Preorthodontic implant placement in the planned postorthodontic position: A simplified technique and clinical report
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Interdisciplinary cases can require orthodontic correction with implant anchorage prior to the placement of implant-supported restorations. Definitive implants for orthodontic anchorage offer several advantages compared to temporary attachment devices. Preorthodontic definitive implant placement requires accurate and detailed treatment planning to visualize the final orthodontic result and the optimal restoration position. This article describes a simplified method for creating a radiographic-surgical template for preorthodontic imaging and correct implant placement in the planned postorthodontic position. This approach uses common materials to combine the information from a preorthodontic diagnostic cast and the orthodontic setup/diagnostic wax-up/trial equilibration cast.

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Prosthetically driven implant placement is the accepted approach when treatment planning restorations require implant support.1-3 The restoration of edentulous areas with implant-supported crowns can be straightforward when the adjacent teeth are properly positioned. Treatment plans that involve orthodontic movement prior to implant-supported restorations are more complex. The restorative dentist might ask an orthodontist to complete tooth movement prior to planning the final restoration. When orthodontic movement is not possible without using implants for anchorage, the restorative dentist is required to determine the final restoration and implant positions prior to orthodontic treatment. The goal of restorative-orthodontic communication is to ensure that the orthodontic correction permits a harmonious final restoration.

Temporary attachment devices (TADs) have revolutionized orthodontists’ ability to move teeth by creating direct or indirect absolute anchorage.4-7 Implant anchorage can facilitate orthodontic movement that would not be possible otherwise.8,9 Once the interdisciplinary treatment goals are determined, the orthodontist can finish TAD-assisted tooth movement; at that point, the surgeon and restorative dentist can place the final implant-supported restoration adjacent to the properly positioned teeth.

Alternatively, the surgeon can place definitive implants in the postorthodontic position prior to orthodontic therapy. The placement of definitive implants for orthodontic anchorage offers several advantages over the use of TADs:
• Implant-supported provisional restorations provide patients with immediate function and esthetic improvement while establishing a precise endpoint for orthodontic movement.
• The midcrestal position creates direct anchorage with a straight vector of force and simplifies orthodontic movement.
• Treatment time is reduced, as gingival maturation occurs during orthodontics.
• Definitive implants reduce the time, cost, and complications associated with TADs.

Prior to any procedure, it is essential for each dentist involved in the treatment plan to visualize the final result of interdisciplinary treatment. Definitive implant placement for orthodontic anchorage requires detailed and accurate planning to establish the implant sites away from the current tooth position, correlating to future orthodontic movement.10,11 A diagnostic wax-up and orthodontic setup (that is, model surgery) are made to determine if the final result will be clinically realistic. The restorative dentist should confirm that the orthodontist can achieve the planned tooth positions and that the surgeon can create the optimal periodontal environment for predictable restoration. The preoperative and orthodontic setup/diagnostic wax-up casts can be shared with the patient to communicate the anticipated result and value of treatment.
The literature offers several methods for planning the pre-orthodontic placement of definitive implants in the postorthodontic position. Smalley transferred the position of wax-up teeth (representing future restorations on a model surgery cast) to the preoperative cast, which was duplicated to form a composite cast. A surgical guide was created on this cast using acrylic resin transfer templates and a molding machine to register implant location.\(^{12,13}\)

Willems et al employed a similar method, using a flexible resin stent to transfer the location of the center of the prosthetic tooth outline as the implant position on the orthodontic setup cast to the preoperative cast, prior to surgical guide fabrication. The composite cast was used to program the provisional restorations.\(^{14}\)

More recently, Lai et al used customized plastic cast bases and clear position plates to fabricate identical duplicates of preoperative casts. A diagnostic wax arrangement was completed on one set; at that point, the implant-supported crown positions (which were visible through the clear surface of the position plate) were marked and the plate was transferred to the preoperative cast to visualize the proposed implant positions.\(^{15}\)

In a 1999 report, Drago altered preoperative casts, set denture teeth in the anticipated restorative positions, and created clear plastic vacuum-formed surgical guides by using a molding machine.\(^{16}\) In a
1996 study, Kokich used a diagnostic wax-up to determine the implant position. The distance from this position to the nearest tooth that would not be moved during orthodontics was used as a guide for implant placement.

