Reliability of Implant Surgical Guides Based on Soft-Tissue Models

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The purpose of this study was to determine the accuracy of implant surgical guides fabricated on diagnostic casts. Guides were fabricated with radiopaque rods representing implant positions. Cone beam computerized tomograms were taken with guides in place. Accuracy was evaluated using software to simulate implant placement. Twenty-two sites (47%) were considered accurate (13 of 24 maxillary and 9 of 23 mandibular sites). Soft-tissue models do not always provide sufficient accuracy for fabricating implant surgical guides.

Key Words: dental implants, surgical guides, soft-tissue models, accuracy

INTRODUCTION

Dental implants are a widely accepted and predictable option for replacing missing teeth. Precise placement of endosseous implants is necessary for optimum restoration. To facilitate implant placement in optimal positions, restorative dentists fabricate surgical guides that are used during surgery to guide the surgeon’s drill and ultimately place implants in the correct position and at the correct angulation. An ideal surgical guide incorporates the ideal implant angulation and facial contour, stability and asepsis during surgical implant placement, and transparency for good visualization and adjustability.1

Traditionally, implant surgical guides are fabricated based on a study cast. The edentulous area of the study cast is a reproduction of the soft tissue and does not always accurately represent the underlying osseous morphology. Various techniques and design modifications have been described to improve the accuracy of surgical guides for implant placement, such as presurgical radiographic assessment2–5 and presurgical computed tomography assessment of guides,6–13 the use of computer-aided design and computer-aided manufacturing (CAD/CAM) based guides,14,15 optimization of mesiodistal paralleling,16 the use of guides for sequential implant drills,17 However, the use of surgical guides based on diagnostic casts is still one of the most commonly used techniques, especially in partially edentulous patients.

Typically, once the guide is fabricated, a drill press is used to place a pilot hole in what looks like an ideal restorative position for the implant on the study cast. Unfortunately, that position does not always line up with the osseous morphology of the underlying alveolar ridge. For this reason, surgical guides fabricated from these diagnostic casts frequently cannot be used by surgeons to place the implant within the bony housing. Often, additional bone augmentation procedures are required before or immediately after implant placement to ensure an implant position that corresponds to an ideal restorative outcome. This study was developed to investigate the accuracy of these traditionally fabricated implant surgical guides in partially edentulous patients.

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MATERIALS AND METHODS

Ethical approval was obtained from the Louisiana State University Health Sciences Center-New Orleans Institutional Review Board. Sixteen patients with a total of 47 edentulous sites were used for this study.

Hydrocolloid/alginate impression material (Identico, Dux Dental, Oxnard, Calif) was used to take accurate impressions. The impressions were poured with stone (Fugirock, GC America, Alsip, Ill), and accurate diagnostic casts were made. Each of these casts was then mounted on an articulator (Artex, Girrbach Dental GMBH, Pforzheim, Germany), and the missing teeth were waxed up to proper morphology and function (Figure 1a). After the wax-up was completed, the models were duplicated and clear acrylic templates were made using Copyplast 1 mm (Scheu-Dental GMBH, Iserlohn, Germany). The clear acrylic templates were placed on the original casts and accurate fit was confirmed. Pilot holes were drilled into the stone models through the clear acrylic, with a drill press as close to the center of the each missing tooth as possible (Figure 1b). These holes were centered on the ridge in an ideal restorative position that appeared to have the maximum available alveolar bone width. A radiopaque rod fabricated from methyl methacrylate (Jet Acrylic, Lang Dental, Wheeling, Ill) impregnated with 20% barium sulfate was placed into each prepared site (Figure 1c). These rods were picked up with Triad Gel (Dentsply International, York, Pa) to form a radiographic guide in which the planned implant sites were represented by the radiopaque rods. The guides were delivered to the patient and a cone beam computerized tomography (CBCT) scan was taken for each patient using i-CAT (Imaging Sciences International, Hatfield, Pa) with the surgical guides in place.

