

Maxillary Fixed Prosthesis Design Based on the Preoperative Physical Examination

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The purpose of this article is to illustrate the use of physical examination findings that can be used to determine the design characteristics of a full arch restoration in the maxilla. These anatomic findings include 1) the resting and 2) smile line exposures of the central incisor; 3) the vertical position of the edentulous ridge when smiling; 4) the anteroposterior relation of the teeth to the edentulous ridge; 5) the presence of bone posterior to the premolar region; 6) the anterior height of the alveolar bone in relation to the floor of the nose; and 7) the planned inclination of the maxillary teeth. Based on these physical findings, the final prosthetic plan can be established before surgery. Determination of the final restorative plan determines the surgical procedures to be performed.

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To restore the maxillary arch, the clinician should recommend one of several options for the patient. Knowing which option is best for a given patient is based on a complex set of factors. These decisions can appear to be complex to the clinicians involved with the patient's care.

Failure to recognize the limitations of various options can result in poor esthetics and poor health around the implants owing to maintenance problems.

Prosthetic Options

ANTERIOR IMPLANT-SUPPORTED HYBRID PROSTHESIS

A hybrid-type prosthesis should allow for the superior edge of the labial flange to be hidden within the lip during all lip movements. The flange should be positioned to allow for hygiene access for cleaning the implants using floss or a brush. A major incidence of peri-implant gingivitis and a small but important prevalence of bone loss have been reported when implants are not accessible to cleaning.¹⁻¹⁹

A hybrid denture usually requires at least 15 mm of space from the incisor tip to the bone to contain all the mechanical needs for the hybrid prosthesis.²⁰ This includes the trans-gingival thickness, the 5 to 7 mm of framework height, the amount of acrylic needed to secure denture teeth, and the dimensions of the

denture teeth. If bone is to be removed to provide this distance, then sufficient bone should be available for an appropriate implant length to provide mechanical stability and to locate the flange within the lip. Unfortunately, specific clinical trial evidence on the minimal length for implant use for maxillary full arch provisional prostheses is not clear for currently used implants. Most clinicians prefer implants at least 11 mm in length. This requires 26 mm of space from the planned incisive edge to the floor of the nose or excessive angling of the implants to gain implant length.²⁰ If the final restoration requires positioning the teeth on the ridge, then the teeth and the flange of the hybrid prosthesis will rest on the gingival tissue with the implants palatal to the flange. This creates a cleaning problem.

POSTERIOR IMPLANT-SUPPORTED PROSTHESIS

In the patient with adequate posterior maxillary bone, implants can be placed from the canine locations posteriorly. A ridge lap design can be used for the anterior dentition with less concern for hygiene access.²¹ If there is minimal bone in the second premolar region, the implants will be required to have a more anterior location and, hence, the ridge position will affect hygiene access owing to prosthetic design considerations. Even with modified ridge lap designs, plaque can be difficult to remove and can result in problems in some patients.^{1-19,22}

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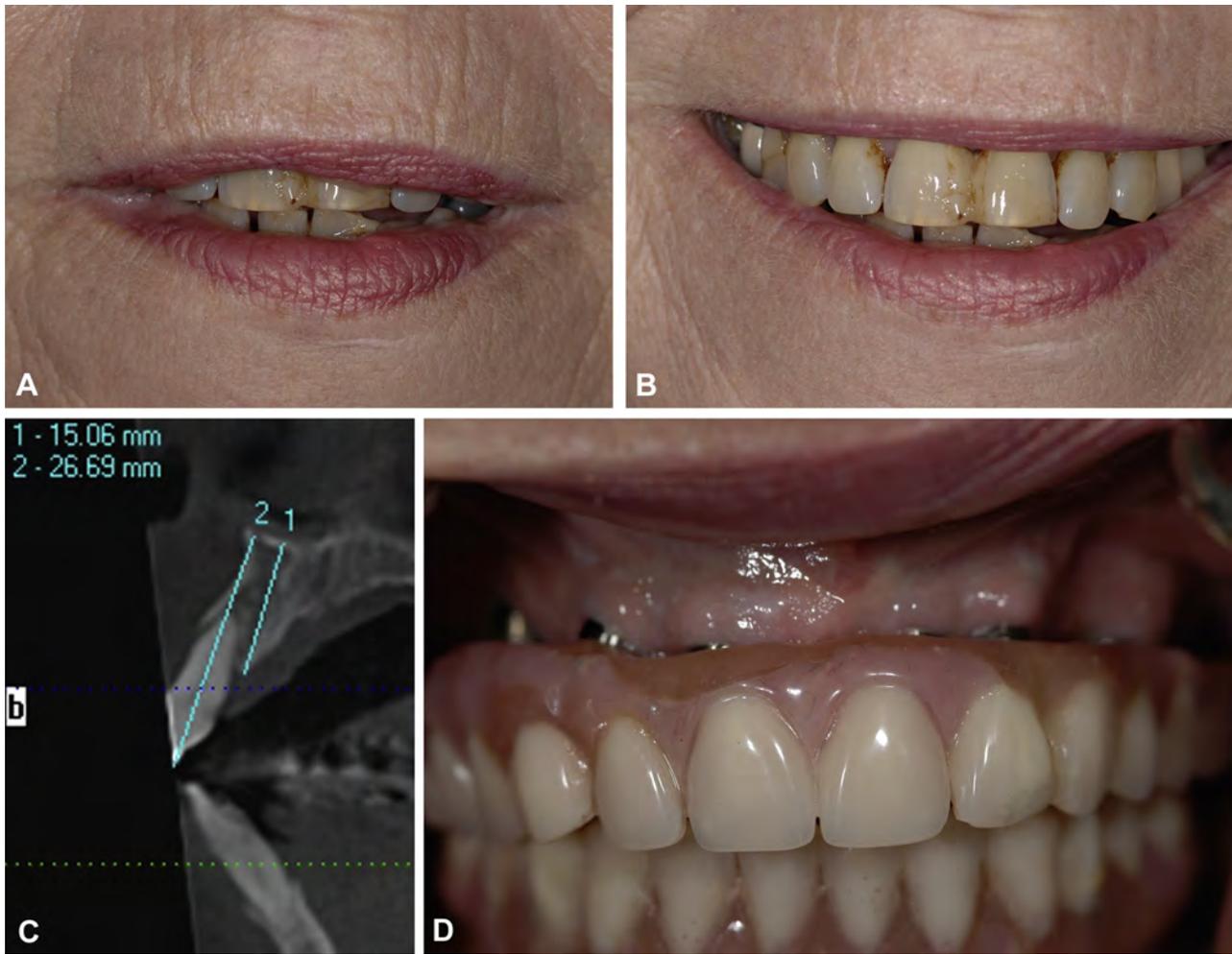