The method described in this article uses a surgical template to transfer the planned implant positions on the orthodontic setup/diagnostic wax-up cast intraorally. A plethora of surgical template designs are currently available, ranging from simple vacuum-formed outlines of a diagnostic cast to stereolithographic templates derived from computed tomography. All designs can be divided into fixed or variable surgical templates. Fixed designs determine the implant drill position and angulation for the surgeon, while variable designs allow the surgeon to alter position or angulation during surgery. Ideal requirements for an implant template include good implant orientation in the mesiodistal and buccolingual positions, contrast during diagnostic imaging, stability during oral manipulation, surgical access and visibility during external irrigation, and freedom to alter the implant position within the confines of the surgical template.

Implant templates should also be practical and easy to use during surgery. Good design features that make the template acceptable for clinical use include:
- inexpensive and commonly available materials;
- simple design for fabrication by an assistant;
- precise angulation, parallelism, and spacing control for single or multiple implants;
- easy modification during surgery without creating debris;
- small size with stability;
- versatile use with full or partial edentulous cases;
- the ability to function as both a radiographic and a surgical template;
- indexing to an abutment analog so that a provisional restoration can be generated.

A versatile radiographic-surgical template that fulfills these requirements and design features was described by the author in 2001. It is a clear acrylic resin template showing the planned prosthetic tooth contour with the pilot drill channel defined by radiopaque composite resin.

This clinical report illustrates the fabrication and use of a fixed-position radiographic-surgical template for pilot drill control in the placement of multiple implants in the planned orthodontic position prior to tooth movement. A simple armamentarium of the preoperative cast, an orthodontic setup/diagnostic wax-up cast, and common materials are used.

Case report
A periodontist referred a 57-year-old man to the restorative dentist for a comprehensive evaluation after a series of emergency extractions and socket preservation grafts. The patient’s chief concern was difficulty in chewing following tooth loss. His medical history was noncontributory. The patient’s preclinical interview, clinical examination, radiographs, photographs, and mounted diagnostic casts were used to generate a problem list and treatment plan (Fig. 1–6) (Tables 1 and 2). The radiographs revealed that tooth No. 14 had an endodontic infection with bone loss on the short distobuccal root. Tooth No. 15 was not restorable due to severe caries (Fig. 4). A significant posterior crossbite was evident on the diagnostic casts, with the arc of closure interference on the palatally

Fig. 5. A panoramic radiograph taken in 2007 showing a history of periodontal disease, tooth loss, failed restorations, and altered occlusal plane.

Fig. 6. Diagnostic casts mounted in CR.
tilted tooth No. 7. In addition, non-working crossover excursion interferences were present on teeth No. 21 and 28 (Fig. 6).

For occlusal analysis and subsequent treatment planning to have any clinical significance, the diagnostic casts must accurately identify the true maxillomandibular relationship. Patients with limited remaining teeth can unintentionally move the mandible, masking the type and degree of malocclusion, to establish more contact between teeth.

Using Dawson bimanual guidance and an anterior acrylic platform, a bite record was obtained in centric relation (CR).\textsuperscript{27,28} The casts were mounted on a semi-adjustable articulator, with the CR record and facebow. The intraoral mandibular incisor contact on the acrylic platform was identical to the mounted cast incisor contact, verifying CR (Fig. 7).

Using a laboratory carbide bur, three fiducial indents (5 mm x 5 mm) were created in a tripod arrangement on the lingual land area of the mandibular cast. The diagnostic casts were duplicated with irreversible hydrocolloid placed in the indents to ensure accurate reproduction of this critical area. The duplicate casts were mounted on a second identical articulator with the same facebow and CR record. The diagnostic casts must be preserved so that alterations to the duplicate casts during treatment planning can be compared accurately. The tripod indents serve as a reference position for the accurate transfer of matrices and indexes between the diagnostic and duplicate casts.