The CBCT scans were studied by two board-certified periodontists (P.M. and A.P.) and one restorative dentist (D.S.) for accuracy of implant alignment with the alveolar ridge in order to allow successful implant placement. Each examiner determined accuracy using the InVivoDental5.0 software (Anatomage, San Jose, Calif). The software was used to simulate implant placement in the edentulous ridge along the long axis of the radiopaque barium sulfate rods. Simulated implant placement was considered accurate if it did not result in any fenestrations, dehiscences, perforations of the buccal and lingual cortical plates, or violations of vital structures (Figure 2a and b). Accuracy was confirmed if the simulated implant was considered to be in an acceptable functionally restorable position. Accuracy was measured as a percentage of the sites on the surgical guides evaluated as sufficiently accurate to be used for dental implant placement. Comparison of accuracy of sites between the maxilla and mandible was done using the Fisher exact test.

RESULTS

Of the total edentulous sites examined (N = 47), 24 were located in the maxilla and 23 in the mandible. Of these, 22 sites were considered accurate for dental implant placement (47%). Of the 24 maxillary sites, only 13 sites were evaluated as accurate (54%). Of the 23 mandibular sites, only 9 sites were evaluated as accurate (39%). No statistically significant difference was found between the mandible and the maxilla (P = .385, Fisher exact test) (Figure 3).
Reasons for inaccuracy were classified as too buccal or too lingual if the examiners determined that placement of the implant at the proposed position could result in a lingual perforation, a buccal fenestration, or a buccal or lingual dehiscence (Figure 4). No statistically significant difference was found between the maxilla and mandible with respect to the 2 reasons for inaccuracy ($P = 1$, Fisher exact test). However, in both arches combined, more sites were found to be inaccurate because of lingual plate perforations (64%) than because of buccal dehiscences (36%) (Figure 4).

**DISCUSSION**

The use of diagnostic casts to determine the precise position of an implant does not seem predictable. Based on our findings, to accurately place the...
Implants, surgeons would have been able to use only 13 of 24 sites in the maxilla (54%) and 9 of 23 sites in the mandible (39%) from the surgical guides fabricated in our study. Although we observed a slight trend toward higher inaccuracy in the mandible than the maxilla, the difference was not statistically significant. A previous study reported a significantly higher discrepancy in mandibular molar sites. The difference between the 2 studies may be explained by the small number of sites examined (n = 47) in our study vs 235 sites examined by Almog and Sanchez. The overall accuracy of surgical guides based on a soft-tissue model was considered inadequate for precise implant placement. A systematic review by Schneider et al. on the accuracy of computer-guided template-based implant placement showed a reasonable mean accuracy with relatively high maximum deviations. Nokar et al. compared the accuracy of CAD/CAM guides to conventional surgical templates and found the latter to be significantly less accurate. Other studies are in agreement with this finding, also suggesting a higher accuracy of computer-aided guide manufacturing over conventional preparation of soft-tissue model guides. Implants placed using this type of guide have survival rates of 91%–100%. Additionally, use of CAD/CAM-based guides results in implant placement with a low deviation that ranges from 3° to 8° in any direction. However, it is not always practical to use CAD/CAM-based surgical guides, especially for single-implant cases. For both single and multiple implants in partially edentulous patients, traditional surgical guides based on a soft-tissue model are still very commonly used. In such situations it would be advisable to use additional techniques that allow a more accurate estimation of the ridge morphology, such as palpation, bone sounding, and ridge mapping followed by comparison of the clinical findings to the radiographic findings on a CBCT scan. Bone augmentation procedures should be planned in sites with ridge deficiencies, so that the implant may be placed in an ideal position for an optimal restorative outcome. The use of CBCT scans and CAD/CAM technology allows for significantly more accurate surgical guide fabrication. Further research is needed to investigate accuracy of other techniques for surgical guide fabrication without use of computer-aided fabrication.

**Conclusion**

Implant surgical guides based on soft tissue models can often be inaccurate and should be verified for accuracy before use. A good knowledge of the underlying osseous morphology is the key to successful implant placement and restoration.

**Abbreviations**

CAD/CAM: computer-aided design and computer-aided manufacturing

CBCT: cone beam computerized tomography

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**References**

14. Sarment DP, Al-Shammari K, Kazor CE. Stereolithographic...


