Implant Use in the Tuberosity, Pterygoid, and Palatine Region: Anatomic and Surgical Considerations

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The posterior maxilla frequently presents as a challenging site for implant placement. The poor bone quality characteristic of this region, coupled with limited vertical bone height related to damage caused by periodontitis and sinus pneumatization, creates difficulties in providing a significant number of implants of sufficient length to predictably support an implant prosthesis.

The placement of implants in the tuberosity region and grafted sinus sites and the availability of wide diameter implants have enhanced the prognosis of implants placed in the posterior maxilla. These procedures may be combined to allow distribution of a sufficient number of implants of adequate length and width to withstand posterior occlusal forces.

The purpose of this chapter is to evaluate more closely the use of implants placed in the tuberosity region. The anatomy is described, the surgical placement of implants in this region is discussed, and restored cases documenting site placement variations of the posterior implant are presented.

Anatomy of the Posterior Maxilla

Several articles have assigned various labels to the posteriorly placed maxillary implant. Implants in this region have been described as tuberosity implants, pterygoid plate implants, and pterygomaxillary implants. The varied terminology arises as a result of the various anatomic structures that may be engaged in the placement of implants in this region. Anatomic investigations utilizing cadaver dissection have enabled the author to examine the articulation between the maxilla, the palatine bone, and the pterygoid process of the sphenoid bone. The precise structures offering potential support for implant placement are the tuberosity of the maxillary bone, the pyramidal process of the palatine bone, and the pterygoid process of the sphenoid bone (Figs 14-1 and 14-2).

The tuberosity is the posterior convexity of the maxillary alveolar ridge. Its medial and posterior boundary is the pyramidal process. The pyramidal process of the palatine bone and the anterior surface of the pterygoid process of the sphenoid bone are located behind and slightly medial to the tuberosity. This process binds to the anterior surface of the pterygoid plates of the sphenoid bone and is interposed between the inferior end of the pterygoid plates and the maxillary tuberosity. This junction of the palatine bone and pterygoid plates forms a narrow column of dense bone, referred to as the pterygoid pillar, into which the apical portion of an implant can be fixed.

If the tuberosity is of favorable dimension-height, width, and length-an implant may be successfully placed within this structure (Figs 14-3a and 14-3b) and a more distal placement of the implant apex avoided. However, if the dimension and/or quality of the tuberosity is insufficient, a more medially angled and posteriorly placed implant is determined by the angle of the posterior wall of the maxillary sinus. The implant must be placed parallel to the posterior sinus wall to prevent penetration of the sinus (Figs 14-4, 14-5, and 14-6). Depending on the angle of placement and length of the posterior implant, four apical anatomic bone engagements are possible and can be classified as follows:
**Fig 14-1a** Region of a skull demonstrating the inferior relationship of the tuberosity, the pyramidal process of the palatine bone, and the pterygoid process of the sphenoid bone.

**Fig 14-1b** Cadaver dissection demonstrating the inferior view of the tuberosity (blue), the pyramidal process of the palatine bone (green), and the lateral and medial pterygoid plates (red). The path of a twist drill passing at an angle through the tuberosity and emerging into the pterygoid fossa is demonstrated. Actual surgical instrumentation would terminate in the pterygoid process or pyramidal process and not perforate the pterygoid fossa, thereby preventing damage to the medial pterygoid muscle.

**Fig 14-2a** Lateral relationship of the tuberosity, pyramidal process, and lateral pterygoid plate. The alveolar process, maxillary sinus, pterygoid fossa, and pterygomaxillary fissure are also identified.

**Fig 14-2b** Region of a skull demonstrating laterally the relationship of the tuberosity, pyramidal process, and the pterygoid process. The hamulus extends inferiorly from the medial plate of the pterygoid process (arrow).

**Fig 14-3a** Three-unit implant-supported fixed partial denture. The posterior implant is located in the tuberosity and parallels the posterior wall of the maxillary sinus.

**Fig 14-3b** Oblique section of a computerized tomography scan demonstrating an implant placed within the maxillary tuberosity.

**Fig 14-4** Posterior implant engaging the tuberosity and pterygoid process.

**Fig 14-5** Posterior implant engaging the tuberosity and pyramidal process.
The tuberosity Implant

If the anatomy of the tuberosity is favorable, a long implant can be placed so that it is confined to this structure (Figs 14-3a and 14-3b). Care must be taken to avoid perforating the posterior wall of the maxillary sinus (Fig 14-6b), the location of which is determined radiographically. The bone within the tuberosity is typically of poor quality; therefore, if the dimensions of this structure are favorable, implants of wide diameter should be used. The wide-diameter implant fills a greater volume of the tuberosity and may provide an osteotome-like effect by condensing and compacting the internal bone of this structure between the implant and the cortical plates of bone (Figs 14-7 to 14-9).