The duplicate casts were altered (using an orthodontic setup) to preview ideal orthodontic correction. Missing teeth were restored with a diagnostic wax-up so that the position of implant-supported crowns could be previewed. At that point, the casts were trial-equilibrated so that all teeth contacted within 20 µ in occlusion. Smooth anterior guidance on the central incisors and canines was established, as was immediate disclusion of the posterior teeth in all eccentric excursions (Fig. 8).

Consultation with the orthodontist concluded that the ideal orthodontic setup/diagnostic wax-up position could not be obtained without moving teeth through existing alveolar bone and exacerbating the gingival recessions. The patient declined root coverage grafting. It was decided that creating anterior guidance on the central incisors and canines would create a predictable outcome and that restoring teeth No. 19, 20, 29, and 30 with crowns in a crossbite relationship (without excursive contact interferences) was the best way to optimize the occlusion and preserve the current root-to-buccal bone relationship.\textsuperscript{29,30}

Table 1. Problem list generated from the clinical examination, radiographs, diagnostic casts, and photographs.

<table>
<thead>
<tr>
<th>Problem</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Missing teeth No. 2–4, 18–20, and 29–31</td>
<td>Orthodontic correction of crossbite</td>
</tr>
<tr>
<td>Crossbite relationship on teeth No. 6, 11, and 12</td>
<td>Orthodontic realignment</td>
</tr>
<tr>
<td>Uneven incisal plane with crowded teeth No. 6–11 and 22–27</td>
<td>Implants with stock abutments; single implant-supported all-porcelain crowns</td>
</tr>
<tr>
<td>Generalized moderate to severe maxillary gingival recession</td>
<td>Buccal cusp composite resin augmentation</td>
</tr>
<tr>
<td>Worn, short buccal cusp on tooth No. 5</td>
<td>All-porcelain crowns</td>
</tr>
<tr>
<td>Exposed metal collar and opaque porcelain crowns on teeth No. 7 and 10</td>
<td>Composite resin interproximal augmentation</td>
</tr>
<tr>
<td>Enlarged maxillary incisor gingival embrasures</td>
<td>Recontour incisal edge</td>
</tr>
<tr>
<td>Root caries on teeth No. 14 and 15</td>
<td>Distobuccal root resection; endodontic treatment</td>
</tr>
<tr>
<td>Distobuccal bone loss on tooth No. 14</td>
<td>Partial veneer gold crown</td>
</tr>
<tr>
<td>Apical radiolucency on tooth No. 14</td>
<td>Extraction</td>
</tr>
<tr>
<td>Fractured enamel on tooth No. 28</td>
<td>Composite resin restoration</td>
</tr>
<tr>
<td>Arc of closure interference on the crown of tooth No. 7</td>
<td>Occlusal equilibration</td>
</tr>
<tr>
<td>Non-working side occlusal interferences on teeth No. 21 and 28</td>
<td></td>
</tr>
<tr>
<td>Residual ridge crossbite sites on teeth No. 3 and 4 due to narrow maxilla</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Treatment plan designed to address the comprehensive problem list.

