



Treatment of edentulous and partially edentulous maxillae: Clinical guidelines

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Edentulous maxillae differ from edentulous mandibles in their resorptive and loading patterns, as well as in the bone quality and quantity typically associated with both. Consequently, clinical guidelines for treating each arch must differ. This article presents a literature-based, systematic approach aimed at helping clinicians with treatment planning and the decision-making process for maxillary treatment. The process requires balancing patient preferences and finances with a number of clinical factors. Because the choice of fixed versus removable options for both provisional and definitive prostheses is often the most difficult step in treatment planning, special attention is given to considerations regarding both.

Key Words: maxillae, clinical guidelines, treatment planning, implants

Introduction

Despite advances in modern dentistry, age-specific rates of edentulism are expected to increase over the next several decades in most industrialized countries throughout the world.^{1,2} It is important to note that these studies do not take into account partially edentulous patients with severely compromised teeth; this segment of the population represents a large and important group of patients who will also be seeking care.

The goal of early implant researchers was to eliminate mandibular complete dentures and treat patients with edentulous mandibles with fixed-implant prostheses.³

Over the past two decades, numerous worldwide studies have demonstrated that the mandibular two-implant overdenture is a simple and effective option.^{4,5} This has led to a shift in therapeutic philosophy and eventually to the development of the McGill Consensus Statement on Overdentures.⁶ The consensus suggested “the mandibular two-implant overdenture was the first-choice minimal-treatment objective for edentulous patients.” Current concepts for edentulous mandibles include both fixed and various removable options that often lead to high levels of implant success, prosthesis survival, and a consistently high level of patient satisfaction.⁷



Maxillary treatment presents different challenges. Based on a careful review of the literature,⁸ the present authors would like to suggest that the most appropriate starting point among a hierarchy of acceptable treatment options is a thorough examination and diagnosis of the edentulous (or partially edentulous) condition prior to treatment planning. However, decision-making may still be confusing for a significant number of clinicians. How does one choose among various fixed and removable designs? What is the correct/optimal number and position for implants? Does splinting implants improve implant survival? How are mandibular guidelines applied to the maxilla?

Treatment of edentulous maxillae should be considered different from that of edentulous mandibles for the following reasons:

1. **Different Resorptive Patterns:** Maxillae resorb superiorly, posteriorly, and medially, while mandibles resorb inferiorly, anteriorly, and laterally (Fig. 1).^{9,10} These differences often lead to unfavorable implant relationships between the opposing jaws.
2. **Anatomic Factors:** Multiple studies indicate that bone density is one of the most important factors for implant success.^{11,12}

Maxillae generally present with less bone quality (density) as compared to mandibles. The maxillary and nasal sinuses also are associated with diminished quantities of bone.¹³

3. **Loading Patterns:** Because maxillae are stationary, with loss of teeth and proprioceptive mechanisms, they are ill-equipped to respond to large occlusal forces.¹⁴⁻¹⁶

To compensate for these factors, surgical treatment plans can be developed that include such strategies as optimally positioning an adequate number of implants, undersizing the osteotomies, and using tapered implant designs. In the prosthetic phase of treatment, three factors are mostly affected by maxillary determinants.¹⁷

1. **Aesthetics:** Oral/facial symmetries and lip contours are significantly influenced by maxillary tooth positions, vertical dimensions, and/or the need for flanges of varying thicknesses for lip support.^{18,19}
2. **Phonetics:** It is important to understand that maxillary prostheses affect speech more than mandibular prostheses. Patients have identified speech quality as a major factor in perceived satisfaction with their prostheses.²⁰⁻²³



3. Prosthesis Design and Fabrication: Clinicians must understand technical difficulties, fabrication options, material choices for replacing large volumes of missing tissues, and precision fit issues prior to developing maxillary treatment plans.^{24,25}

Clinical guidelines established for treating edentulous mandibles should not be directly extrapolated to treatment of edentulous maxillae. Rehabilitation of edentulous maxillae is significantly more complex.

