CLINICAL REPORT

Management of unfavorable implant positions and angulations in edentulous maxillae with different complete-arch fixed prosthetic designs: A case series and clinical guidelines

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Implant-supported fixed prostheses in the edentulous maxilla can be difficult from a surgical as well as a prosthetic perspective.1 The maxilla also presents anatomic limitations such as the proximity to the nasal floor and pneumatization of the maxillary sinus.1,2 The centripetal resorption pattern and bone configuration may lead to unfavorable implant angulations, and high esthetic demand makes treatment complex and technique sensitive. Maxillary edentulism may be treated successfully by using different approaches involving 4, 6, or more implants.3 The procedural diagnostics, treatment, and maintenance for these different approaches all require advanced knowledge and careful communication among the therapeutic team.3 While fixed prostheses can be cement or screw retained,4 retrievable implant-supported fixed dental prostheses are preferred whenever feasible, as a retrievable screw-retained design facilitates the maintenance and management of technical problems and is preferable from a biologic perspective.5 For the fabrication of a screw-retained prosthesis, the implant angulations must be such that the access holes emerge through the occlusal surfaces of the posterior teeth and the lingual fossa of the anterior teeth. A cement-retained prosthesis design can be chosen when the access holes emerge labially or through the incisal edges of the anterior teeth. However, the cement-retained design makes retrievability for maintenance and intervention difficult. Moreover, residual excess cement has been reported to be a primary cause of peri-implant disease.6,7 The available vertical restorative space governs the selection of the implant prosthesis.8 When the implant angulations are unfavorable and there has been extensive bone resorption, it has been a common practice to use a metal framework along with the acrylic resin and the denture teeth.8 However, this type of prosthesis requires frequent repairs and maintenance.8 Figure 1 illustrates such a prosthesis where the implant angulations were such that the access holes emerged labially. Composite resin was used to seal the access holes. However, the seal discolored over time, and the esthetics were compromised. Therefore, although this prosthesis design is common, it is not recommended.10 This article presents clinical scenarios encountered with unfavorable implant

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ABSTRACT

Implant-supported fixed prostheses in the edentulous maxilla can be difficult because of anatomic limitations and high esthetic demand. The choice between cement and screw retention depends on factors such as esthetics, occlusion, retrievability, and passivity. The choice is also often governed by the ability to manage technical or biologic complications. In the edentulous maxilla, because of the bone trajectory and resorption pattern, unfavorable implant angulations may be encountered. In such situations, a conventional screw-retained prosthesis is difficult to design. This article describes the restoration of edentulous maxillae for a series of patients with different complete-arch fixed prosthesis designs. The clinical guidelines, including indications, advantages, and limitations of each design, were discussed. (J Prosthet Dent 2022;127:6-14)
angulations in the edentulous maxilla and describes fixed prosthetic design options.

**CLINICAL REPORT**

This clinical report describes 5 patients with unfavorable implant trajectories in the maxillary arch who were treated with fixed implant-supported complete-arch prostheses by using different prosthetic abutment designs.

Patient 1 was treated by using angled or custom abutments with a cement-retained prosthesis. A 67-year-old healthy woman reported with multiple missing teeth and multiple carious teeth (Fig. 2A, 2B). All teeth were extracted, and 7 implants (Tapered Internal; BioHorizons) were placed on the same day. A removable denture was delivered on the day of surgery as an interim restoration. After 6 months of osseointegration, cement-retained angled abutments (BioHorizons) were placed on the anterior 4 implants, and straight abutments were placed on the posterior 3 implants (Fig. 2C). The prosthesis was cemented with elastomeric resin cement (Premier Implant Cement; Premier Dental Co) (Fig. 2D, 2E). Post-treatment periapical radiographs indicated proper fit of the abutment with no residual cement in the gingival sulcus (Fig. 2F). The mandibular arch was treated with a cast partial denture with acrylic resin denture teeth to restore the severely resorbed residual ridge in the bilateral posterior region. Excess cement in the sulcus can be avoided if custom abutments are used with buccal restorative margins at not more than 0.5 mm subgingivally and with supragingival palatal and proximal margins.\(^1\) Additionally, radiopaque cements are recommended.\(^1\)