FIGURE 1. A, Appearance of patient with lips slightly apart and relaxed, with an incisor show of 3 mm. B, Smile line of patient at the level of the gingival margin of a 10.5-mm-long central incisor. C, Cone-beam computed tomographic section showing the 15-mm-long implant site with 11 mm of space between the crest and the incisor edge. D, Provisional hybrid prosthesis with the teeth positioned anterior to the ridge to match the patient's preoperative appearance. Notice there is space available for hygiene. (**Fig 1 continued on next page.**)

Michael S. Block. *Prosthesis Based on Preoperative Examination.* *J Oral Maxillofac Surg* 2015.

FULL ARCH CROWN-AND-BRIDGE-TYPE PROSTHESIS

For a crown-and-bridge-type prosthesis, where the implants are to be placed within the teeth and avoid embrasures, the distance required is limited to the length of the clinical crowns plus the trans-gingival thickness of the abutments. Implant positioning is different for this prosthetic design compared with a hybrid-type prosthesis.

If there is sufficient vertical bone present, the use of a traditionally designed full arch crown-and-bridge prosthesis might be the ideal prosthetic design choice. In these patients, implants are placed within the confines of the teeth, thus avoiding the embrasures and mimicking single-tooth implant restorations with traditional hygiene access through the embrasures with minimal ridge lap design.

In this case, the interarch space requirement is less than with a hybrid-type prosthesis, which requires

room for the teeth and gingival thickness. This could lessen the need for major bone reduction, allowing for longer implants.

Treatment Planning Considerations

The tooth show at rest and at smile is used to plan the position of the central incisors (Fig 1). Teeth of proportional length and width are designed and placed within a try-in or using a virtual digital plan. Then, the location of the facial gingival margin of proportioned crowns is used to access the location of the ridge. If there is space present and the smile line allows, then a hybrid prosthesis can be used. If the smile line is high and shows the ridge with minimal space available, then a fixed crown-and-bridge (FCB) type of design is planned (Figs 2, 3).

The amount of bone available for implant placement is determined using a cone-beam computed tomographic (CT) scan. The cross sections provide



FIGURE 1 (cont'd). E, Smile line shows an improved appearance. The patient desired her teeth to be positioned to match her wedding picture, 35 years before this treatment. The new position locates the teeth on the ridge. F, The prosthesis in zirconia creates an improved esthetic appearance with less access for hygiene. The patient is following her maintenance program and seeing the dentist for cleaning every 3 months. (Prosthetics by Dr Mary Beilman and laboratory work by Mr Lars Hanson.)

Michael S. Block. Prosthesis Based on Preoperative Examination. J Oral Maxillofac Surg 2015.

information on the width, height, shape, and quality of bone in the maxilla. If the ridge is thin, then an augmentation could be planned. If the ridge width is augmented, then the surgeon might decide to avoid

flap elevation over the graft and use CT-guided implant placement, which, if performed flapless to avoid graft displacement, will not allow for ridge height modification, thus leading to an FCB-type restoration.

