the impression material had enough time to reset, the model was fabricated at the earliest two hours after the impression was made from the patient's mouth. To wait for the complete plaster expansion phase, the models were stored for seven days under laboratory conditions. For measurement, the exact lengths of the respective scan

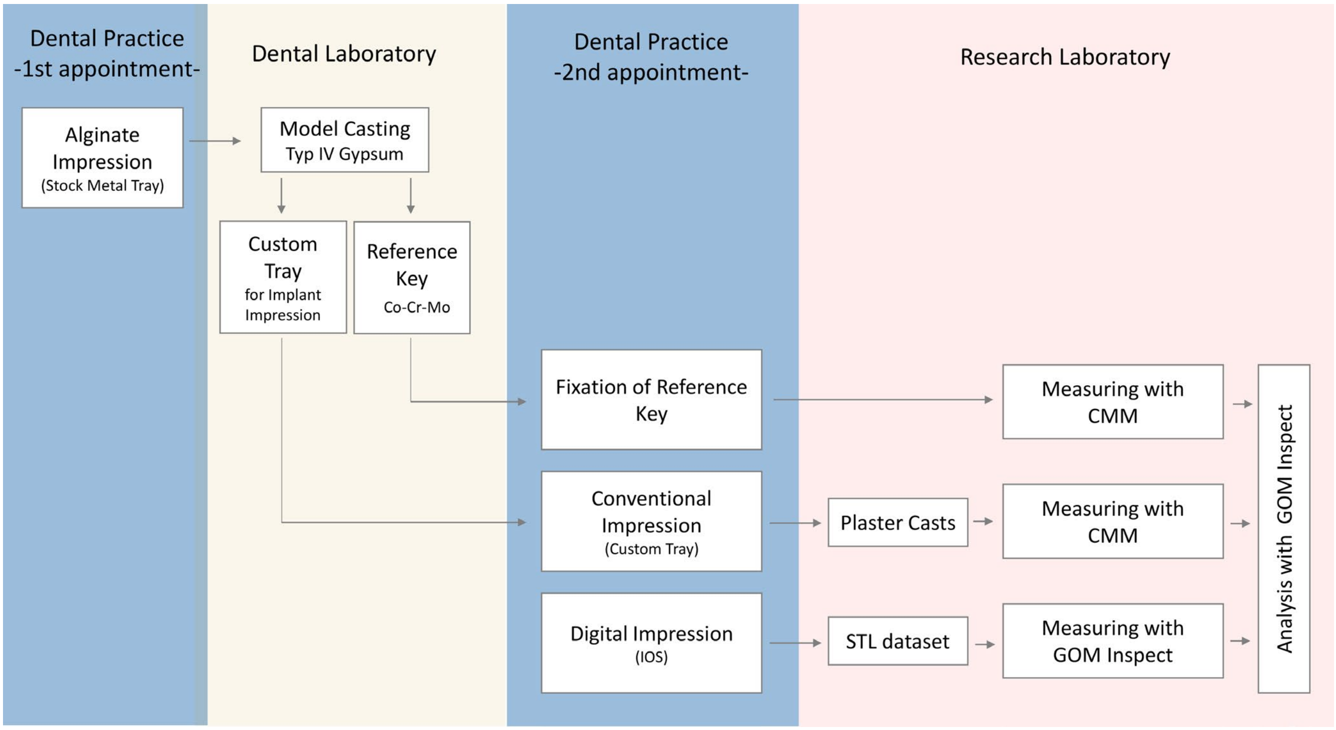


FIGURE 3 Overview over the entire clinical examination and analysis (IOS = intraoral scanner, CMM = coordinate measurement machine, GOM = 3D analysis software, STL = standard tessellation language, $n = 39$ cases)