Patient 2 was treated with a screw-retained prosthesis with angled screw hole abutments. A 55-year-old healthy man presented with multiple missing maxillary posterior teeth and a worn anterior dentition (Fig. 2A, 2B). All teeth were extracted, and 7 implants (Tapered Internal; BioHorizons) were placed on the same day. A removable denture was delivered on the day of surgery as an interim restoration. After 6 months of osseointegration, cement-retained angled abutments (BioHorizons) were placed on the anterior 4 implants, and straight abutments were placed on the posterior 3 implants (Fig. 2C). The prosthesis was cemented with elastomeric resin cement (Premier Implant Cement; Premier Dental Co) (Fig. 2D, 2E). Post-treatment periapical radiographs indicated proper fit of the abutment with no residual cement in the gingival sulcus (Fig. 2F). The mandibular arch was treated with a cast partial denture with acrylic resin denture teeth to restore the severely resorbed residual ridge in the bilateral posterior region. Excess cement in the sulcus can be avoided if custom abutments are used with buccal restorative margins at not more than 0.5 mm subgingivally and with supragingival palatal and proximal margins.\(^1\) Additionally, radiopaque cements are recommended.\(^1\)

Patient 3 was treated by using multiunit abutments. A 56-year-old man with advanced periodontitis (Fig. 4A, 4B) required the extraction of all his remaining teeth. Six implants (Tapered Internal; BioHorizons) were placed in the maxillary arch (4 in anterior and 2 in posterior region). Angled multiunit abutments (Multi-unit abutment; BioHorizons) were used to correct the undesirable angulations in the anterior maxilla (Fig. 4C). A screw-retained fixed interim prosthesis was delivered after 6 months. The interim prosthesis was replaced with a definitive screw-retained prosthesis fabricated with a polyetheretherketone (PEEK) (BioHPP; bredent UK) framework and composite resin teeth (Fig. 4D, 4E). The post-treatment radiograph revealed a more radiolucent PEEK framework than the metal-ceramic prosthesis (Fig. 4F). The mandibular arch was also restored with a PEEK prosthetic framework. The multiunit abutments redirected the screw openings to the occlusal or cingulum areas of the prosthesis. The angled variant involves the use of 2 off-axis screws, one to fix the abutment to the implant and the second at an angle to secure the prosthesis to the abutment. However, to provide sufficient abutment structure to house the retention screw for the restoration, the long axis of the implant and path of the retention screw diverged significantly. The multiunit abutments raised the prosthesis platform from implant (or bone) level to abutment (supracrestal) level. The accuracy of the prosthesis fit was evaluated visually and esthetically (Fig. 3D, 3E). Post-treatment radiographs revealed a well-fitting complete-arch prosthesis (Fig. 3F). The mandibular arch was restored with an implant-supported metal-ceramic fixed dental prosthesis in the right posterior region and tooth-supported metal-ceramic crowns and fixed dental prostheses in the anterior and left posterior region. Dynamic abutments were considered ideal for situations where the interarch space was less than 15 mm.\(^1,\)\(^1\)

Patient 4 was treated with an interim restoration during the healing period. A 75-year-old healthy woman reported with multiple missing teeth and multiple carious teeth (Fig. 2A, 2B). All teeth were extracted, and 7 implants (Tapered Internal; BioHorizons) were placed on the same day. A removable denture was delivered after 6 months. The interim prosthesis was replaced with a definitive acrylic resin prosthesis.

