Vol. 121 No. 4 April 2016

Retrospective study to determine the accuracy of template-guided implant placement using a novel nonradiologic evaluation method

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Objectives. With a novel, noninvasive method for determining three-dimensional accuracy, the realized implant position relative to the planned implant position was analyzed retrospectively. Additional postoperative cone beam computed tomography was thus dispensable.

Study Design. Twelve cases with distal extension situations (DESs) or single tooth gaps (STGs) were evaluated. The data sets of the planned implant position were superimposed on the actually achieved implant position, retrieved from digitizing the implant impression. The deviations were measured and statistically analyzed.

Results. The mean deviation was 5° in the DES group and 4° in the STG group for the implant axes, 1 mm (DES) and 0.9 mm (STG) at the implant neck, and 1.6 mm (DES) and 1.5 mm (STG) at the implant apex. The mean height discrepancy was 0.5 mm (DES) and 0.5 mm (STG). No significant differences ($P > .05$) were found between the DES and STG groups.

Conclusions. The innovative, noninvasive evaluation method is suitable and sufficiently accurate for the assessment of larger cohorts. The results of our study showed a sufficiently high degree of accuracy when using a virtual planning program for which no radiopaque template is needed when performing cone beam computed tomography. (Oral Surg Oral Med Oral Pathol Oral Radiol 2016;121:e72-e79)

The computer-aided planning of implants with subsequent static or dynamic implementation of the implant position (three-dimensional implant planning and insertion [3-DII]) aims to predictably achieve the best possible prosthetic restoration of the implants and to make optimal use of the available bone for this purpose.[1] Based on a knowledge of the bone as radiologically depicted in three dimensions and of the prosthetically driven wax-up/set-up and focusing on the prosthodontic needs, the software is used to plan the positions of the implants.

In dynamic systems, the drill is navigated in three dimensions relative to the patient. For static, stent-based methods, the proposed implant position is realized with the help of surgical templates (stents or guides).

Drilling and insertion templates help complete the preparation of the implant bed and the insertion of the implant. Several methods available for this purpose: reworking of laboratory-fabricated scanning templates, templates milled during the computer-aided design/computer-aided manufacturing (CAD/CAM) process, or stereolithographic templates (3-D printing). Systems utilizing a drilling sequence with increasing drill diameters require the use of additional inner sleeves within the templates. Depending on the system, the implant bed can be prepared and the implant placed with or without a height stop.

Alternatively, the depth can be adjusted visually. A possible simplification is to drill only the pilot hole with the help of a template and then to widen the implant bed manually. The surgical effort might be reduced by inserting implants at an angle because this can help avoid augmentation procedures.[2] Prosthetic restoration options will have to be taken into account when inserting implants at an angle.

Where suitable, 3-DII facilitates a minimally invasive approach without the need to reflect a soft tissue flap. This “flapless surgery” has been described as causing less pain, swelling, and patient discomfort.[3] The flapless approach yields results similar to the conventional flap approach with regard to the remodeling of the crestal bone around the implant.[4] Possible disadvantages included the fact that the

Statement of Clinical Relevance

Dispensing with templates for implant planning with cone beam computed tomography saves time and money. Instead, information can be gained by digitizing the existing gypsum models. Data can be aligned to the cone beam computed tomography data (matching). The results show a sufficiently high degree of accuracy.

Within the framework of another prospective study, Camlog, Swissmeda, and Resorba provided materials. The first-named author has held presentations for Camlog, Swissmeda and Resorba.

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Received for publication Aug 30, 2015; returned for revision Dec 4, 2015; accepted for publication Dec 15, 2015.

2212-4403/$ - see front matter

http://dx.doi.org/10.1016/j.oooo.2015.12.012

Table I. Patients and treatment characteristics of the distal extension situation (DES) and single-tooth gap (STG) groups

		Arch		*Surgical technique*		*Implant length*		
Group		*Maxilla*	*Mandible*	*Open flap*	*Flapless*	*9 mm*	*11 mm*	*13 mm*
DES	No.	5	7	3	9	—	11	1
STG	No.	7	5	5	7	1	5	5

insertion depth (vertical endpoint) of the implant cannot be visually checked, and no corrective manipulation of the soft tissue around the implant is possible. Punching results in loss of keratinized gingiva, with possible aesthetic and functional disadvantages.[5]

The additional time and money required with 3-DII can be justified if the implants are placed more accurately, which would yield better results in terms of function or aesthetics. Comparative studies of 3-DII implants clearly show more accurate placement results.[6-8] Although some studies are now available on the subject, the number of in vivo studies and the follow-up sample sizes are still limited.[1] The follow-ups compare different systems with different software programs and different template-fabrication processes (conventional production, stereolithography, or milling). Possible factors that may influence the 3-D design, template fabrication, or implant placement have not been described.

The studies on the accuracy of 3-DII are based on 3-D data sets that include planning data and actually realized implant positions in a common coordinate system. The mostly frequently used analytical method is based on additional postoperative cone beam computed tomography (CBCT) data on which the planning data are superimposed. Since the increased radiation exposure of CBCT, compared with conventional two-dimensional X-ray images,[9] must be justified on a case-by-case basis and a CBCT should be performed only if a strict indication exists, the use of this analytical method—making an evaluation CBCT in addition to the necessary planning CBCT—in larger cohorts is limited for ethical reasons. A method based on CBCT images of master casts with implant analogs[10] has been described as an alternative. Digitizing the master casts instead of obtaining a CBCT image could lower systematic errors in the evaluation procedure. First, using a high-accuracy digitizer (measurement uncertainty less than 10 μm) will reduce data acquisition errors. Second, the precise digital master model data will allow for reduce alignment errors in preimplant and postimplant insertion data.

The objective of this article is to present a new evaluation method for studying the 3-D accuracy of the realized implant position relative to the proposed position without performing additional postoperative CBCT. The clinically resulting implant position after using an online implant planning software (Swissmeda online implant planning [SMOP], Swissmeda, Zürich, Switzerland) will be evaluated.

MATERIALS AND METHODS

In this retrospective study, the implant positions of 24 patients from the first-named author's practice were evaluated. Consecutive cases were considered for inclusion if 3-D implant planning and template-guided implant placement were performed between February 2012 and June 2013. Twelve cases with a distal edentulous situation (DES) and 12 cases with either a single tooth gap (STG) or an edentulous space were included and evaluated (Table I).

One criterion required for inclusion in this study was that in the patients with STG, the drilling template had to have tooth-supported rests mesial and distal to the edentulous space. In the patients with DES, a contact area on the gingiva of the alveolar ridge had to be present distal to the implant position. Only implants for which the drilling protocol required no exchange of inner sleeves were examined (Camlog Biotechnologies, Basel, Switzerland).

All cases with documentation that showed that the final position of the implant had been corrected after removing the template were excluded.

Patient-related inclusion criteria were a minimum age of 18 years and written consent to the treatment provided. Exclusion criteria for implant placement were a poor overall health status; uncontrolled diabetes; drug, nicotine, or alcohol abuse; a history of radiation therapy in the relevant area; or serious mental disorders.

One implant per patient was evaluated. If several implants were present, the one located farthest anteriorly with respect to the remaining dentition was examined. The patient group comprised 15 female and 9 male patients with a mean age of 52.2 years (range 34—76 years).

Institutional approval was granted by the local Ethics Committee at the University of Ulm (No. 339/14, dated April 12, 2014).

Implant planning, surgical procedures, and prosthetic treatment were all performed by the same surgeon (SiS), who is a specialist in oral implantology and an experienced implant prosthodontist.