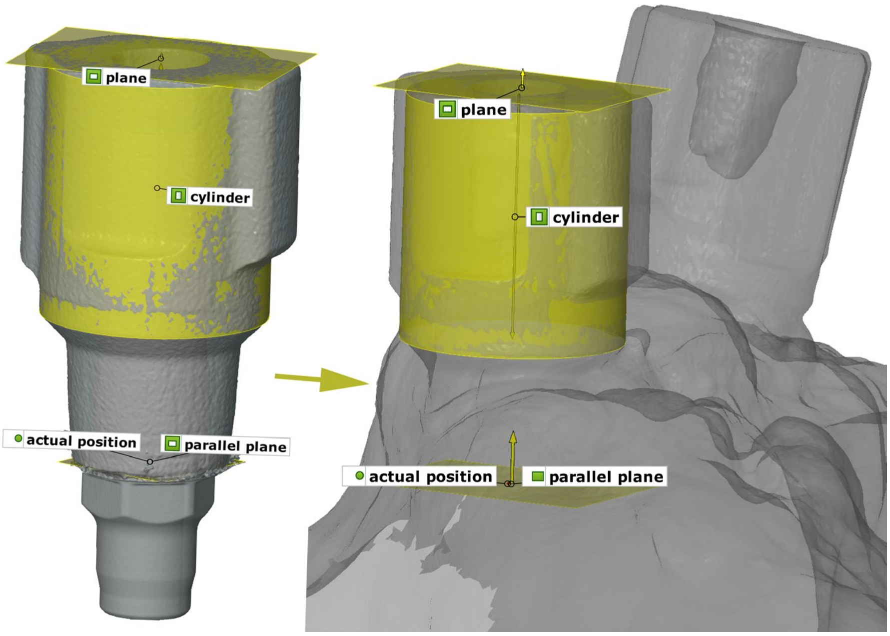


FIGURE 4 Schematic representation of the determination of the current position of the point on the scan body by planes and cylinders in the intraoral scan (right) and corresponding scan body (left)

bodies (NT trading) were measured with the CMM and screwed into the model. A plane and a cylinder were constructed on the scan body to determine the deviations of the centers of the implant position. This plane was transferred downwards with the previously determined lengths of the scan bodies, and a parallel plane was constructed. Figure 4 shows a schematic overview of the measurements, which were performed identically in the conventional and digital measurements.

The data were also imported into the GOM Inspect 2019 Software in the IGES format.

The STL data of the digital models were imported into GOM Inspect 2019, and the deviation of the implant position was determined by creating planes and cylinders on the corresponding scan bodies. The center points of the implant positions of the conventional and digital models were each defined as actual positions and superimposed with the center points of the reference keys (target position) according to the best-fit method. Therefore, it was possible to compare the deviations of the conventional and digital models with a reference structure (Figure 5).

Statistical analysis was conducted using IBM statistics 26 (Armonk, USA); the alpha error level was set at 5%. Data were checked for normal distribution (Kolmogorov–Smirnov /Shapiro–Wilk), and a normal distribution was found. An ANOVA with MIXED procedure was performed, and the mean value and the square root of the dependent variable were calculated and analyzed for pairwise comparisons; the correlations were considered in a multi-level model (variance component model, random-intercept model). For the analysis, unsigned values of the deviations were used. For a better overview, results were presented in boxplot format; trueness (mean) and precision (*SD*) were reported according to ISO 5,725 (International O rganization for Standardization, 1994).

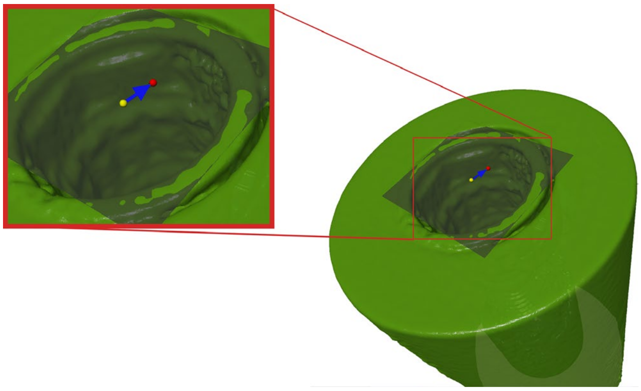


FIGURE 5 Schematic drawing of the deviation (blue arrow) between the target position (center point; yellow dot) and actual position (red dot) of the implant position

3 | RESULTS

Regarding the center point deviation, no significant difference was detected between the conventional and digital impression techniques in the upper jaw, and the conventional impressions in the upper and lower jaw, whereas significant differences were observed between the conventional and digital impression techniques in the lower jaw and between the digital impressions in the upper and lower jaw (Figure 6, $p < .05$).

However, with regard to the particular number of remaining teeth in the partially edentulous group, no significant differences were observed. Pooled data of partially edentulous cases compared with edentulous patients revealed a tendency toward more accurate results for digital impressions in partially edentulous patients.