The purpose of this article is to present a literature-based, systematic approach that will aid clinicians in the decision-making process specifically related to the maxilla, including:

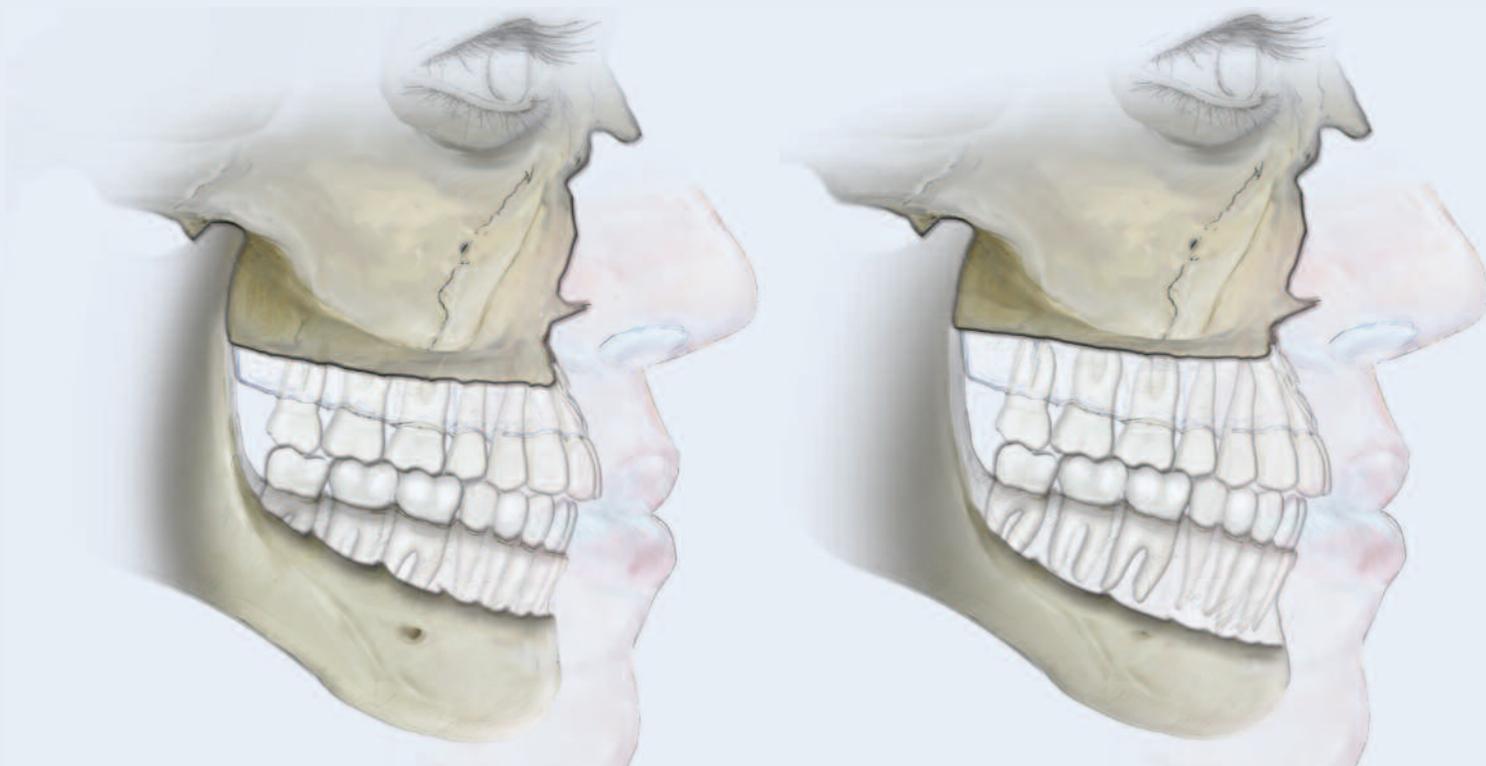
- The patient interview
- Collection of basic diagnostic data
- Discussion of provisional restorative options
- The decision-making process
- The confirmation letter

I. Patient Interview

Without question, the patient interview is the first and most important step in this process.²⁶ History-taking is both an art and a science. What is said in response to questions is as important as the way it is said; what is omitted is also important. A thorough dental and medical history should be part of the patient interview.

It is important to understand that edentulism and partial edentulism affect patients on personal and emotional levels. When replacing lost teeth, clinicians need to consider patients' specific needs, psychological considerations, and personal objectives and preferences.²⁷ Sufficient time should be devoted to asking patients about their expectations, rather than telling them what they need. Table I suggests some questions for inclusion in the patient interview.

It is important for patients to understand that there are numerous options available to meet their specific needs, and that the benefits, limitations, and financial commitments required for each option vary. To most efficiently direct the decision-making process, basic financial considerations should be reviewed at this initial interview appointment.



II. Collection of Basic Diagnostic Data

A thorough clinical examination, diagnostic casts, diagnostic wax patterns, radiographs, and an evaluation of intra- and extra-oral factors are all necessary early in the treatment process.