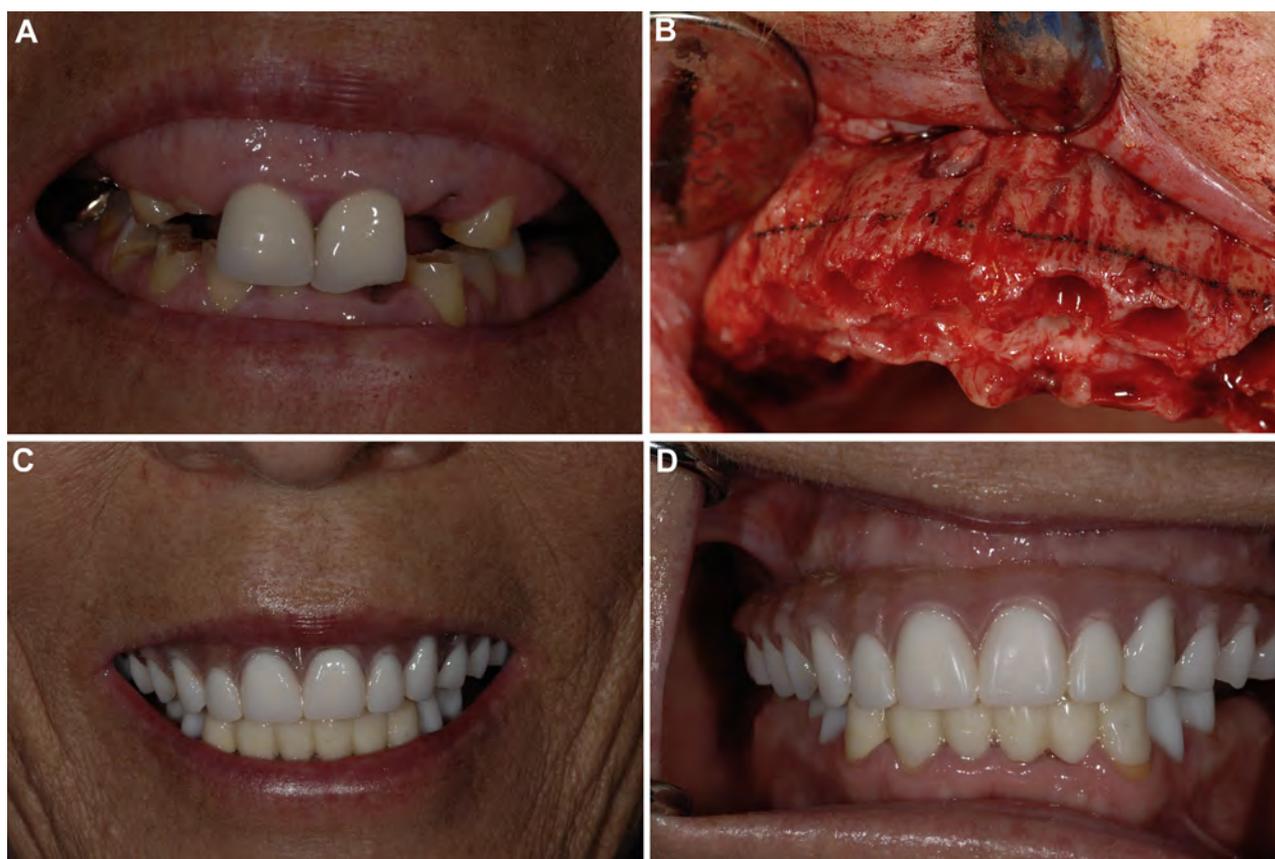


FIGURE 2. A, Smile line shows 6 mm of gingiva superior to the gingival margin of the 10-mm-long central incisor. B, At the time of surgery, 5 mm of labial bone reduction was marked, with 6 mm of palatal bone reduction planned. Photograph shows the planned bone reduction. C, Frontal appearance that satisfies the patient's esthetic desires. D, The final prosthesis in this patient is a hybrid design because of cost restraints. She sees the hygienist every 8 weeks for cleaning because access to the implants is difficult. She uses a Waterpik (Water Pik, Inc, Fort Collins, CO) to aid in cleaning and the palatal slope of the intaglio surface allows for palatal access to the implant surfaces.

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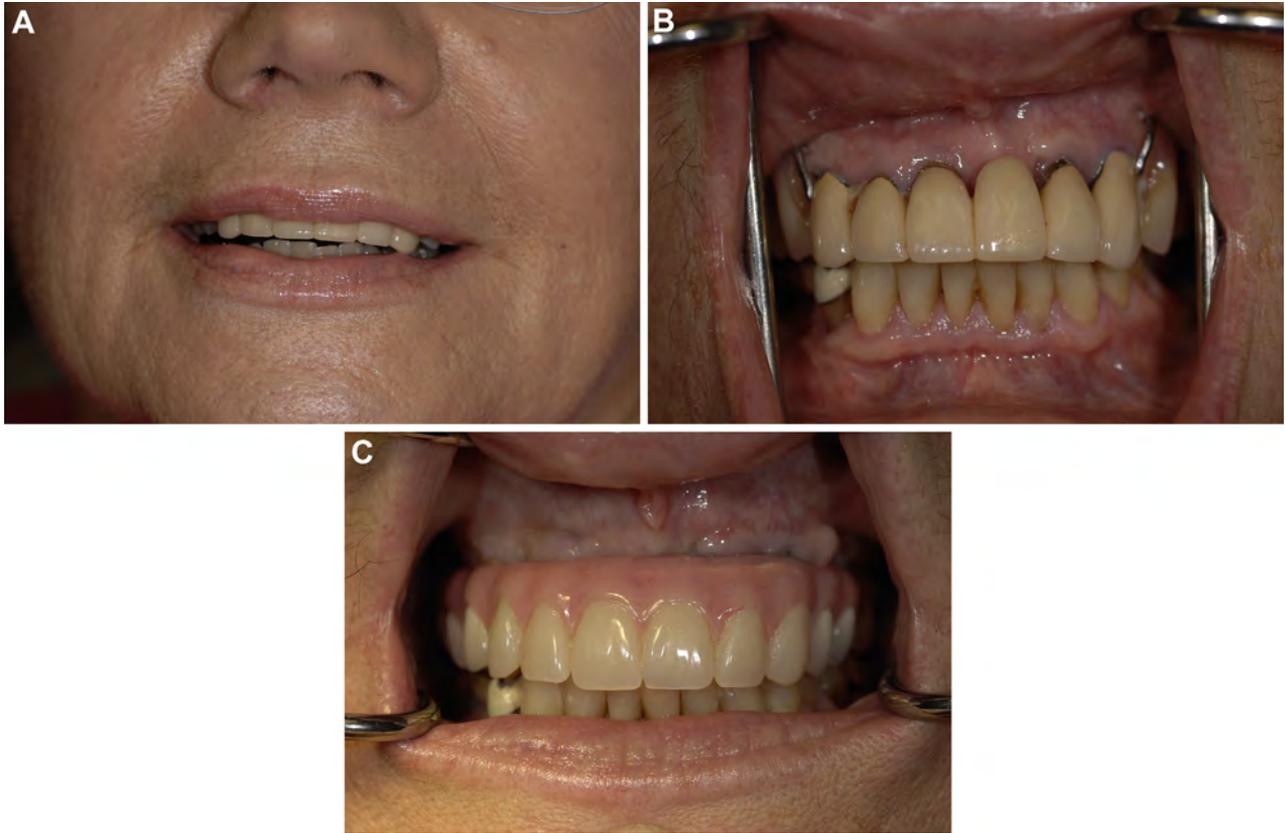