Patient 5 was treated with a screw-retained prosthesis fabricated with a talladium international implantology. This allowed the accuracy of the prosthesis fit was evaluated visually and esthetically (Fig. 3D, 3E). Post-treatment radiographs revealed a well-fitting complete-arch prosthesis (Fig. 3F). The mandibular arch was restored with an implant-supported metal-ceramic fixed dental prosthesis in the right posterior region and tooth-supported metal-ceramic crowns and fixed dental prostheses in the anterior and left posterior region. Dynamic abutments were considered ideal for situations where the interarch space was less than 15 mm.\(^1,\)\(^1\)

Patient 6 was treated by using angled or custom abutments with a cement-retained prosthesis. A 67-year-old healthy woman reported with multiple missing teeth and multiple carious teeth (Fig. 2A, 2B). All teeth were extracted, and 7 implants (Tapered Internal; BioHorizons) were placed on the same day. A removable denture was delivered on the day of surgery as an interim restoration. After 6 months of osseointegration, cement-retained angled abutments (BioHorizons) were placed on the anterior 4 implants, and straight abutments were placed on the posterior 3 implants (Fig. 2C). The prosthesis was cemented with elastomeric resin cement (Premier Implant Cement; Premier Dental Co) (Fig. 2D, 2E). Post-treatment periapical radiographs indicated proper fit of the abutment with no residual cement in the gingival sulcus (Fig. 2F). The mandibular arch was treated with a cast partial denture with acrylic resin denture teeth to restore the severely resorbed residual ridge in the bilateral posterior region. Excess cement in the sulcus can be avoided if custom abutments are used with buccal restorative margins at not more than 0.5 mm subgingivally and with supragingival palatal and proximal margins.\(^1\) Additionally, radiopaque cements are recommended.\(^1\)

Patient 2 was treated with a screw-retained prosthesis with angled screw hole abutments. A 53-year-old healthy man presented with multiple missing maxillary posterior teeth and a worn anterior dentition (Fig. 2A, 2B). All teeth were extracted, and 7 implants (Tapered Internal; BioHorizons) were placed on the same day. A removable denture was delivered on the day of surgery as an interim restoration. After 6 months of osseointegration, cement-retained angled abutments (BioHorizons) were placed on the anterior 4 implants, and straight abutments were placed on the posterior 3 implants (Fig. 2C). The prosthesis was cemented with elastomeric resin cement (Premier Implant Cement; Premier Dental Co) (Fig. 2D, 2E). Post-treatment periapical radiographs indicated proper fit of the abutment with no residual cement in the gingival sulcus (Fig. 2F). The mandibular arch was treated with a cast partial denture with acrylic resin denture teeth to restore the severely resorbed residual ridge in the bilateral posterior region. Excess cement in the sulcus can be avoided if custom abutments are used with buccal restorative margins at not more than 0.5 mm subgingivally and with supragingival palatal and proximal margins.\(^1\) Additionally, radiopaque cements are recommended.\(^1\)
from radiographs. Soft tissue impingement was minimized.

Patient 4 was treated by using a screw-retained milled framework with cemented individual crowns. A healthy, 65-year-old woman presented with a failing and unrestorable maxillary dentition and the inability to masticate food (Fig. 5A, 5B). All maxillary teeth were extracted and 7 implants (Nobel Biocare) were placed. After 6 months, the definitive impression was made with open tray impression copings and the definitive cast was mounted onto the articulator and assessed for the implant angulations (Fig. 5C). A milled interim restoration was fabricated and delivered at the second stage surgery and used as a template for the design the definitive prosthesis. The definitive prosthesis was fabricated as a milled titanium framework with individual struts that supported metal-ceramic crowns (Fig. 5D, 5E). The intact crowns (without vent holes) fabricated and cemented with an interim cement on the struts where the screw accesses emerge from the facial aspect (Fig. 5E). However, the crowns, on the struts having lingual or occlusal access, can be fabricated with corresponding
vent holes to allow future abutment screw access. The gingival facial aspect was fabricated with resin, and the intaglio surface had titanium contacting the tissues (Fig. 5F). Post-treatment radiographs revealed a well-fitting prosthetic framework (Fig. 5G). The mandibular anterior teeth were restored with composite resin, and posterior teeth on both sides were replaced with implant-supported metal-ceramic fixed prostheses (Fig. 5G).