On the most basic level, patients will be differentiated as dentate, partially edentulous, or edentulous. For edentulous patients, the first step in prosthetically driven treatment planning is to determine ideal tooth positions. Patients who present with existing dentures should be evaluated with and without the dentures in place. Such evaluation can yield significant information about the ideal tooth positions, vertical dimension of occlusion, vertical dimension at rest, and whether or not a flange is needed for facial and lip support. If the patient's existing denture is unsatisfactory, a wax denture should be fabricated to enable agreement between the patient and clinician about tooth position and facial/lip support. Additionally, this wax denture should be evaluated with both a full and partial (cut back) flange.

Clinicians need to assess the general ridge anatomy, inter-arch distance, and inter-arch relationships. Articulated casts usually

provide significant data in this regard. Clinicians also need to consider what structures are missing and what replacement materials may be used in the rehabilitation.²⁸ Once the aesthetic outcome has been agreed upon, the wax denture prosthesis should be duplicated for use as a conventional surgical guide with three-dimensional analysis (cone-beam computerized tomography (CBCT)) or for CT guided surgery.

According to the American Academy of Oral and Maxillofacial Radiology, "a single panoramic image is not sufficient for pre-surgical dental implant-site assessment."²⁹ An accurate diagnosis and subsequent treatment plan may only be determined in conjunction with three-dimensional analysis; this should be considered basic diagnostic information.

After the diagnostic data have been collected, the factors summarized in Table 2 will favor either a fixed or removable treatment option.

However, the definitive choice between fixed or removable treatment options cannot be solely based on the factors presented in Table 2. Deciding between those options is often the most difficult step in the treatment-planning process.

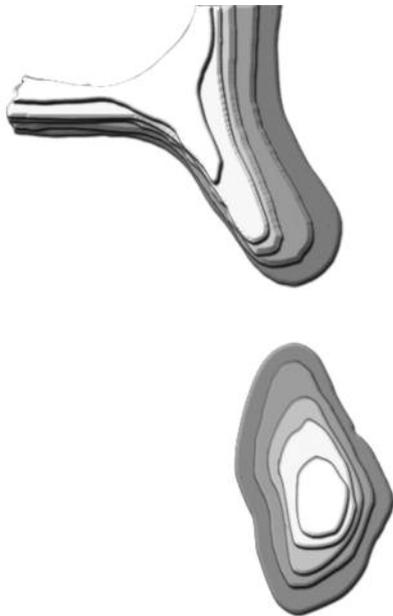


Fig. 1. Schematic drawing showing that maxillae resorb superiorly, posteriorly, and medially. In contrast, mandibles resorb inferiorly, anteriorly, and laterally.

III. Discussion of Provisional Restorative Options

After interviewing the patient and evaluating the diagnostic data, clinicians need to review with patients the provisional restorative options that are available to them. Discussion of these options early in the process has an enormous impact on case acceptance. Once the type of provisional prosthesis has been chosen, this choice will assist clinicians in designing the definitive prosthesis (fixed/removable). Moreover the treatment sequence will influence the choice of how many implants must be placed and where they will be positioned.

Each provisional prosthetic option has benefits and limitations. Treatment options for fixed prostheses include the following:

I. Serial Extraction Protocol: For partially edentulous patients with periodontally compromised teeth, clinicians may consider a serial extraction protocol. This protocol involves the selective extraction of teeth, with or without immediate implant placement. If implants are not placed immediately, the extraction sites should be grafted to maintain the volume of the alveolar ridge.³⁰ Full-crown preparations of the remaining teeth and conventional tooth-supported provisional prostheses are also typically required. This option is often the treatment of choice.³¹

For Patients:

- How can I help you?
- What are the treatment goals that you would like to achieve?
- Are you satisfied with your appearance?
- For patients wearing removable prostheses:
 - Do you need improved retention?
 - Would you like to be able to feel the roof of your mouth and cut out the palatal aspect of the denture?
 - Would you like to eliminate the removable prosthesis altogether and replace it with a prosthesis that does not come in and out?

For Clinicians:

- What type of provisional prosthesis is appropriate?
- Will the patient tolerate a removable provisional prosthesis at any time or does the patient want/have to be maintained with a fixed provisional prosthesis?

Table 1. Patient interview questions.

2. Extractions and Immediate Implant Placement with or without Immediate Provisionalization:

Immediately after tooth extraction, implants may be placed and restored with provisional prostheses.^{32,33} Clinicians should proceed with great caution if this protocol is selected, as compromised tooth positions may lead to aesthetic, phonetic, and other difficulties with the definitive prostheses.