FIGURE 6 Boxplot diagram of the conventional and digital impression technique in upper and lower jaws regarding the center point deviation [mm] (significant differences are indicated with an asterisk (*), and the zero line represents the reference key)

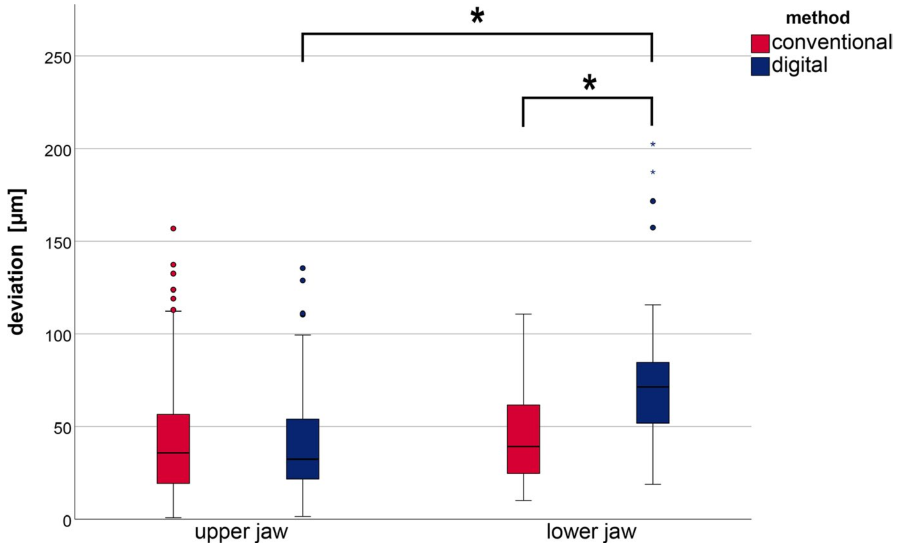
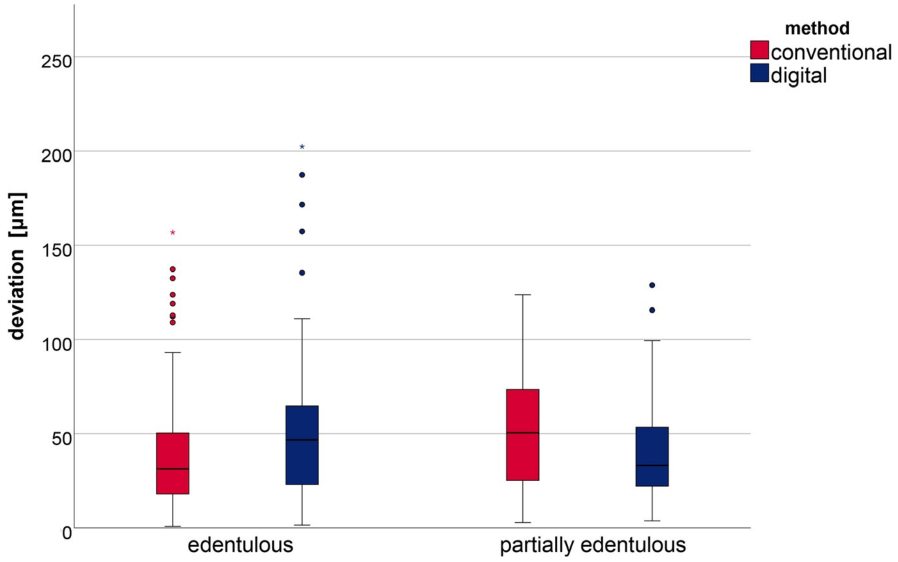


FIGURE 7 Boxplot diagram of the conventional and digital impression technique in partially and complete edentulous patients (the zero line represents the reference key)



Furthermore, less deviation could be found for conventional impressions in edentulous cases (Figure 7).

The point deviation for precision and trueness according to ISO 5,725 in mean value and standard deviation is displayed in Table 2.

The null hypothesis that there are no significant differences in transfer accuracy between conventional and digital implant impressions in patients has to be rejected. There was no statistical influence of the remaining teeth as covariates.

4 | DISCUSSION

All conventional and digital impressions were made by one dentist with several years of experience in private practice. Thus, an operator cause-related bias was eliminated in advance (Ender & Mehl, 2013b). In addition, it was possible to integrate the study into a typical treatment procedure, which ensured proximity to daily patient care.

For conventional impressions, the often recommended pick-up technique (Schmidt et al., 2018) with the corresponding impression material was used. Digital impressions were obtained using an IOS used in numerous studies (Hamalian et al., 2011; Moreira et al., 2015; Stimmelmayr et al., 2012). Because a previous study showed significant differences between different scan bodies regarding manufacturing tolerance, the scan body with the lowest manufacturing tolerances was used in this study (Schmidt et al., 2019).

