Predictable implant-supported restorations require a determination of the final prosthesis in the treatment planning stage. A radiographic-surgical template (RST) can illustrate the final result and the procedures needed to accomplish it. Bone density and contour, fixed and removable prosthetic options, healing time, discomfort, and cost should be discussed with the surgeon before consultation with the patient. It is the responsibility of the restorative dentist to fabricate an RST and plan all phases of treatment with the appropriate specialists.

It has been suggested that lack of detailed planning may result in occlusal stress that can overload bone adjacent to angled implants and abutments. Horiuchi1 simulated such overload by using finite element analysis, which demonstrated that stress was most evenly distributed in cortical bone when occlusal force was directed at the center of the implant through its long axis.

Poorly spaced implants can be difficult to restore. Lazzara2 emphasized the proper mesiodistal placement of implants to preserve papillae and ensure an esthetic implant-restoration emergence profile. He categorized surgical templates as variable position stents and fixed stents. Variable position stents allow multiple implant positions without interfering with the adjacent papillae; such stents include vacuform or acrylic resin templates adapted over duplicated casts of diagnostic wax-ups. Facial or lingual contours can be sectioned out with the remaining contour, or grooves in the acrylic resin can be used to guide the implant drill.3-13 Fixed stents do not allow variation of implant location and require confidence in the dimension and quality of bone. Fixed stents include plastic or metal tubes and channels in acrylic resin that dictate the position of the implants.14-25

Radiographic templates commonly are converted into surgical templates by removing the marker and creating a channel in the plastic base. A method for fabricating an RST that does not require modification of the radiographic template to parallel multiple implants is presented. The appliance is designed as a fixed stent and is easily altered to a variable position stent when bone contours dictate an alternate implant position.

**PROCEDURE**

1. Make 2 duplicate casts of the arch to be restored from diagnostic casts mounted in an articulator in centric relation at the accepted vertical dimension of occlusion (VDO).
2. Mount 1 set of the duplicate casts with a centric

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A radiographic-surgical template can facilitate consultation with a surgeon and patient when implant-supported restorations are planned. A template that provides radiographic evaluation of the implant site and precise or modified surgical placement is presented. (J Prosthet Dent 2001;85:26-9.)
relation transfer record in the same articulator at the established VDO.

3. Complete occlusal equilibration and diagnostic wax-up to determine the final prosthetic contours (Fig. 1).

4. Duplicate the diagnostic wax-up, and form retention pads with baseplate wax on the stone cast (Fig. 2).

5. Form a putty matrix (Sil-Tech, Ivoclar North America, Inc, Amherst, N.Y.) over the stone cast.

6. Reduce teeth planned for implants to 0.5 mm above the gingiva on the stone cast. Remove the wax retention pads, and coat the cast with Liquid Foil Separator (Great Lakes Orthodontics, Ltd, Tonawanda, N.Y.). Pour clear Jet acrylic resin (Lang Dental Mfg Co, Wheeling, Ill.) into the putty matrix to duplicate the contours of the teeth planned for implants. Reseat the matrix on the cast, and process the acrylic resin at 30 psi for 10 minutes (Aquapress, Lang Dental Mfg Co). Separate the RST from the cast, remove excess with acrylic resin burs, and high polish with pumice.

7. Outline the cervical margin on the stone cast of each tooth planned for implants. Draw mesiodistal and faciolingual lines to locate the center of the implant site. Cut a 3-mm access opening in the RST over these points (Fig. 3).

8. Place a 1-mm–deep rest at the center of each implant site with a No. 6 round bur. Place a straight handpiece bur shank into each rest. Parallel each shank with the surveyor rod, stabilize with Starflow flowable composite (Danville Engineering, San Ramon, Calif.), and light polymerize (Fig. 4). Inject Starflow around the shank on the tissue side of the RST and polymerize (Fig. 5).

9. Reduce the second duplicate cast to the gingiva for each planned implant site. Place the RST on this cast to compare the prosthetic outline with the gingival contour of the residual ridge. Bur shanks can be inserted to demonstrate pilot drill destination (Fig. 6).