<table>
<thead>
<tr>
<th>Tooth/Teeth No.</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>6, 11, 12</td>
<td>Orthodontic correction of crossbite</td>
</tr>
<tr>
<td>6–11 and 22–27</td>
<td>Orthodontic realignment</td>
</tr>
<tr>
<td>4, 19, 20, 29, 30</td>
<td>Implants with stock abutments; single implant-supported all-porcelain crowns</td>
</tr>
<tr>
<td>5</td>
<td>Buccal cusp composite resin augmentation</td>
</tr>
<tr>
<td>7 and 10</td>
<td>All-porcelain crowns</td>
</tr>
<tr>
<td>8 and 9</td>
<td>Composite resin interproximal augmentation</td>
</tr>
<tr>
<td>11</td>
<td>Recontour incisal edge</td>
</tr>
<tr>
<td>14</td>
<td>Distobuccal root resection; endodontic treatment</td>
</tr>
<tr>
<td>14</td>
<td>Partial veneer gold crown</td>
</tr>
<tr>
<td>15</td>
<td>Extraction</td>
</tr>
<tr>
<td>28</td>
<td>Composite resin restoration</td>
</tr>
<tr>
<td>Full mouth</td>
<td>Occlusal equilibration</td>
</tr>
</tbody>
</table>
The diagnostic wax-up demonstrated that additional restorations distal to tooth No. 4 would create a problematic horizontal cantilever from the crossbite of the right residual ridges. No molar replacement was planned for tooth No. 3; this resulted in a shortened dental arch on the right side. As with natural teeth, the shortened dental arch design can be used with implant dentistry and did not create an esthetic deficit in the present case.31-34 The patient declined the alternative option of surgical sectioning and expanding the maxilla.

During treatment planning, it was determined that tooth No. 4 was the only tooth in the maxillary arch that would be restored using an implant-supported crown. The implant and crown for site No. 4 were determined from the diagnostic wax-up to be placed in the existing mesial-distal dimension since only buccal tilting of tooth No. 5 was planned, without mesial-distal movement. The maxillary surgical guide could be made on the existing preorthodontic cast (using the author’s technique cited above) and the pilot hole orientation could be tilted buccally to match the anticipated final alignment of tooth No. 5.26

The treatment plan included restoring the sites of teeth No. 19, 20, 29, and 30 with implant-supported crowns. Since the orthodontic correction would involve moving teeth No. 21 and 28 distally, the implants would need to be placed further distal to the current positions of teeth No. 21 and 28 and align with their postorthodontic root inclination. The information obtained from the orthodontic setup/diagnostic wax-up cast was combined with the preorthodontic cast so that the radiographic-surgical template would fit precisely on the teeth during surgery while also creating the proper implant placement.

Mandibular radiographic-surgical template procedure

The preorthodontic mounted mandibular cast was duplicated with irreversible hydrocolloid and poured in vacuum-mixed dental stone. It is important to preserve the original diagnostic casts for the patient’s permanent record, as casts can be damaged during fabrication of the radiographic-surgical template. This duplicate cast (referred to as cast No. 1) does not need to be mounted (Fig. 9).

Baseplate wax was placed on the teeth of cast No. 1 to create the retentive area of the radiographic-surgical template. Soft orthodontic wax was placed in the edentulous areas that were to be restored with implant-supported crowns. The volume of this blockout wax should be greater than the anticipated contour of the final restorations (Fig. 10). A putty matrix was formed over cast No. 1 and pushed into the tripod indents for complete adaptation. After setting, the borders of the matrix were cut back.
to confirm the intimate fit to the land portion of the cast. All wax retained in the matrix was removed (Fig. 11 and 12).

The mandibular orthodontic setup/diagnostic wax-up cast is referred to as cast No. 2. The teeth that were to be moved orthodontically were removed. The wax-up teeth and the teeth that were not to be moved were preserved (Fig. 13 and 14). The matrix derived from cast No. 1 was placed on cast No. 2 to confirm complete seating.

Windows in the matrix were cut out in the diagnostic wax-up sites to create an access for impression material with the pickup impression (Fig 15). Soft orthodontic wax was placed in the matrix, confining the impression material to the area of the wax-up teeth. The matrix was held against cast No. 2 and low-viscosity vinyl polysiloxane (VPS) impression material was injected around the wax teeth (Fig. 16 and 17). The matrix was separated from cast No. 2 after the impression material had set. The pickup impression in the matrix contained the wax-up teeth. The wax-up teeth and barriers were removed, and the matrix was returned to cast No. 1 to confirm complete seating.