FIGURE 3. A, Preoperative view with the patient attempting to smile. She has a low smile line. B, Frontal photograph of her teeth showing long crown length before tooth removal. She does not show her gingiva in all attempts to have her animate her smile. C, Her provisional prosthesis was made by an inexperienced dentist, leaving excessive flange in the presence of a low smile line. She has a very difficult time cleaning under the flange.

Michael S. Block. *Prosthesis Based on Preoperative Examination. J Oral Maxillofac Surg 2015.*

The cone-beam CT scan can be used to create a virtual plan. The image of the patient's maxilla allows for visualization of the bone and teeth separately. The teeth are "split" from the bone to allow their removal during the setup of the virtual tooth design. The previous examination of the patient should have identified the ideal placement of the new central incisors. The new position of the central incisors vertically, horizontally, and proclination is used to set virtual teeth in relation to the patient's current dentition. The current dentition, which has been "split" from the bone, is removed and the implant planning is performed with the virtually planned tooth positions guiding implant placement. If needed, a CT guide can be fabricated or specific extraction site landmarks can be used to place implants, with the virtual setup as the intended final result (Fig 4).

Preoperative Evaluation of the Patient

DATA COLLECTION

1. Photographs should be taken to document incisor show at rest and at animated smile.

2. Determination of bone height, width, and angulation should be accomplished using a cone-beam CT scan.
3. Determination of the location of the smile line in relation to the osseous ridge, allowing for measurement of the bone available superior to the smile line, might be used to assess the presence of 15 mm of space between the planned incisor edge and the floor of the nose. This is accomplished using CT planning software or the software provided by the cone-beam CT scanning company.
4. Determination of the planned anteroposterior (A-P) position of the teeth in relation to the edentulous crest is performed by evaluating the intended tooth placement using models or digital imaging.

The following list is a set of physical findings that can be used to create and orchestrate a plan for restoration of the patient's maxilla.

