

Anatomical Study of the Pterygomaxillary Area for Implant Placement: Cone Beam Computed Tomographic Scanning in 100 Patients

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Purpose: The aim of this study was to describe the average angulation and dimensions of the pterygomaxillary area in the atrophic maxilla to facilitate the orientation of pterygoid implants during their placement.

Materials and Methods: A retrospective radiologic study was made. A virtual pterygoid implant, 13, 15, or 18 mm long, was placed in the pterygomaxillary area following the axis of the bone, with a distance of at least 2 mm maintained between the artery and palatine nerve and the implant. The long axis of the implant was inclined slightly toward the palatal to follow the cortical palatal bone. The angles between the long axis of the virtual implant and Frankfort horizontal were measured in both sagittal and frontal views. To calculate the average length of the pterygomaxillary area, the virtual long axis of the implant was measured from the alveolar crest to the pterygomaxillary suture. **Results:** The average anteroposterior axis inclination of the pterygomaxillary area was 72.5 ± 4.9 degrees relative to Frankfort horizontal. The average angulation of the palatal vestibule was 81.3 ± 42.8 degrees relative to Frankfort horizontal. The average length of the pterygomaxillary area was 22.5 ± 4.8 mm. **Conclusion:** Pterygoid implant placement requires thorough knowledge of each patient's anatomy and individual needs. The mean position of the pterygomaxillary buttress axis was 72.5 ± 4.9 degrees to the distal and 81.3 ± 2.8 degrees to the palatal relative to Frankfort horizontal. Placement of pterygoid implants in this inclination may increase accuracy of implant placement. The average length from the tuberosity to the most apical point of the pterygoid apophysis was 22.5 ± 4.8 mm. These results suggest that an implant 15 to 18 mm in length would fit in the pterygomaxillary area to reach the cortical bone. INT J ORAL MAXILLOFAC IMPLANTS 2014;29:1049–1052. doi: 10.11607/jomi.3173

Key words: atrophic maxilla, implant angulation, pterygoid implant, pterygomaxillary region, radiologic assessment, tilting

Rehabilitation of the atrophic maxilla is a challenge in dental practice. Alveolar crest resorption, the

presence of the maxillary sinus, and the poorer mineralization of the posterior atrophic maxilla render it difficult to restore this area by means of dental implants.^{1,2}

The sinus grafting technique is a popular method to restore the posterior atrophic maxilla. However, this technique requires a bone graft, and time for the graft to mature must also be allowed.^{1,2} Pterygoid implants may make it possible to avoid sinus elevation and restore the posterior area more quickly, with only 2 to 3 months needed for osseointegration of the implants.^{3,4} The pterygoid implant placement technique requires thorough knowledge of each patient's anatomy and their individual needs. Thus, dental implant placement must respect the pterygomaxillary anatomy of each patient. The pterygoid implant must enter at the level of the maxillary tuberosity and travel lengthwise through the palatine bone until it is inserted in the pterygoid apophysis.^{5,6} Some authors state that the pterygoid implant must be placed on the anteroposterior axis with a 45-degree angulation relative to Frankfort horizontal plane.^{7–9} Another study found that the implant angulation was around 70 degrees relative

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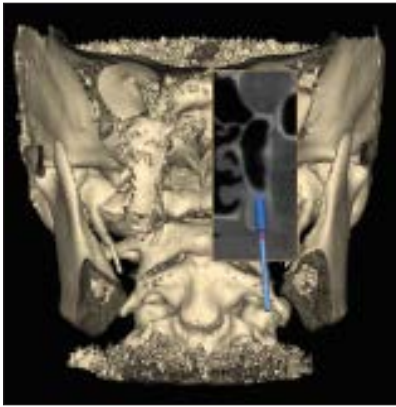


Fig 1 Coronal posterior view showing the implant in place with a safe distance of 2 mm to the palatine artery maintained.

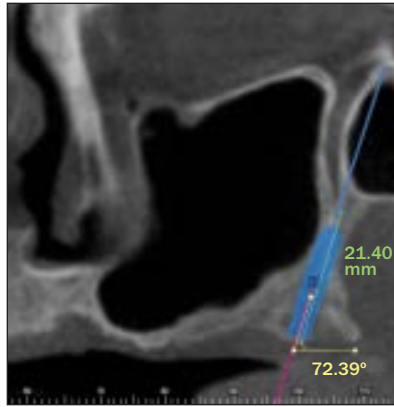


Fig 2 Panoramic view showing the mesiodistal angulation of an 18-mm-long virtual implant in the pterygomaxillary area relative to Frankfort plane (*yellow line*). The distance from the alveolar crest to the most apical area of the pterygomaxillary buttress following the long axis of the implant is shown (*green*).