Technique

A mucoperiosteal flap is elevated from the facial aspect and reflected palatally. The incision design is such that the entire tuberosity, including its posterior aspect, is uncovered for visualization and instrumentation. Sequential drilling procedures are followed in usual step-by-step fashion, as dictated by protocol for the placement of screw-type implants. Radiographic information is used to determine the proper drilling angle necessary to avoid perforation of the posterior sinus wall. Because of the poor bone quality typically found in the tuberosity, tapping and countersinking of the bone should be avoided in order to gain optimal implant fixation and stabilization.

At the time of second-stage surgery to uncover the tuberosity implant, the surgeon should consider soft tissue reduction in order to reduce the submucosal extension of the abutment. The tuberosity implant may require an angulated abutment, depending on the angle of implant placement.

Case

A second molar, serving as the distal abutment tooth for a fixed partial denture, was lost to advanced periodontitis. The tuberosity implant placed was 18 x 4 mm, and the second premolar implant placed was 10 x 4 mm (Figs 14-10a to 14-10c). A three-unit implant-supported fixed partial denture was provided.

The Pterygoid Process Implant

The dimensions of the tuberosity may not be sufficient for the placement of an implant. In such cases, the angle of the posterior wall of the sinus is determined radiographically. If the angle is not severe, and if the tuberosity provides ample dimension crestally, an implant of sufficient length can be placed so that it initiates in the tuberosity and terminates apically in the pterygoid process of the sphenoid bone.

Technique

The sequential steps followed are the same as for the placement of the maxillary tuberosity implant. To place the implant apex into the pterygoid plate, the surgeon must angle the handpiece medially (Fig 14:11). The thickest area of supporting bone is located in the middle part of the pterygoid process between the plates. This is 3 to 4 mm medial to the alveolar ridge. An implant must, therefore, be angled slightly medially to bisect this dense juncture of bone in the pterygoid region. The hamular process on the medial pterygoid plate is typically
**Fig 14-6a** Posterior implant engaging the tuberosity, pterygoid process, and pyramidal process.

**Fig 14-6b** Incorrect path of a twist drill passing through the tuberosity and emerging into the maxillary sinus (cadaver).

**Fig 14-7** Wide-diameter implant placed in the poor-quality bone typically found to constitute the maxillary tuberosity. The fatty marrow is condensed because of the osteotome-like effect of the wide-diameter implant (arrow).

**Fig 14-8** Cadaver maxilla demonstrating the placement of a wide-diameter implant within the tuberosity (arrow).

**Fig 14-9** Periapical radiograph demonstrating the placement of a 6-mm-wide implant into the maxillary tuberosity (cadaver).

**Fig 14-10a** Periapical radiograph demonstrating severe periodontitis involving the maxillary right second molar.

**Fig 14-10b** Three-unit implant-supported fixed partial denture. The distal implant is 18 X 4 mm and has been placed within the tuberosity.

**Fig 14-10c** Completed three-unit implant-supported fixed partial denture.

**Fig 14-11** Angulation of implant placement of a tuberosity/pterygoid implant. The handpiece must be angled medially (cadaver). Exudate indicative of a chronic sinus infection is noted (arrow).

**Fig 14-12** A tuberosity/pterygoid implant has been inserted, and bone has been removed from the apical region of the implant so that implant angulation may be visualized. A periodontal probe is in place, paralleling proper mesiodistal implant angulation. The shadow of the maxillary sinus is visualized through the thin maxillary process (cadaver).
palpable in the oropharynx. The implant is placed just lateral to this key landmark. There is a natural tendency for the surgeon to err by using the center of the maxillary ridge as a directional drilling guide for implant placement. Because the pterygoid process is located medial to the maxillary tuberosity, care must be taken to avoid perforation of the lateral pterygoid plate, otherwise the external pterygoid muscle may be traumatized and the opportunity to achieve osseointegration lost due to the implant apex being situated in soft tissue.

Again, care must be taken to avoid perforating the posterior wall of the maxillary sinus (see Figs 14-6b, 14-7, and 14-12 to 14-14). If the sinus is inadvertently penetrated, the surgeon can develop a second, more posterior, access. Angling the twist drill more distally enables the placement of a more angulated implant, thus avoiding re-entry into the sinus. The length of the pterygoid implant is determined during drilling by encountering the dense pterygoid plate (Figs 14-13 and 14-14).

Concern regarding the violation of the pterygoid vasculature may be somewhat overstated in that these structures are located superior to the planned apical placement of the pterygoid process implant. The internal maxillary artery courses superior and lateral to the pterygomaxillary suture and terminates in the sphenopalatine fossa. The internal maxillary artery crosses 1 cm superior to the pterygomaxillary suture as it enters the pterygopalatine fossa. The mean distance from the inferior pterygomaxillary suture to this artery is approximately 25 mm.