1. Resting exposure of the central incisor: The patient is asked to open the lips slightly in a relaxed

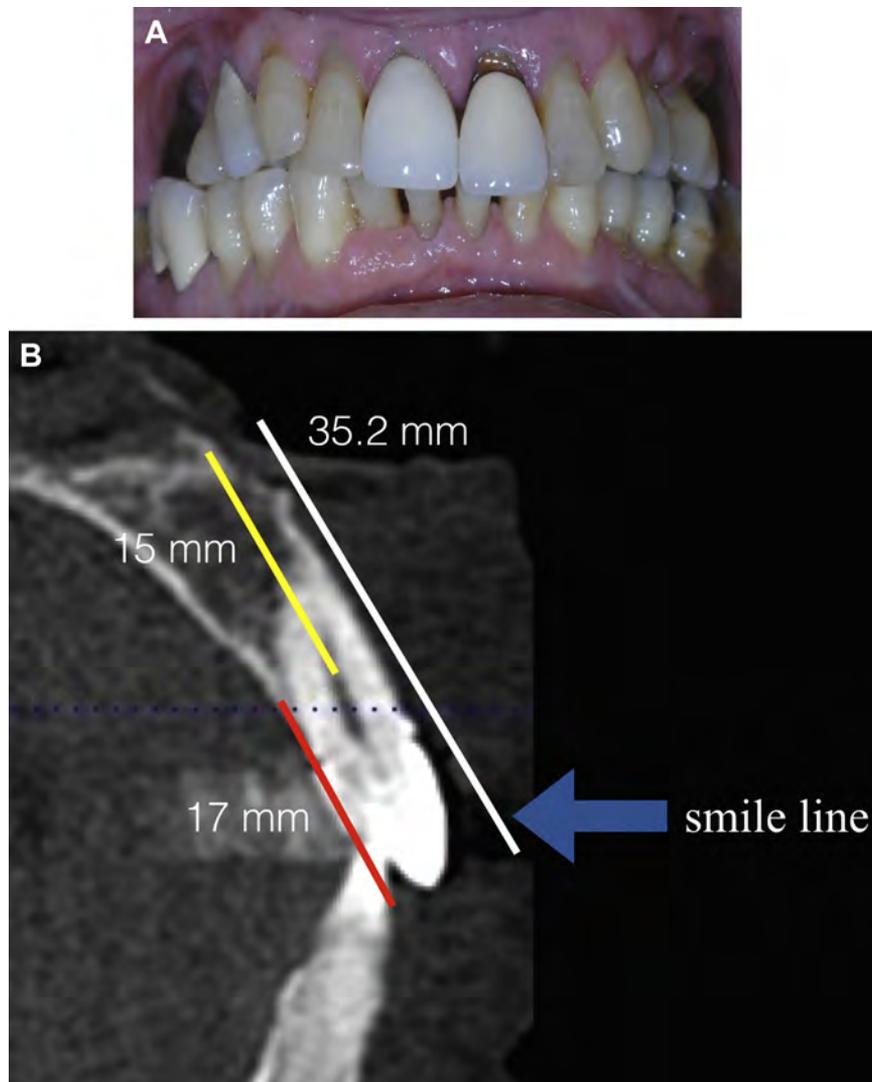


FIGURE 4. A, The treatment plan for this 35-year-old man is removal of his maxillary teeth and the placement of 6 implants for a full arch hybrid prosthesis. He shows 4 mm of tooth at smile. B, Cross-sectional image of his incisor shows adequate bone available after reduction of the vertical height of bone to allow for 15 mm of distance from his planned incisor edge to the alveolar bone after bone reduction. He will have at least 13 mm of bone remaining for implants. (Fig 4 continued on next page.)

Michael S. Block. *Prosthesis Based on Preoperative Examination.* J Oral Maxillofac Surg 2015.

position. With the lips relaxed, the length of the exposure of the central incisor is measured and recorded. The height of the clinical crown of the central incisor is measured and recorded. The vertical positioning of the central incisor locates the facial gingival margin, which sets the intended vertical position of the implant if a fixed-type restoration is planned.

2. Smile line exposure of the central incisor: The patient is asked to smile and animate as much as possible. The exposure of the central incisor to the inferior border of the lip is measured and recorded. When the patient animates a high smile, the lip line will set the edge of the restoration. The flange of the prosthesis must be superior

to the lip line to mask the unesthetic junction of the prosthetic flange to the alveolar ridge. If the lip line is high and the distance from the lip line to the nasal floor is short, then it will be difficult to use a hybrid-type restoration because it will not be possible to achieve ideal implant length to support an immediate-loaded prosthesis. Short implants do not have evidence-based data available to support full arch maxillary implant-borne restorations.

3. Vertical position of the edentulous ridge at the smile: The smile line can be located on the cone-beam CT image using the teeth as a reference or by direct observation of the edentulous ridge without teeth in place. This reference point

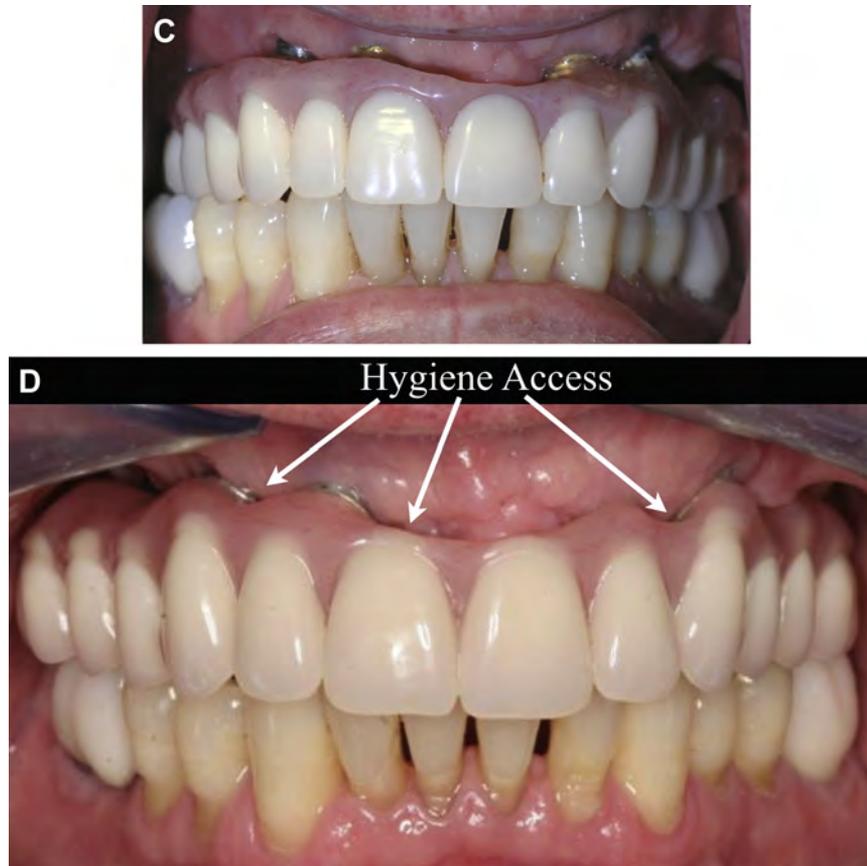


FIGURE 4 (cont'd). C, The provisional hybrid restoration has been modified to allow for hygiene access, which was expected because of his smile line and ability to keep the flange off the gingiva. D, The final hybrid prosthesis has spaces designed to allow for access to the implants for excellent maintenance. (Fig 4 continued on next page.)