The use of custom-made reference keys allowed for a direct comparison of the two impression methods (Keul & Güth, 2020). Although the results are inevitable affected by the measuring uncertainty (± 10 µm) of the method itself, it can be concluded that the applied technique is a suitable means to assess the transfer accuracy in this experimental setting (Schmidt, Billig, et al., 2020) as the results were significantly higher. For fixation of the impression posts in the tubes of the reference keys, polyether was used. Though the final hardness of the material is lower than of pattern resin, which may have been an alternative, the shrinkage of polyether is decisively

TABLE 2 Deviations (mean ± standard deviation [mm]) between conventional and digital impressions (jaw and tooth status) and statistical analysis for trueness (mean) and precision (*SD*) according to ISO 5,725

Jaw (mean ± standard deviation (*SD*) from reference key)			***p*-value**
Upper jaw	Conventional (0.045 ± 0.035 mm)	Digital (0.040 ± 0.029 mm)	.822
Lower jaw	Conventional (0.046 ± 0.027 mm)	Digital (0.079 ± 0.050 mm)	**.014**
Method (jaw)			
Conventional	Upper jaw	Lower jaw	.700
Digital	Upper jaw	Lower jaw	**.005**
Tooth			
Edentulous	Conventional (0.042 ± 0.034 mm)	Digital (0.052 ± 0.040 mm)	.136
Partially edentulous	Conventional (0.053 ± 0.031 mm)	Digital (0.043 ± 0.031 mm)	.285
Method (tooth)			
Conventional	Edentulous	Partially edentulous	.583
Digital	Edentulous	Partially edentulous	.653

Note: Significant differences (*p*-value < .05) are highlighted in bold.

lower. This was also confirmed in pretests and in investigations from Gibbs et al. and Walker at al. (Gibbs et al., 2014; Walker et al., 2007).

Overall, compared to other measuring techniques (scanning, digitization of models)(Basaki et al., 2017; Kim, Seo, & Kim, 2019), the mean uncertainty is extremely low, which is a clear advantage of the reference key-based method.

With regard to the analysis of accuracy, trueness and precision was assessed according to ISO 5725–1 (International Organization for Standardization, 1994). Though the method for describing trueness is generally agreed on different approaches for the assessment of precision and have been reported (Aswani et al., 2020; Ender & Mehl, 2013a) (28, 29). We decided to use the ISO approach as a standardized method, which we consider helpful for a later comparison of our results with studies to come (Keul & Güth, 2020).

In comparison with numerous other investigations, in the present study, the conventional models were measured directly with a CMM. This made it possible to avoid further errors, which can often occur when the models are digitized again using laboratory scanners (Mühlemann et al., 2018).

As scan bodies may have an influence on the accuracy of intraoral scans (Schmidt et al., 2019), the scan bodies were measured and used based on a previous study. In addition, the scanbodies used were screwed into model implants and laboratory analogs and measured with a coordinate-measuring machine. This ensured a high level of standardization during screwing in. There may be an influence on the accuracy when screwing into the implant in the patient, but this is to be classified as very low in comparison.

As a shortcoming of the study, the angulation of the implants was not analyzed. This was due to the fact that close to parallel implants were necessary for fixation of the custom reference key. Therefore, implants with an angulation of more than 15 degrees were excluded from the clinical study. This is a clear limitation of the present study, as angulated implants are regularly found in a clinical setting.

In principle, comparison with other studies is difficult, as there are currently no clinical studies for which an external reference has been used. Nevertheless, the results of the available data with regard to the conventional impression are comparable to those of other investigations, which also reported deviations of approximately 11 µm to 70 µm (Basaki et al., 2017; Chew et al., 2017; Flügge et al., 2016; Gedrimiene et al., 2019; Huang et al., 2020; Kim et al., 2019; Lin et al., 2015; Malik et al., 2018; Menini et al., 2018; Moura et al., 2019; Rech-Ortega et al., 2019; Revilla-León et al., 2020; Rutkunas et al., 2020).

In contrast, investigations by Alshabarty et al. (Alsharbaty et al., 2019), Amin et al. (Amin et al., 2017) and—in one measured distance—Rech-Ortega et al. (Rech-Ortega et al., 2019) showed deviations of approx. 160 µm. In contrast, Ozan and Hamis (Ozan & Hamis, 2019) measured deviations of over 400 µm. However, a direct comparison is only possible to a limited extent due to the reference structure available in the present study, the clinical setup, and the consideration of the center point deviations in comparison with distance deviations between individual implants.