**DISCUSSION**

Sicilia et al has suggested 5 characteristics of an ideal surgical template: (1) good orientation of the implant in a mesiodistal and buccolingual position, (2) contrast during diagnostic imaging procedures, (3) stability during oral manipulation, (4) surgical access and visibility during external irrigation, and (5) freedom to alter implant position within the confines of the surgical template. The RST provides precise orientation of the 2.0-mm–diameter surgical pilot drill with the composite channel formed around a 2.35-mm bur.
The length of the channel through the clinical crown of the tooth restricts deviation of the bur without having to create a close tolerance.

The flowable composite functions as a radiopaque marker, eliminating the need to alter the radiographic template into a surgical template. Retention pads waxed on the occlusal third of the stone cast provide retention and stability of the RST during implant surgery. The gingival surface of the RST is reduced 2 mm to enhance visibility and external irrigation of the pilot drill. The occlusal surface can be reduced when access for the pilot drill is needed in small mouths or for posterior implants. The composite channels can be enlarged with a high-speed handpiece to alter the implant position on intrasurgical observation of the bone contour. The widened channel maintains buccolingual and mesiodistal limits of the prosthetic tooth outline, whereas the facial and lingual contours of the RST guide the inclination of the new implant position.

A surgical template also can function as a radiographic template during tomographic evaluation. The radiographic template relates the position of the planned implant site to the remaining bone. A variety of materials have been used as radiographic markers, including barium sulfate applied to the teeth or the denture base,26-30 gutta-percha resin,31,32 lead foil,33 and titanium rods.34 Almog et al35,36 compared these and found that all were good radiographic markers but that metal tubes were the most accurate because they also were used as a surgical guide. It is preferable to have a single appliance that functions as both a radiographic and surgical template.

Garber37 emphasized implant site analysis and development when treatment planning restoration-driven implant placement for optimum esthetics and function. The RST is a critical step in this planning because it previews the definitive restoration and its relationship to the periodontium. It is important that the RST be made by the restorative dentist so that this clear vision of the final restoration can be communicated to the patient and surgeon. For routine implant placement without the need for bone augmentation, the patient can assess final tooth contours, symmetry, lip support, and appearance of the diagnostic wax-up and RST. When bone grafting may be needed, the RST can demonstrate the need for tomographic evaluation and then serve as an accurate radiographic template. When extensive bone augmentation procedures are definitely indicated, the RST may help patients choose an appropriate treatment plan before committing to the time, exposure, and cost of tomograms.

The advantages of this technique include the following: (1) A simple appliance is made from common materials. A surveyor-mounted handpiece is not required. (2) Clean enlargement of the access opening is possible without shredding plastic or metal tubing. (3) The pilot drill alignment is controlled. A surveyor is used to orient the composite channel to the ideal position or to match the emergence profile of adjacent teeth. (4) Correction of pilot drill channel is possible after radiographic evaluation. The desired correction in angulation is measured with a protractor on the tomogram. The composite channel is enlarged, and the bur shank is rebonded with composite to this new

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Fig. 5. Composite pilot drill channels. A, Occlusal surface; B, intaglio surface.

Fig. 6. Radiographic-surgical template seated on second duplicate cast. Implant sites are reduced to gingival contour. Note relationship of acrylic resin facial surface and bur shanks to residual ridge.
angle by placing the protractor on the surveyor rod. Any desired horizontal change is measured with calipers from the tomogram. This dimension is transferred to the new bur shank position in the enlarged channel, and the composite is rebonded. (5) The RST technique allows control of marker orientation. The composite marker represents the central axis of the prosthetic tooth and is a better indicator of the tooth-to-bone relationship than a radiopaque outline of the tooth or denture base. The access opening in the RST that confines the composite should be perpendicular to the occlusal plane or parallel to the adjacent teeth. The marker angulation is apparent in the vertical slices of the tomogram. (6) The RST can be used in fully edentulous patients by extending the acrylic resin to cover the palate, tuberosity, or retromolar pads on the duplicate diagnostic cast. (7) The RST is retained as a guide to locate healing screws at the second stage surgery.

SUMMARY

A versatile radiographic-surgical template for multiple-parallel implant placement has been described. Simple materials and methods allow the restorative dentist to evaluate the final prosthetic contours, implant locations, and treatment plan before surgical or patient consent. The precise guide for implant pilot drills can be modified easily after radiographic evaluation or during surgery.

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