Michael S. Block. *Prosthesis Based on Preoperative Examination. J Oral Maxillofac Surg* 2015.

is used to locate the superior edge of the flange of the hybrid prosthesis. If the smile is high, then 1) more bone must be removed; 2) implants will not be placed in the incisor locations; 3) the prosthesis might not be hygienic; or 4) an FCB-type restoration will be needed with the crowns emerging from the implants, which is commonly performed with single-implant crown restorations.

4. A-P relation of teeth to the edentulous ridge: If the teeth are anterior to the edentulous ridge, then access for cleaning can be created within the space between the flange and the crest. If the teeth are close to the ridge, then less access is available for plaque control (Fig 5).
5. Vertical height of bone: Cone-beam CT scanning can be used to determine the vertical height of bone from the crest to the floor or nose and to the floor of the maxillary sinus. The location of the smile line is placed on the scan using the cone-beam CT software. The distance from the incisor edge to the smile line is measured. On

the cone-beam CT cross-sectional scan, a perpendicular line is drawn at this distance. Then, 15 to 17 mm of space is measured from the incisor edge to the bone. Then, the remaining height of bone to the nasal floor can be determined and the implant lengths are determined. It is reasonable to use implants of at least 11 to 12 mm for maxillary implant-borne restorations. In patients who have had bone loss secondary to periodontal-type bone recession, the height of the bone from the crest to the nose could limit implant placement. These patients might benefit from opening of their vertical dimension to re-establish proper vertical occlusal and skeletal relations. Short vertical bone might require adjunctive grafting, including sinus grafting, to allow for implant placement and a full arch restoration, as seen in patients with combination syndrome.²¹ The width of the bone must be sufficient to allow for placement of an appropriately wide implant with sufficient bone to the labial and palatal for primary stability. If there is less than ideal bone width,

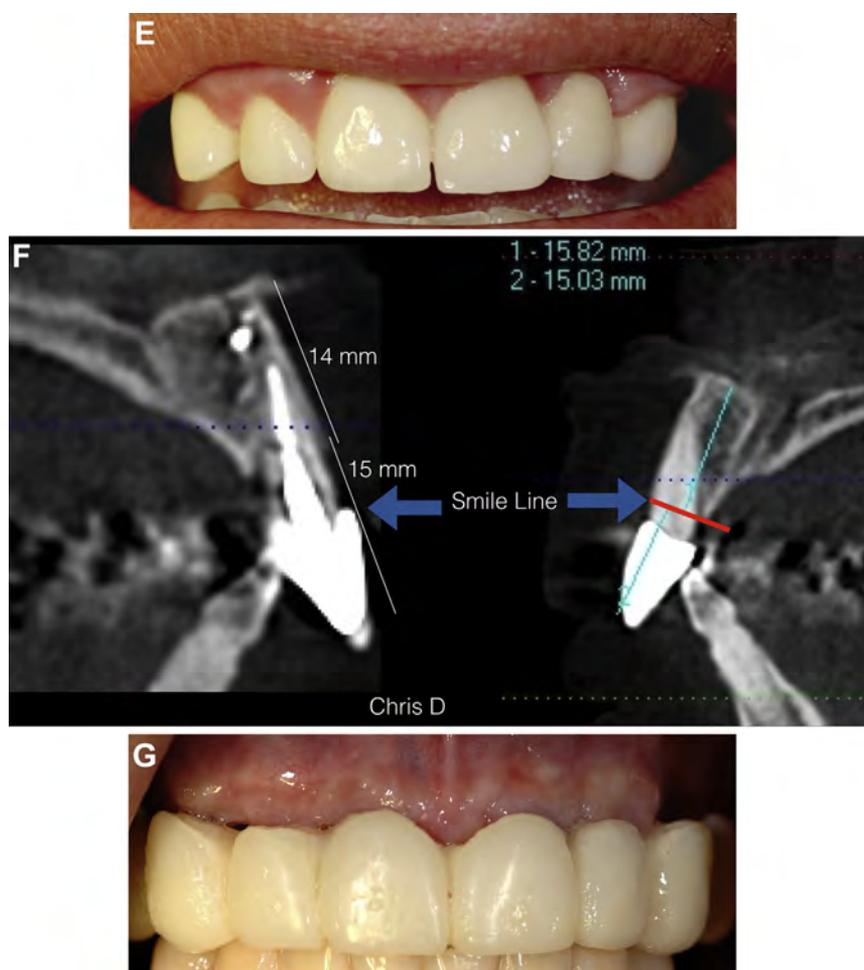


FIGURE 4 (cont'd). *E*, Treatment plan for removal of the patient's remaining anterior maxillary teeth with placement of 6 implants for a full arch fixed prosthesis. His smile line is at the level of the facial gingival margin. *F*, Cross-sectional image and the level of the patient's smile show less than adequate bone to allow for 15 mm of space for the hybrid with enough bone for long implants. For this situation, a fixed crown-and-bridge-type restoration was chosen. *G*, Photograph of the fixed screw-retained provisional prosthesis that mimics the plan for the final prosthesis. The implants are positioned within the confines of the teeth and avoid the embrasures. This design allows the patient adequate space for maintenance similar to a traditional dental prosthesis.

Michael S. Block. Prosthesis Based on Preoperative Examination. J Oral Maxillofac Surg 2015.

then the ridge might require augmentation and a delayed implant placement after the graft has healed. Depending on the type of graft used, the surgeon could decide to avoid a labial reflection of the overlying gingiva to avoid disruption of the graft. Flapless implant placement will limit the amount of bone height reduction that might be necessary if a hybrid prosthesis is planned.