Patient 5 was treated with a screw-retained 1-piece metal-ceramic prosthesis with lateral screw abutments. A 58-year-old woman presented with all molar teeth missing and advanced periodontitis in both the maxillary and mandibular arch. All remaining teeth were extracted. Six implants (blueSKY; bredent UK) were placed in the maxillary arch and 4 implants (with 2 distal tilted implants) in the mandibular arch. The lateral screw abutments were used for all 6 implants in the maxillary arch (Fig. 6A) to provide sufficient thickness to the metal-ceramic fixed prosthesis (Fig. 6B). The posterior lateral screw abutments helped compensate for the severe implant angulations and limited interocclusal space (Fig. 6B, 6C). The prosthesis was fabricated in single piece
without screw-access holes on the occlusal or facial surfaces (Fig. 6D). The mandibular arch was restored with an implant-supported fixed complete-arch prosthesis.

**DISCUSSION**

The maxillary edentulous ridge often leads to placement of implants in nonaxial positions that need to be addressed with the definitive prosthesis. The trajectory of the implants determines the type of retention of the prosthesis. Table 1 outlines different prosthetic options for managing implant trajectories in the edentulous maxilla. Figure 7 depicts the different abutment designs used for the patients in this clinical report to manage unfavorable implant positions and angulations. Angled abutments are an option for correcting nonaligned implants, thereby facilitating prosthesis fabrication. This technique allows the placement of implants with increased width and height, avoiding guided bone regeneration (GBR) procedures and reducing treatment time and cost. However, angled abutments result in

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**Figure 4.** A, Pretreatment intraoral view of patient 3. B, Pretreatment cone beam computed tomograph. C, Multiunit abutments tightened in position. D, Screw-retained definitive prosthesis. E, Frontal view indicating definitive prosthesis in place with no screw access hole on facial aspect. F, Post-treatment panoramic radiograph.
increased stresses and the application of unfavorable forces to screws, implant abutment connections, implants, or bone, although these increased stresses are usually within the limits physiological tolerance. An individualized abutment allows the dentist and the technician to provide screw-retained restorations and avoid a cemented prosthesis. However, abutments with angulations of more than 28 degrees are difficult to manage. These abutments are generally suited for fixed restorations which replace only the clinical crowns and some part of the soft tissue. In the authors’ opinion, they are not amenable to use in patients with excessive restorative space, as the biomechanical challenges are difficult to overcome.

Multiunit abutments are a beneficial alternative in situations with unfavorable implant angulations and subsequent unesthetic screw access hole openings. They require sufficient abutment height to accommodate the

Table 1. Advantages and limitations of different prosthetic designs for complete-arch fixed restorations in edentulous maxillae

<table>
<thead>
<tr>
<th>Type of Prosthetic Design</th>
<th>Indications</th>
<th>Advantages</th>
<th>Limitations</th>
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</thead>
<tbody>
<tr>
<td>Cement-retained prosthesis with angled abutments</td>
<td>Favorable or unfavorable implant positions with adequate interarch space</td>
<td>Ease of fabrication Low cost</td>
<td>Excess cement removal difficult Lack of retrievability</td>
</tr>
<tr>
<td>Screw-retained prosthesis with angled screw-access holes</td>
<td>Unfavorable implant positions with limited interarch space</td>
<td>Best used in interarch space less than 15 mm Angle corrections up to 28 degrees Retrievable</td>
<td>Not useful when more interocclusal space available</td>
</tr>
<tr>
<td>Screw-retained prosthesis with multiunit abutments</td>
<td>Unfavorable implant positions with adequate interarch space</td>
<td>Retrievable Ease of prosthetic steps</td>
<td>Need more interocclusal space</td>
</tr>
<tr>
<td>Screw-retained framework and cement retained crowns</td>
<td>Unfavorable implant positions with adequate interarch space</td>
<td>Retrievable Easy to repair</td>
<td>Costly Technique sensitive</td>
</tr>
<tr>
<td>Screw-retained prosthesis with lateral screw abutments</td>
<td>Unfavorable implant positions with limited interarch space for occlusal screw access</td>
<td>Retrievable Ease of maintenance More esthetic single piece prosthesis</td>
<td>Technique sensitive</td>
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procedures. The different materials used for fabricating milled titanium frameworks, can improve accuracy and (CAD-CAM) or computer numeric controlled (CNC) aided design and computer-aided manufacturing term success. Digital technologies, including computer-communication of complete-arch protheses is important for long-layering of pink porcelain or composite resin. can be milled in titanium or zirconia with suitable situations. The framework can be customized easily and with individual crowns is an effective alternative in such situations. The framework can be customized easily and can be milled in titanium or zirconia with suitable layering of pink porcelain or composite resin.