3. Immediate Provisional Restorations:

Implants may be placed in healed sites and restored with immediate provisional prostheses. Immediate loading of a maxillary fixed implant prosthesis requires careful case selection but is considered scientifically and clinically valid. One- to three-year implant-survival rates range from 95.4-100%, and prosthesis-survival rates range from 87.5-100%.³⁴⁻³⁹ In these studies, prostheses generally were full-arch, one-piece, cross-arch-stabilized designs supported by four to eight implants placed with adequate initial insertion torque.

4. Interim Removable Prostheses:

For patients with removable provisional prostheses who will be receiving fixed definitive prostheses, it is essential eventually to fabricate fixed provisional prostheses. This is necessary to determine aesthetic final tooth positions and

Intraoral Factors	Fixed Prosthesis	Removable Prosthesis
General ridge anatomy	Adequate B/L width	Inadequate width, buccal concavity
Interarch clearance	10mm or less	Greater than 15mm
Skeletal jaw relationship	Class I or moderate Class II	Class III
Facial/lip support	Not needed	Required

Table 2. Evaluation and summary of intraoral and extraoral factors.

emergence profiles of the abutments and definitive prostheses, as well as to establish the palatal contours of the prostheses for optimal phonetics. These provisional prostheses will be used as a prototype for the definitive prostheses. It is difficult and unpredictable for both patients and clinicians to transition from removable provisional prostheses to definitive fixed prostheses without some interim use of fixed provisional prostheses.

If the treatment plan includes a removable definitive prosthesis that will change the patient's lip support and overall aesthetic appearance, new interim dentures should be fabricated. If the existing prostheses are satisfactory, clinicians may choose to have patients continue to wear those prostheses. Diagnostic wax patterns for surgical guides are mandatory unless tooth positions will not be altered. For definitive removable prostheses, fixed provisional prostheses need not be discussed as a treatment option.

The importance of provisional prostheses cannot be overemphasized.

IV. The Decision-Making Process

The decision-making process must balance three key factors.

Patient Preferences: It is important to understand the difference between wants and preferences. "Wants" may or may not be related to treatment realities; "preferences" means that patients have clear understandings of the advantages and disadvantages of a given type of prosthesis. Clinicians should use the interview process, along with an understanding of the diagnostic factors, to turn the "wants" into "preferences." The benefits and limitations of each design, including maintenance (aftercare) considerations

and costs, must be explained. All full-arch implant prostheses require some degree of prosthetic maintenance. An understanding of these requirements and costs, as well as the limitations inherent in removable prostheses (movement, palatal coverage, unnatural feeling), will significantly assist patients in arriving at an optimal treatment choice.

Studies clearly indicate that with patient-centered care, when patient preferences are taken into consideration in the decision-making process, patients tend to do better with the treatment.⁴⁰

Finances: Cost is often the most significant factor for patients deciding among treatment options. It is therefore critical to present patients with realistic options. If a fixed definitive prosthesis is simply unaffordable, clinicians should recognize this and offer a removable prosthetic option (or options).

Clinical Factors: These include the bone quality and quantity. In addition, clinicians need to consider the form of the ridge (V-shaped versus U-shaped) relative to the anterior/posterior (A-P) spread (or other biomechanical factors), as well as the skeletal jaw relationships.

Other Fixed Versus Removable Considerations

Number of Implants

There is no consensus on the ideal number of implants needed to support either fixed or removable restorations, and the number of implants being placed should not be the determining factor in choosing a fixed versus removable option. The literature does indicate that four to six implants are sufficient to support both fixed and removable prostheses.^{35,36,38,41} It is important to relate the number of implants to the number of planned prosthetic teeth. Fewer implants are required for shortened arch treatment (premolar occlusion). The final decision about the number of

Fig. 2a.