6. Presence of bone posterior to the premolar region: If bone is present to allow for implant placement in the molar and premolar regions, then implants can be placed from the canine teeth posteriorly and allow for maximal prosthetic versatility. This allows the 4 incisors to be prosthetically placed with ridge lapping in the absence of implants. The anterior extent of the maxillary sinus will affect implant positioning. The posterior implant should be angled or placed

vertically to allow implant emergence within the first molar. This prevents extensive cantilever forces in the maxilla. If the sinus extends anteriorly, then it might be difficult to place an implant in the posterior region to provide ideal posterior restoration support. The A-P spread of the implants, owing to arch contour, might decrease when implants are limited to first premolar and anterior locations. The patient might need restoration to a second premolar occlusion or a sinus graft might be indicated to properly position the implants. Each patient will need careful ridge mapping of the proposed implant positions to aid in the design of a mechanically satisfactory prosthesis.

7. Planned inclination of the maxillary teeth: Patients with malposed maxillary teeth include those with protrusion, supraeruption, and

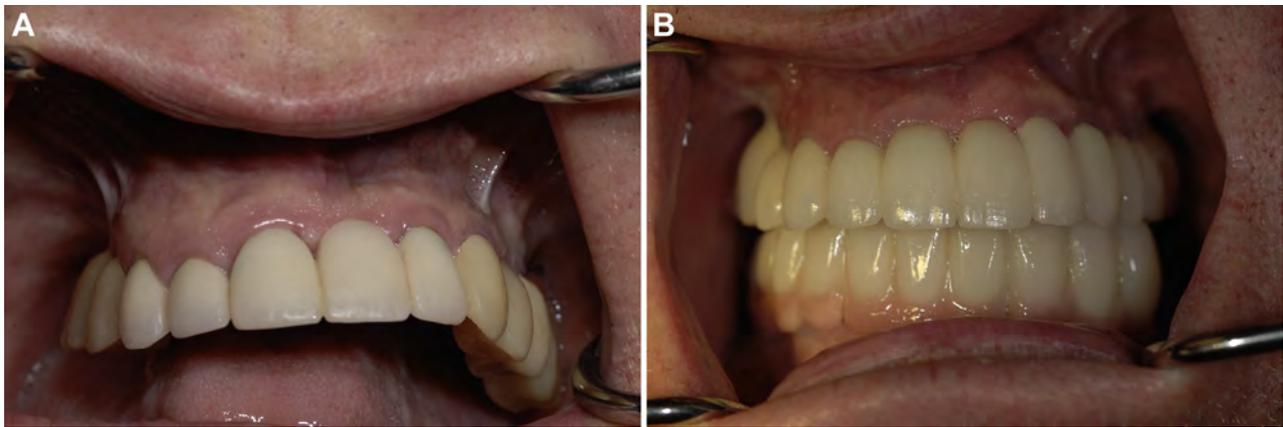


FIGURE 5. A, A 65-year-old man has extensive recurrent decay on his remaining maxillary teeth. He desires to have a fixed prosthesis that looks as natural and youthful as possible. He refused to wear a removable prosthesis. Based on the preoperative examination, it was decided to replace his missing teeth with a fixed crown-and-bridge-type restoration. B, Implants are placed immediately after tooth removal in the anterior maxilla. The final ceramic restoration is cemented on custom-milled abutments, with restoration of form and function. The mandibular full arch fixed restoration was made from zirconia. This patient shows the use of traditional fixed crown-and-bridge restoration that has been proved to be hygienic with minimal need for special hygiene methods. He sees the hygienist on regular recalls. (Prosthetics by Dr Elizabeth Riggs.)

Michael S. Block. *Prosthesis Based on Preoperative Examination. J Oral Maxillofac Surg* 2015.

retroclination. These patients might initially believe that the protrusion of their teeth is esthetically acceptable to them. They have had this appearance for several years and are accustomed to it. However, once they have a provisional prosthesis in place, they might decide that a less protrusive position is more desirable. When the A-P location of their anterior teeth is changed after implants have been placed, using the protrusive ridge location of the initial plan, the final restorative setup will have to account for implants now in a labial position relative to their optimal position. Assessment of the pa-

tient's desires when there is any dental protrusion must be carefully and thoroughly discussed before implant placement (Tables 1, 2).

USING PREOPERATIVE DATA TO CHOOSE A PROSTHETIC DESIGN (FIG 6)

- Rest exposure of central incisor
 - Normal: might require an FCB-type prosthesis
 - Small to negative: lip line requires a low hybrid-style prosthesis
- Smile line exposure of central incisor

Table 1. PRETREATMENT PLANNING—DATABASE

	Data and Comments for Each Patient
Photographs	should be standardized—frontal view with lips relaxed and smile line, lateral view with lips relaxed and smile line; intraoral photographs should include frontal, right and left lateral, maxillary, and mandibular occlusal views
Clinical measurements	central incisor show at rest central incisor show at smile gingiva show at smile height of central incisor edentulous ridge exposure to lip at smile
Position of lip in relation to alveolar crest	with the patient smiling, note the position of the lip line to the alveolar crest
A-P position of teeth relative to alveolar crest	CEJ of tooth to ridge; A-P position of incisor edge to crest; tooth proclination, retroclination

Abbreviations: A-P, anteroposterior; CEJ, cemento enamel junction.