Cast No. 1 was lightly lubricated to avoid any lubricant pooling in the indents that would prevent adaptation of the matrix. A thin mix of clear acrylic resin was poured into the matrix; at that point, the matrix was firmly reseated on cast No. 1 until all excess acrylic resin was expressed past the borders of

Fig. 11. Cast No. 1 with a putty matrix. Retention holes will retain the impression material without the use of adhesive.

Fig. 12. Intaglio of putty matrix prior to retention hole placement. Note the tripod registration and the relief created after removing wax retention pads and blockout.

Fig. 13. Cast No. 2 is the mandibular orthodontic setup/diagnostic wax-up cast.

Fig. 14. Cast No. 2 with the teeth, after removal of the teeth that are to be moved orthodontically.

Fig. 15. Putty matrix on cast No. 2 with access window over planned restorations.

Fig. 16. Intaglio of putty matrix with white orthodontic wax barriers to contain impression material.

Fig. 17. Wax-up teeth retained in putty matrix by low-viscosity VPS impression material.

Fig. 18. The gingival contour of the radiographic-surgical template prosthetic teeth are outlined on cast No. 1. Mesiodistal and buccolingual lines intersect at the center of the prosthetic outline, the target for the pilot drill.
The matrix. The matrix was secured against the model with rubber bands and placed in a pressure pot for 10 minutes (at 30 psi) to polymerize the acrylic resin.

The radiographic-surgical template was separated from the cast. The excess acrylic resin was trimmed with acrylic resin burs and the template was polished with pumice. The template was placed on cast No. 1 and the cervical margin was outlined for each tooth for which implants were planned (Fig. 18). The center of each implant site was marked and an access opening of 3 mm was cut in the occlusal aspect of the radiographic-surgical template over these centers.

Using a round bur, a rest was placed at the center of each implant site (1 mm depth). A straight handpiece bur shank was inserted through the access opening into each rest. Each bur shank was oriented within the long axis of the acrylic resin tooth and perpendicular to the bony ridge (Fig. 19). Flowable composite resin was injected through the access opening around the bur shank (to stabilize its position) and photocured. Flowable composite resin was injected and photocured around the shank on the intaglio of the radiographic-surgical template. The bur shanks were removed by rotating with a pliers. The long, smooth composite resin channel centered over the implant site was 2.35 mm wide, providing precise guidance for the 2 mm pilot drill. The radiopaque composite resin indicates the central axis of each implant site during imaging.

**Treatment**

Implants with stock abutments (NobelReplace and NobelActive, Nobel Biocare USA, LLC) were placed in tooth sites No. 4, 19, 20, 29, and 30. The composite shells generated from the diagnostic wax-up were relined with acrylic resin at the surgical appointment and provisionally cemented (Fig. 20). The adjacent provisional restorations were splinted to resist orthodontic forces. Orthodontic
appliances were placed 10 days later (Fig. 21); endodontic treatment was completed on tooth No. 14 and the distobuccal root was resected (Fig. 22). After orthodontics, the provisional restorations were augmented with the same composite resin to finalize their contours (Fig. 23). Casts of the provisional restorations served as a guide for the final restorations, which were completed using conventional procedures. The implant-supported single porcelain crowns had a harmonious relationship to the orthodontic-corrected arch and were the most hygienic and biomimetic restoration option (Fig. 24–26). The planned implant placement and orthodontic correction created the desired vertical alignment, parallel to the adjacent roots (Fig. 27).

Discussion
Interdisciplinary dental teams rely on each member’s specialized skills to create the optimum result for the patient. In the present case, the restorative dentist did the orthodontic setup and diagnostic wax-up and made the radiographic-surgical template. The final step in this interdisciplinary case utilized restorative dentistry to recreate lost posterior teeth, improve anterior esthetics, and establish an occlusion compatible with the periodontium, teeth, and implants. The diagnostic work made the restorative dentist familiar with the tooth size and position, posterior occlusion, and anterior guidance factors needed for predictable implant-supported restorations. Each item on the problem and treatment plan lists could then be discussed with the specialist (Tables 1 and 2). A comprehensive treatment plan should address all of the patient’s problems and allow the specialist to predictably accomplish the preparation for restorative work.