Case
An existing fixed partial denture failed as a result of caries and periodontitis (Fig 14-15a). An 18 x 3.75-mm pterygoid process implant was placed in conjunction with first and second premolar implants (Fig 14-15b). The first premolar implant was 13 x 3.75 mm; the second premolar implant was 8 x 5 mm in diameter. The use of a standard and wide-diameter implant in conjunction with a long posterior implant contributed to the patient's ability to withstand significant posterior occlusal forces in a long-span fixed partial denture. To engage the pterygoid process, the vertical drill angle was significantly steeper than that used during tuberosity implantation.

A preangulated or cast custom abutment (Fig 14-15c) can be used in restoring the pterygoid process implant. In this case, a cast-gold framework was provided in order to engage the posterior implant, as well as the two premolar implants (Fig 14-15d). The framework was cemented to the two premolar custom implant abutments and was screw retained by the distal implant. The casting is a nonanatomic bar in the region extending distally beyond the mandibular dentition (Figs 14-15e to 14-15g).

The Pyramidal Process Implant
In patients demonstrating exaggerated angulation of the posterior sinus wall, an implant of sufficient length may be placed so that it initiates in the tuberosity and terminates apically in the pyramidal plate of the palatine bone (see Fig 14-5).

Technique
The surgeon must flatten the angle of the twist drill compared to the angle used for the placement of the pterygoid process implant, to avoid sinus perforation and to engage the pyramidal process of the palatine bone.

Case
An existing fixed partial denture failed as a result of severe periodontitis involving premolar abutment teeth. The posterior sinus wall was determined radiographically to be at a significantly greater angle than that shown in the previous patient, thus limiting the height and length of the tuberosity. As a result, a posterior implant of 18 x 3.75 mm was placed at a greater angle, and the pyramidal process of the palatine bone was engaged (Figs 14-16a to 14-16c). Implants provided in the second premolar and first molar sites, both 15 x 3.75 mm, were placed simultaneously in conjunction with sinus graft procedures.
Fig 14-13 Placement of a tuberosity/pterygoid implant (distal/apical aspect). The implant is situated in the dense pterygoid plate.

Fig 14-14 Periapical radiograph of a tuberosity / pterygoid implant. This implant has been placed approximately parallel to the posterior wall of the sinus. and violation of the sinus has been avoided (cadaver).

Fig 14-14a Failure of an existing three-unit fixed partial denture. The failure is due to a combination of periodontitis and caries.

Fig 14-15 Placement of three implants in the maxillary right posterior segment from which the failed premolar teeth have been removed. The implant placed in the first premolar site is 13 X 3.75 mm. The implant placed in the second premolar site is 8 X 5 mm. The posterior implant placed in the pterygoid process is 18 X 3.75 mm.

Fig 14-15a Custom cast: gold abutments retained by the two premolar implants.

Fig 14-15d Cast-gold superstructure that is cemented onto the two premolar custom cast abutments and screw retained by the pterygoid process implant. The distal aspect of the superstructure is a bar design lacking dental anatomy. Dental anatomy in this posterior region is unnecessary because the bar is unopposed by mandibular teeth. The nonanatomic cast bar facilitates the patient’s tongue adaptation and hygiene procedures.

Fig 14-15e Final four-unit implant-supported fixed partial denture.

Fig 14-15f Periapical radiograph demonstrating the restoration of the two premolar implants. Note the 5 mm-wide implant replacing the second premolar tooth.

Fig 14-15g Panographic view showing the restoration of the implanted segment.
The Tuberosity/Pyramidal Process/Pterygoid Process Implant

In some cases the angle of the posterior wall of the sinus may permit a twist drill angulation that places the apex of the implant at the junction of the pyramidal process of the palatine bone and the pterygoid process of the sphenoid bone. The implant placed would then engage all three bone segments that constitute this region (see Fig 14-6a).

Technique

The sequential steps followed are the same as those used for the maxillary tuberosity implant. The drill angle approximately bisects the angles utilized in the placement of tuberosity and pyramidal process implants.

Case

A four-unit fixed partial denture failed because of periodontitis involving the maxillary right first premolar and second molar teeth. A 15 x 3.75-mm implant was placed in the region of the articulation of the tuberosity, pyramidal process, and pterygoid process in conjunction with two premolar implants. The first premolar implant was 13 x 3.75 mm, and the second premolar implant was 10 X 3.75 mm (Fig 14-17 a). The restoration of the implant placed in this region was similar to that of the pterygoid process implant. (Figs 14-17a and 14-17b).

The Distal Implant Combined With Sinus Graft Implant Sites

A long posterior implant used with implants that are placed in conjunction with sinus elevation procedures offers yet another possible solution for managing the compromised maxillary posterior segment.