In addition to abutment design, the precision fabrication of complete-arch protheses is important for long-term success. Digital technologies, including computer-aided design and computer-aided manufacturing (CAD-CAM) or computer numeric controlled (CNC) milled titanium frameworks, can improve accuracy and passive fit compared with the technique-sensitive casting procedures. The different materials used for fabricating the teeth (and the occlusal surfaces) and prosthetic frameworks influence stress concentration in the teeth or frameworks or abutments. The frameworks used in different patients in this report were fabricated from the cobalt-chromium alloy or PEEK and the occlusal surfaces are relatively convex, within the limitations of esthetic demands, the surfaces can be maintained plaque free. Use of electric toothbrushes or professional oral hygiene with glycine air polishing has been reported to provide high levels of both cleaning efficacy and patient acceptance of such prostheses.

Figure 7. Types of abutment designs used for complete-arch fixed prostheses in managing unfavorable implant positions and angulations.

surfaces are relatively convex, within the limitations of esthetic demands, the surfaces can be maintained plaque free. Use of electric toothbrushes or professional oral hygiene with glycine air polishing has been reported to provide high levels of both cleaning efficacy and patient acceptance of such prostheses.

SUMMARY

Advances in biomaterials and technology have greatly enhanced the prosthetic options available. This article summarizes the different prosthetic options available for managing unfavorable implant axes and aims to help clinicians plan and execute treatment for these challenging patients.

REFERENCES

Noteworthy Abstracts of the Current Literature

Incidental findings in cone beam computed tomography for dental implants in 1002 patients

Balshi SF, Balshi TJ, Kachlan MO, Wolfinger GJ, Yang J

JP: 2021: 30: 665-75

**Purpose.** The purpose of this study is to analyze the frequency and elevate the awareness of the prevalence of nondental pathology in cone beam computed tomography (CBCT) scans taken for implant placement treatment planning and postplacement evaluation. The data from the CBCT should be read by an oral and maxillofacial radiologist for proper diagnosis of dental and nondental pathology and referred to the medical specialist for proper management when necessary.

**Material and methods.** This retrospective study analyzed 1002 consecutive CBCT scans taken at a single private practice noting the prevalence of nondental pathology in CBCT images for all dental implant procedures. All scans were taken from November 2007 to March 2020. One board certified oral and maxillofacial radiologist systemically read all scans and reported all findings in the maxilla and mandible, condyles and TMJ, paranasal sinuses, nasal fossa, pharyngeal airway, skull base and temporal bone, neck soft tissues, and cervical spine. The incidental findings, variation of normal anatomy, or pathology reported in these structures were categorized based on anatomic location and significance and the incidence was investigated.

**Results.** Pathologies ranged from innocuous sinusitis, to more serious atherosclerotic calcification of the carotid arteries, narrowed airways, and neoplastic lesions. Fifty-one different findings were noted, of which 36 were pathologies that required referral or follow-up.

**Conclusions.** Incidental findings can be detected in CBCT scans for dental implants. The clinician must be familiar with the radiographic diagnosis of head and neck pathology, and/or must refer these images to an appropriate specialist for the radiographic interpretation of the full volume.

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