Even though there were no significant differences between the upper and lower jaws in conventional impression making, a tendency of decreasing accuracy was observed in partially edentulous patients. This may be due to a compression of the impression material during setting and distortions resulting from the removal of the impression from the patient's mouth. In contrast, these compressions do not occur in edentulous patients, which is supposed to lead to a higher transfer accuracy.

With regard to the results of digital impressions, Moura et al. showed significantly higher deviations from 30 µm to 1900 µm in contrast to the present study (Moura et al., 2019). This could be due to the evaluation of linear distances and on the other hand a different evaluation by superimposing scan bodies. In the study by Lin et al. (Lin et al., 2015), higher deviations were also measured. This may be due to the older software or hardware versions of the intraoral scanners. Lower deviations could be found by few studies (Fukazawa et al., 2017; Malik et al., 2018; Menini et al., 2018; Moura et al., 2019; Papaspyridakos et al., 2014, 2016; Rutkunas et al., 2020). These results could be due to the different methodologies and study designs of the investigations (e.g., short distances between the implants).

The results for the digital impressions of the present study are comparable to the results of numerous other investigations (Amin et al., 2017; Chew et al., 2017; Flügge et al., 2016; Gedrimiene et al., 2019; Huang et al., 2020; Malik et al., 2018; Moura et al., 2019; Rech-Ortega et al., 2019; Revilla-León et al., 2020). In contrast to studies by Renne et al. (Renne et al., 2017) and Gimenez et al. (Gimenez et al., 2014), no increasing deviations were observed with increasing scan path length. However, this could be due to the different study designs. Additionally, for daily clinical work, it should be noted that the data obtained from an IOS are not directly used but first processed into a digital model using a model builder software. During this process—dependent on the algorithms implemented in the software—errors may be reduced during the alignment process of the CAD data from the scanbody (taken from the software library of the model builder) to the STL data set from the IOS. Thus, in clinical reality the resulting error may be smaller as our results.

Nevertheless, the data clearly show that the accuracy of digital impressions decreases significantly in edentulous patients compared with partially edentulous patients. This can be explained by the fact that there are no reference points in edentulous jaws. Although the differences between edentulous and partially edentulous patients were not significant in terms of digital impressions, there is a clear tendency for digital impressions to show more accurate results in partially edentulous patients. This can be explained in a similar way to waypoints on a map, since the IOS takes additional waypoints during the scan due to the existing tooth structures, and can therefore more accurately take the superimposition of the individual images.

While the experiments on the model led to a coordinate-based evaluation (Gimenez et al., 2014; Renne et al., 2017), the present study used a point-to-point comparison. As already described in the in vitro study by Schmidt et al. (Schmidt, Billig, et al., 2020), no identical coordinate systems can be superimposed in patients. However, from a clinical point of view, this is very similar to the procedure for fitting a framework structure. In this case too, the ideal insertion and direction of the superstructure are determined after a kind of best fit method; the framework is not fitted gradually over individual abutments.

Based on the findings of this clinical study, it can be concluded that full-arch digital implant impressions of the upper jaw in partially or completely edentulous patients showed comparable results to conventional implant impressions. However, with regard to the implant transfer accuracy, there are still limitations for digital impression in the lower jaw. However, further developments can be expected in the field of digital impression techniques.

ACKNOWLEDGEMENTS

The authors would like to thank Dr. Jan-Wilhelm Billig for his helpful assistance with the coordinate-measuring machine. Furthermore, we gratefully acknowledge the support of our biostatistician Dr. Johannes Herrmann for the statistical analysis.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

AUTHOR CONTRIBUTION

Alexander Schmidt: Conceptualization (equal); Data curation (lead); Methodology (equal); Project administration (equal); Software (equal); Validation (equal); Writing-original draft (equal). **Peter Engelbert Rein:** Investigation (lead); Resources (equal); Software (equal). **Bernd Woestmann:** Methodology (equal); Resources (equal); Supervision (lead); Validation (equal); Writing-review & editing (lead). **Maximiliane Amelie Schlenz:** Conceptualization (equal); Formal analysis (lead); Project administration (equal); Validation (equal); Visualization (lead); Writing-original draft (equal).

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

How to cite this article: Schmidt A, Rein PE, Wöstmann B, Schlenz MA. A comparative clinical study on the transfer accuracy of conventional and digital implant impressions using a new reference key-based method. *Clin Oral Impl Res*. 2021;32:460–469. https://doi.org/10.1111/clr.13715