The amount of planned orthodontic movement for each tooth was quantified in three ways so that the orthodontist could design an appropriate treatment plan. First, each tooth repositioned during the orthodontic setup was recorded as a mesiodistal and buccolingual change (in mm) relative to the adjacent tooth. Second, wax occlusal matrices of the preoperative and orthodontic setup casts were made prior to adding the diagnostic wax-up teeth. The orthodontic setup cast was placed into the wax record of the preoperative cast, oriented by tooth No. 32 (which was not moved during orthodontics) and the residual ridge. It was determined that the mandibular teeth would occupy a smaller arch circumference than they had originally, as the premolar teeth moved distally toward the anchoring implants. The preoperative cast tooth indents could be visualized to
the facial aspect of the orthodontic setup cast and measured (Fig. 28 and 29). Finally, using the provisional restoration composite shells generated from the diagnostic wax-up, a wax index was constructed. The shells were positioned in the same location as the wax-up teeth in the orthodontic setup cast and attached to baseplate wax. The index was transferred to the preoperative cast to show the amount of movement required for the teeth adjacent to the index (Fig. 30 and 31).

The tripod indents in the cast provided accurate positioning of the matrix on both the preoperative cast and its duplicate. Alternatively, one can use teeth for which orthodontic movement is not planned—or a combination of teeth and indents in the residual ridge away from planned implant sites—as a reference tripod.

When creating the planned restoration form, a diagnostic wax-up is preferable to denture teeth. Custom wax teeth create a detailed...
occlusion, with the optimum size and contour to occlude with the opposing dentition. This wax-up is used to program the fabrication of the provisional restorations, preserving their size and contour and maintaining the planned endpoint of orthodontic movement. Alternatively, denture teeth can be used and modified with wax added to the occlusal and proximal surfaces.

The surgeon should be consulted for preferences of design of the radiographic-surgical template so that it will actually be used during implant placement. For example, the gingival aspect of the template can contact the ridge (so that prosthetic tooth position is evident) or be reduced (to provide space for external irrigation). Also, the retention pad can be extended so that a finger rest will further stabilize the template. The template should be evaluated intraorally before surgery to ensure complete seating and stability. Interproximal septae around crowded teeth should be relieved prior to seating. The occlusal thickness of the radiographic-surgical template should not preclude placement of the pilot drill. The template should have a 2 mm minimum thickness of acrylic resin to avoid fracture during intraoral placement and pilot drill insertion. If access is restricted due to limited mouth opening, a buccal slot can be cut in the radiographic-surgical template, allowing for lateral entry of the pilot drill while preserving the lingual aspect of the composite resin channel to maintain guidance.

Posterior site implant angulation should be vertical so that compressive force through the final restoration is distributed optimally. The root angulation of the teeth that are being moved should parallel the vertical implants for ideal crown position. Treatment planning must consider that if an error in position occurs, the implant should be placed too far from the adjacent tooth instead of too close to it. Lack of available space limits the amount of tooth movement and reduces the ability to achieve the orthodontic and restorative goal.

During fabrication of the template, the bur hole (that is, the pilot drill target) can be displaced from the center of the prosthetic outline on the cast to provide a 0.5 mm margin of error in implant position for each tooth; if necessary, final crown contours can close extra space to the natural tooth.

Summary
This article describes the process for fabricating a radiographic-surgical template, using a diagnostic cast, an orthodontic setup/diagnostic wax-up cast, and common materials. This template is used to determine implant placement in a planned postorthodontic position prior to tooth movement. Implants can be used for orthodontic anchorage and to provide immediate provisionalization, restoring lost function and esthetics. Orthodontic movement is direct with a straight vector of force and a precise three-dimensional endpoint of treatment.

Disclaimer
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References

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