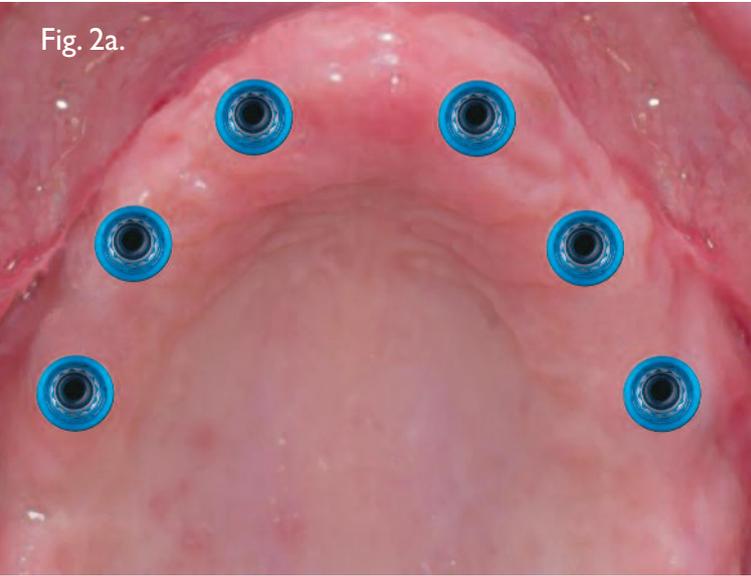


Fig. 2b.

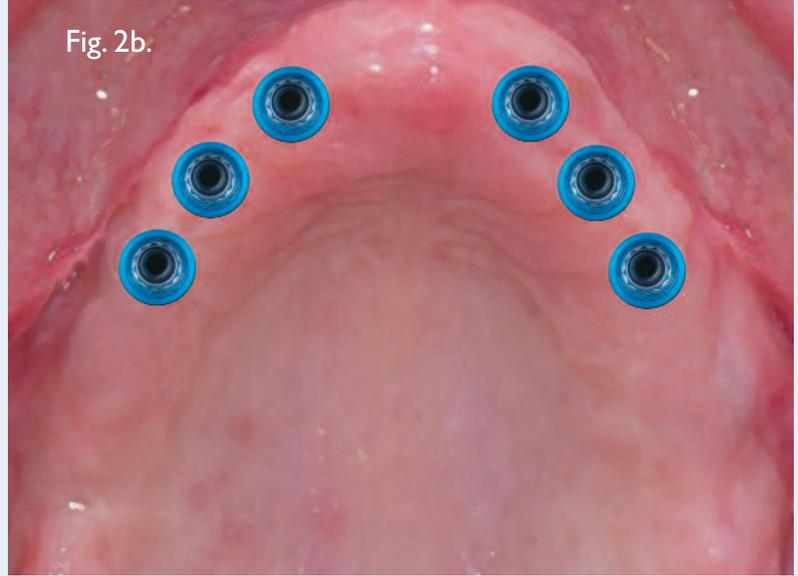


Fig. 2d.

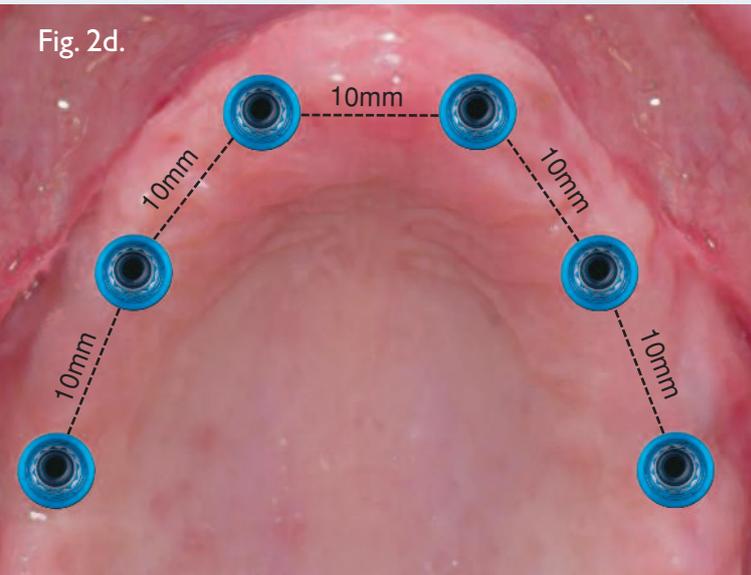
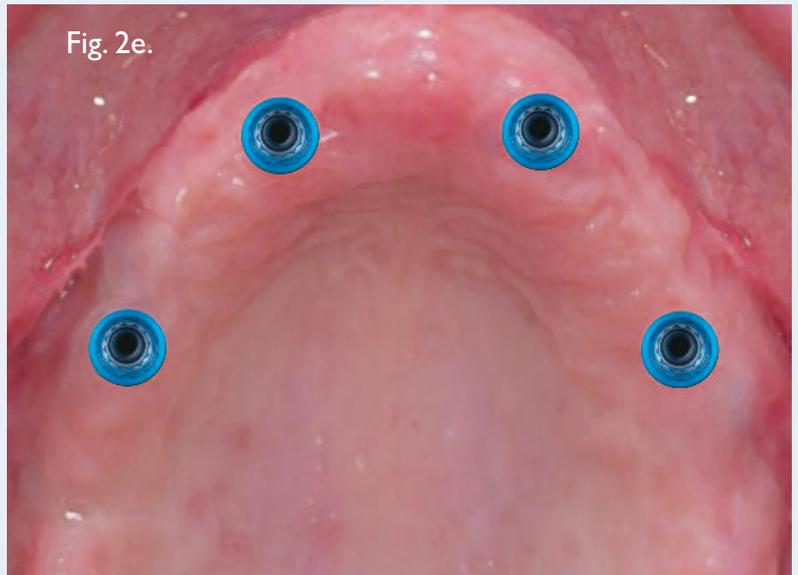