Michael S. Block. *Prosthesis Based on Preoperative Examination. J Oral Maxillofac Surg* 2015.

Table 2. CONE-BEAM COMPUTED TOMOGRAPHIC AND DIGITAL IMAGING MEASUREMENTS

	Site	Distance
Vertical height of bone to nasal or sinus floor	3	
	6	
	8	
	9	
	11	
Distance from planned incisor edge to nasal floor	3	
	6	
	8	
	9	
	11	
Distance from smile line to nasal floor	3	
	6	
	8	
	9	
	11	
Width of alveolar bone	3	
	6	
	8	
	9	
	11	
	14	

Michael S. Block. *Prosthesis Based on Preoperative Examination. J Oral Maxillofac Surg 2015.*

- At level of normal length centrally or shows 1 to 2 mm of gingiva: might require an FCB-type prosthesis
- Greater than 2 mm gingival show at smile: the flange might be needed to be raised superiorly such that an FCB prosthesis is optimal
- Shows to middle of tooth or minimal tooth show at smile: hybrid-style prosthesis
- Vertical position of edentulous ridge at smile
- Edentulous ridge is visible when smiling: indicates minimal bone loss and the patient might be an excellent candidate for an FCB prosthesis

- Edentulous ridge is under the lip when smiling: hybrid-style prosthesis
- A-P relation of the teeth to the edentulous ridge
- Teeth will be anterior to the edentulous ridge: there should be sufficient room for cleaning a full arch prosthesis of either design
- Teeth will be located on the ridge: this patient might be an excellent candidate for an FCB prosthesis and also might be a candidate for a hybrid if sufficient space can be created to allow for access to clean the implants
- Vertical height of bone:
 - Using the cone beam and planned position of the teeth: there is less than 15 mm of bone from the bone crest to the floor of the nose: may be an excellent candidate for FCB prosthesis
 - Using the cone beam and planned position of the teeth: there is more than 15 mm of bone from the bone crest to the floor of the nose: may be an excellent candidate for hybrid prosthesis
- There is sufficient bone in the anterior maxilla to the nose:
 - When removing bone for a hybrid, at least 11 mm of bone remains: hybrid-style prosthesis
 - When removing bone to provide space for a hybrid-style prosthesis, less than 11 mm of bone remains: this patient might benefit from an FCB prosthesis without bone removal
- Presence of bone posterior to the premolar region
- Yes, because there is at least 10 mm of bone height in the first molar locations: might be an excellent candidate for an FCB prosthesis

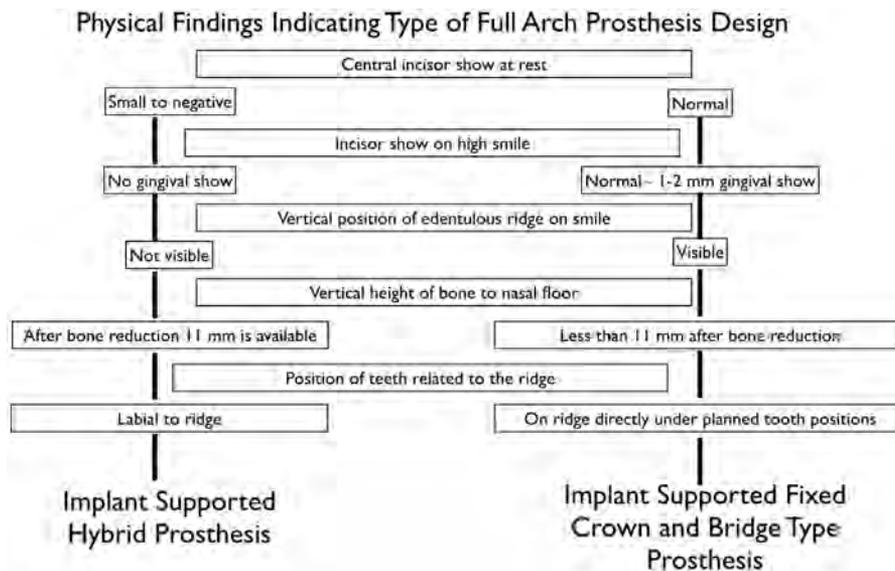


FIGURE 6. Flowchart presents physical findings leading to a prosthetic design.

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- No, because there is less than 10 mm of bone height in the molar locations: sinus graft or angled implants; a sinus graft will be indicated when the patient has insufficient bone height in the incisor locations
- Planned position and inclination of maxillary teeth in relation to the alveolar ridge
- The planned position and inclination of the maxillary teeth locate the implants lateral to the alveolar crest: a hybrid prosthesis might allow for screw emergence through the framework
- The planned position and inclination locate the implants within the bulk of the teeth: an FCB prosthesis can be beneficial for these patients

The long-term success of any dental or implant restoration relies on functional stability with minimal bone loss over time. To achieve this, implants must be placed into adequate bone and avoid maintenance issues. For maxillary full arch fixed restorations, the clinician needs to determine before surgery which prosthetic design will allow the patient to function without compromise and maintain gingival health to preserve bone. Gingival inflammation secondary to plaque is well documented and must be considered with full arch restorations.²² If the surgeon does not recognize the preoperative anatomy of the patient, the implants could be positioned to not allow adequate maintenance and lead to complications after the final restoration is placed.

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