Case

An implant of the right pterygoid process was placed in conjunction with two premolar implants placed simultaneously with sinus graft surgery (Figs 14-18a to 14-18j). This treatment approach allowed longer implants in the premolar region, complemented by the long posterior implant. This approach was advantageous for the management of posterior occlusal forces delivered to the implant-supported fixed partial denture. The posterior implant was 18 x 3.75 mm and the two premolar implants were each 15 x 3.75 mm. Three implants were placed in the left posterior segment in conjunction with sinus graft surgery.

Conclusion

Problems of bone quality and quantity create challenges for implant placement in affected maxillary posterior regions. Solutions for this region, when it is compromised, include the use of implants in the posterior site in sinus augmentation sites, in the placement of wide-diameter implants, and in implant placement in the posterior site. Anatomically, the posterior region is complex and comprises portions of three bones—the tuberosity of the maxillary bone, the pyramidal process of the palatine bone, and the pterygoid process of the sphenoid bone.

The location of the posterior implant is dictated by the dimensions and quality of the tuberosity. The mesiodistal angulation of the implant is dictated by the angle of the posterior wall of the sinus and its proximity to the posterior wall of the tuberosity. The buccopalatal angulation of the implant is dictated by the bone segments to be engaged. When indicated, and when sufficient bone structure is available, the surgeon may place the apical portion of the implant in the pterygoid process of the sphenoid bone and/or the pyramidal process of the palatine bone. A classification for the placement of implants in this region has been suggested. Cases using implants to demonstrate the classification have been presented.
Fig 14-16a Periapical radiograph showing the placement of an 18 X 3.75-mm implant in the pyramidal process region. The angle of the drill is flatter for this implant placement than for placement in the pterygoid process. The distal of two implants placed in the premolar region is also visible. The two premolar implants were placed simultaneously in conjunction with sinus graft surgery, and each is 15 X 3.75 mm.

Fig 14-16b Panographic radiograph demonstrating the completed fixed restoration supported by two premolar implants and an implant located in the pyramidal process.

Fig 14-16c Buccal view of the completed implant-supported fixed restoration.

Fig 14-17a Panographic view of a maxillary right posterior segment showing the placement of two premolar implants and a tuberosity/pyramidal process/pterygoid process implant at the site of a failed four-unit fixed partial denture. The abutment teeth were lost to advanced periodontitis. The final implant-supported fixed partial denture has been placed.

Fig 14-17b Occlusal aspect of the final implant-supported fixed partial denture.

Fig 14-18a and 14-18b Patient suffering from advanced periodontitis and posterior tooth loss.

Fig 14-18c Periapical radiographs demonstrating the maxillary left and right posterior segments. The left second premolar has been lost, and the remaining premolars demonstrate severe periodontitis. The maxillary sinuses are pneumatized bilaterally.
Fig 14-18d Comparison of the maxillary left posterior segment pretreatment (1990) and post-sinus grafting with the staged placement of three implants (1995), which have been occlusally loaded. The first premolar implant is 15 X 4 mm; the second premolar and first molar implants are 10 X 4 mm.

Fig 14-18i Occlusal and facial aspects of the provisional fixed partial denture. The posterior implant is screw retained and the occlusal aspect of the provisional restoration is cast gold. The cast-gold occlusal surface provides durability, rigidity, and the preservation of vertical dimension. The angle of the distal implant is indicated by the distal angulation of the casting.

Fig 14-18j Occlusally loaded implants located bilaterally in the maxillary posterior segments. The right wall includes a tuberosity/pyramidal process/pterygoid process implant and a second premolar implant placed in a sinus grafted site. The left side includes two premolar implants and a first molar implant, all placed in sinus grafted sites.

Fig 14-18e Left lateral view of implants loaded with a heat-processed, acrylic resin, gold-supported provisional fixed partial denture.

Fig 14-18f Right posterior maxilla with three implant impression copings seated. The first premolar implant was placed in mature bone and is 15 X 3.75 mm, the second premolar implant was placed simultaneously with a sinus graft procedure and is 15 X 3.75 mm, and a tuberosity/pterygoid process implant has been placed in the posterior site and is 18 X 3.75 mm.

Fig 14-18g Right side with implants occlusally loaded with a heat-processed, acrylic resin, gold-supported provisional fixed partial denture.

Fig 14-18h Comparison of the maxillary right posterior segment pretreatment (1990) and post-treatment (1995). Two long premolar implants and a tuberosity/pterygoid process implant are occlusally loaded.
Success of implant prostheses in the maxillary posterior region is dependent on the ability of implants to withstand occlusal forces. The use of the long posterior implant anchored in mature bone placed in conjunction with implants positioned in bone developed by sinus grafting, as well as the use of wide-diameter implants, can provide implant solutions for the compromised maxillary posterior segment.

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References