Fig. 2e.



implants is often based on aesthetic parameters (design of the prosthesis, need for a flange) and other patient-specific factors (e.g. bone-grafted sites, parafunction) and psychological factors.

Location of Implants

It is critical to understand that implant-placement locations influence the choice of fixed versus removable prostheses. Whereas either an anterior concentration or a wide distribution of implants is acceptable for maxillary fixed prostheses, only a wide distribution is recommended for removable prostheses. Furthermore, whereas either rigid

or non-rigid (resilient or rotational) removable prostheses are acceptable in the mandible, maxillary removable prostheses must have multiple retentive elements and no rotation, in addition to being supported by widely distributed implants.

Figures 2a-f demonstrate clinical examples of multiple numbers and varying locations of implants for maxillary treatment. Without further diagnostics (e.g. articulator mounting), it is impossible to make a decision relative to fixed versus removable treatment options.

Fig. 2c.

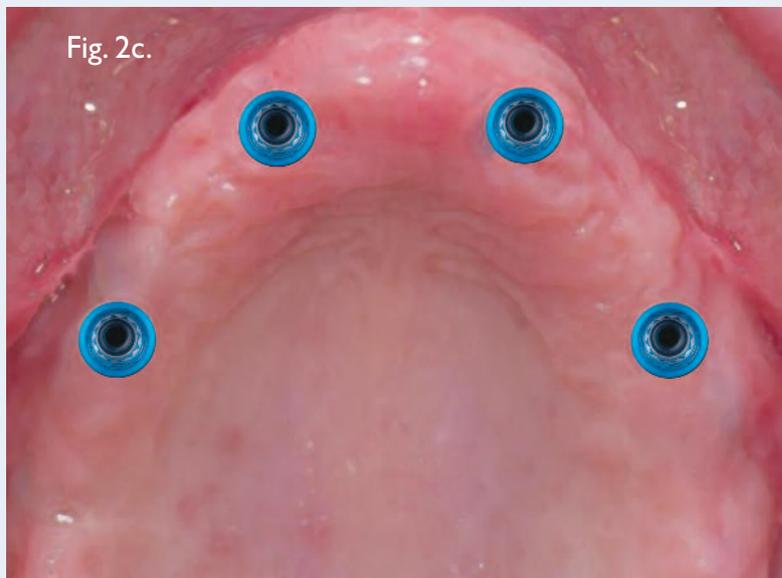


Fig. 2a. Fixed Prosthesis: It is ideal to place six implants, with fewer implants positioned anteriorly (where aesthetics are enhanced by avoiding implants next to each other). In this situation, more implants may be positioned posteriorly (for first molar occlusion). This arrangement applies to large or small, V- or U-shaped arches.

Fig. 2b. Fixed Prosthesis: An alternative treatment plan when six implants are placed is to concentrate the implants in the anterior segment, with exact positioning dependent on the tooth size, position, and quantity/quality of bone. Cantilevered pontics may be provided distal to the second premolar or first molar to avoid sinus grafting. This arrangement may be most ideal for V-shaped arches where the A-P spread is optimal.

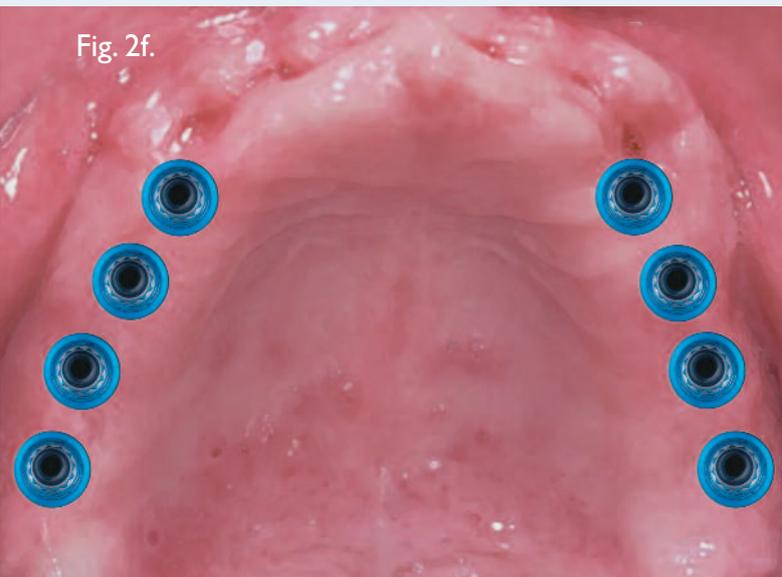
Fig. 2c. Fixed Prosthesis: Depending on the quality and quantity of bone, four implants may be placed but should be positioned to optimize the A-P spread. The posterior implants may be tilted to follow the anterior walls of the maxillary sinus. Angled abutments would be required to correct the non-vertical implant angulations. This implant arrangement may result in shorter prostheses (second bicuspid occlusion). Placing fewer implants requires careful case selection and is most ideal for V-shaped arches. The amount or lack of tooth display during speaking and smiling is critical.

Fig. 2d. Removable Prosthesis (splinted or unsplinted): The placement of six implants continues to be ideal, but the implants must be distributed widely with the center of each implant placed at least 10mm from the center of the adjoining implants. There needs to be adequate space for placement of the denture teeth, base, and attachments facial to the framework. Implant positioning is similar to that for fixed prostheses, but generally the mesial-distal positioning is less critical, since embrasure spacing and aesthetics are not critical. This implant arrangement can provide second molar occlusion and can be used for either large or small, V- or U-shaped arches.

Fig. 2e. Removable Prosthesis: Depending on the quality and quantity of bone, four implants may be placed, but it is essential to achieve a wide distribution (similar to implant positioning for fixed prostheses). Implants should be placed more palatally. The posterior implants may be tilted to follow the anterior walls of the maxillary sinus. Angled abutments would be required to correct the non-vertical implant angulations. For maxillary removable prostheses, anterior concentrations of implants should be avoided. This implant arrangement is ideal for smaller V-shaped arches.

Fig. 2f. Removable or Fixed Prosthesis: If sinus grafting has been accomplished but it is not possible to predictably augment anterior bone, as many as eight implants may be placed in more posterior positions. This arrangement can be applied to either large or small, V- or U-shaped arches.

Fig. 2f.



Space Considerations

Although overdentures are recommended for severely atrophic arches, this option paradoxically requires the most restorative space. Careful pre-operative planning is essential.⁷ In the vertical or inferior-superior dimensions, overdentures will require at least 7mm of space when the implants are unsplinted. Overdentures made for frameworks require considerably more space -- approximately 11mm. Whereas mandibular overdentures are space-sensitive anteriorly, maxillary ones are space-sensitive posteriorly.

Among the range of patients with minimally resorbed maxillae (American College of Prosthodontists Prosthodontic Diagnostic Index (ACP PDI), Class I) to those with severely resorbed arches (ACP PDI Class IV),⁴² treatments will vary. The following hierarchy of space requirements, from least to most, exists:

1. Fixed prostheses (screw-retained).
2. Fixed prostheses (cement-retained). The space requirements for these are basically equivalent to those for removable

- prostheses with unsplinted implants (no frameworks).
3. Removable prostheses with unsplinted implants.
 4. Removable prostheses with splinted implants (frameworks).

Available or attainable restorative volume is another important factor in determining whether fixed or removable prosthetic options are viable. If a given patient presents without adequate restorative volume, increased volume may be obtained by surgically re-contouring the edentulous sites, thereby increasing the vertical dimension of occlusion. This is another critical aspect in implant treatment planning. Generally, removable prostheses require more restorative space than fixed prostheses.

The most ideal candidates for removable prostheses are those who have already reported favorable experiences with removable prostheses. However, studies indicate that just because a patient presents with a removable prosthesis, that need not mean the new prosthesis should be removable as well. In partially edentulous or edentulous arches, the transition from a removable prosthesis to an implant-retained/supported overdenture has been demonstrated to be relatively easy. The transition from a fixed to a removable prosthesis has been reported to be more difficult and may require longer periods for accommodation.⁴³

Summary of the Decision-Making Process

Fixed Prostheses

Fixed implant prostheses generally are straightforward treatment options when patient preferences, finances, and favorable anatomic factors align. Depending on the jaw shape (A/P spread) and the number of posterior teeth needed, a minimum of six well-distributed maxillary implants are recommended (with more implants generally required in areas of poor bone quality). To improve aesthetic outcomes for fixed prostheses, implants may be placed in more posterior sites. For mild/moderately resorbed maxillae, either cement- or screw-retained prostheses may be acceptable. For severely atrophic maxillae, screw-retained prostheses are currently the optimal prosthetic design, although the evolution of lab-designed CAD/CAM abutments may eventually change that. It is generally acknowledged that the most difficult of all maxillary jaws to treat are in those patients with severe resorption who will not accept removable prosthetic designs.

Removable Prostheses

Removable implant prostheses are indicated when there is a mismatch between patient preferences and other factors, e.g. when patients prefer fixed designs but either cannot afford a fixed solution or lack sufficient bone to accommodate appropriate sized implants in optimal positions. General satisfaction as well as ratings of most psychosocial and functional variables have been shown to be very high when patients compared the experience of wearing maxillary long-bar implant overdentures, both with and without palatal coverage, that were opposed by a fixed mandibular implant-supported prosthesis.²⁷ Patients who were previously unsatisfied with maxillary dentures⁴⁴ also rated maxillary long-bar overdentures significantly higher than fixed prostheses. This is distinctly different from patient reports regarding mandibular dentures.

Numerous studies have reported on the efficacy of maxillary overdentures retained and supported by six implants evenly distributed throughout the jaw.⁴⁵⁻⁴⁷ For patients with severe atrophy, bar overdentures tend to be ideal, since frameworks provide significant retention, stability, and most importantly, indirect retention for the prostheses. Such overdentures are non-rotational and tend to require minimal maintenance. For patients with mild to moderate resorption and minimal restorative space, preliminary evidence suggests that a minimum of four unsplinted implants, combined with full metal frameworks and partial palatal coverage, may provide clinically acceptable results.⁴⁸

V. Definitive Treatment Plan

Prosthesis Design

Implant dentistry is a restorative-driven service, but it is highly dependent upon surgical protocols. Implant-specific restorations must be carefully planned and designed to exact specifications prior to commencing patient treatment. If the definitive prosthesis will be fixed, clinicians must pre-determine if it will be cement- or screw-retained, as this design feature may affect implant placement relative to the locations of the screw-access openings within the restorations. Clinicians should also pre-operatively select the type of materials to be used for the prostheses (ceramic or resin) and the fabrication process (cast or CAD/CAM, including copy-milling). If the definitive prosthesis will be removable, clinicians must determine pre-operatively if the implants are to be splinted or not. Long-term prosthetic maintenance concerns are also important relative to prosthesis design because all full-arch prostheses have aftercare (post-insertion) considerations.^{41,49} These should be explained to patients at the start of the process and often may have a

significant impact on prosthetic designs. After all these determinations have been made, the clinician should review the definitive treatment plan once more with the patient.

VI. The Confirmation Letter

The confirmation letter is an important medico-legal document. It should be considered a prosthetic consent form and is a necessary component in the pre-treatment protocol described in this article. It should be signed and returned by all patients prior to beginning treatment, and it should include:

- all previous discussions
- diagnoses
- informed consent /informed refusal
- treatment options
- the definitive treatment plan, including benefits, limitations, and caveats pertaining to the chosen design
- prognoses associated with implants, natural teeth, and prostheses
- fees
- aftercare considerations (expected frequency and costs)
- patient peri-implant maintenance obligations

Clinical Relevance

This paper has described some of the differences between treatment of the maxillary and mandibular jaws. The prosthetic phase of maxillary rehabilitation (aesthetics, phonetics, prosthesis design, and fabrication) is comparatively more challenging than that for the mandible. Optimal decision-making must balance three key factors: patient preferences, finances, and anatomic conditions, including the amount of restorative space available and the question of whether or not a full or partial flange will be necessary to achieve an optimal aesthetic result. The choice of what type of provisional prosthesis will be used is another key consideration. Direct extrapolation of mandibular treatment guidelines should not be applied to maxillary situations. With careful planning and execution, maxillary treatment can result in high levels of implant success, prosthesis survival, and patient satisfaction.

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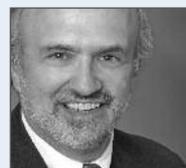
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