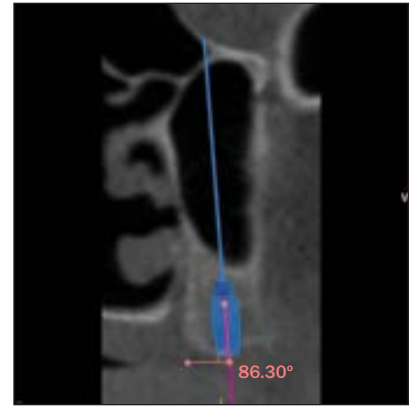


Fig 3 Frontal view showing the palatal angulation relative to Frankfort plane of the same virtual implant shown in Figs 1 and 2 in the pterygomaxillary area.

to Frankfort plane.¹⁰ It would be interesting to do a radiologic study of the atrophic maxilla focusing on the dimensions and positioning of the pterygomaxillary buttress. To the authors' knowledge, no radiologic studies have yet described the bone column angulation of the pterygomaxillary region.

Therefore, the aim of this study was to determine the dimensions and the mean long axis angulation of the pterygomaxillary bone buttress relative to Frankfort plane through the use of cone beam computed tomography (CBCT) to help surgeons achieve more accurate pterygoid implant placement.

MATERIALS AND METHODS

The material of this study consisted of CBCT examinations of the maxillae of patients who had been referred to a private office. Only adults with an atrophic posterior maxilla (ie, less than 10 mm between the bone ridge and the sinus floor in the molar region) were included. All molars had to be missing. Excluded were images that were unclear or incomplete, patients with any maxillary molars, and maxillae with more than 10 mm between the alveolar ridge and the sinus floor. In bilateral cases, one side of the maxilla was randomly selected for the measurements. A CBCT scanning unit (Alphad VEGA, Asahi Roentgen Industries) with a flat-panel detector was used. The exposure volume was set at 102 mm diameter and 102 mm height. The voxel size was $0.2 \times 0.2 \times 0.2$ mm. The exposure volume was set at 0.4 mm. The scan was set at 80 kV and 5 mA, according to the manufacturer's recommendations. The occlusal plane of each patient was set parallel to the floor base using ear rods and a chin rest.

The digital files of the axial images were saved to a portable hard disk. The CBCT images were analyzed with software (Nemo Studio 11.3.0, Software Nemotec). Virtual pterygoid implants, 13, 15, or 18 mm in length, were placed in the pterygomaxillary area following the bone and keeping a distance of at least 2 mm between the artery and palatine nerve and the implant (Fig 1). The implant platform was placed at the crestal level and the implant apex was virtually inserted between the pterygoid apophysis and the posterior sinus wall, as suggested by Tulasne^{5,6} (Fig 2). The long axis of the implant was inclined slightly in the palatal direction to follow the cortical palatal bone. The same investigator performed all radiologic measurements. The following parameters were measured:

- On the panoramic view, anteroposterior axis implant angulation relative to Frankfort horizontal plane (Fig 2)
- On the buccopalatal axis (frontal view), implant angulation relative to Frankfort plane (Fig 3)
- The length from the tuberosity of the alveolar ridge to the most apical point of the pterygoid apophysis following the long axis of the virtual implant (Fig 2)

Descriptive statistics were performed using Excel 2011 (Macintosh version 14.2.3, Microsoft Corporation).

RESULTS

Of the 268 CT scans available, only 100 (42 men and 58 women; mean age of 52 years and range from 35 to 72 years) were eligible for inclusion in the study, yielding an inclusion rate of 37.3%. Of the 100 pterygomaxillary

areas scanned, 57 were on the left side and 43 were on the right side.

Of the 100 included areas, an 18-mm-long virtual implant could be fixed in 72 cases (72%). A 15-mm-long virtual implant could be placed in 19 patients (19%), and a 13-mm-long virtual implant could be fixed in 9 cases (9%). The average anteroposterior axis (sagittal view) implant angulation of the pterygomaxillary area was 72.5 ± 4.9 degrees relative to Frankfort plane (Fig 4). The buccopalatal axis (frontal view) average angulation was 81.3 ± 2.8 degrees relative to Frankfort plane (Fig 5). The average bone column length following the long axis of the implant was 22.5 ± 4.8 mm (Fig 6).

DISCUSSION

Pterygoid implant placement requires thorough knowledge of the unique anatomy of each patient. Some authors have suggested that a pterygoid implant must be placed on the anteroposterior axis (sagittal view) with a 45-degree angulation relative to Frankfort plane.⁷⁻⁹ Other authors recommended placing the pterygoid implant vertically, with an angulation of about 70 degrees on the anteroposterior axis.¹⁰⁻¹⁶ The implant angulation recommended by those authors would allow an implant to fit completely within the pterygoid bone and at the same time to imitate the angulation of the molars.¹⁷ The results of the present study agree with these studies. In the present study, the average anteroposterior axis (sagittal view) angulation of the pterygomaxillary area was 72.5 ± 24.9 degrees relative to Frankfort plane. The average anteroposterior angulation of the maxillary second molars is approximately 75 degrees relative to Frankfort plane.¹⁷ Thus, an angulation of 70 degrees relative to Frankfort plane could minimize potential horizontal forces over the implant rehabilitation.⁸ In addition, the results of the present study are consistent with the findings of Yamakura et al.¹² The small standard deviations seen in the present study suggest that there are few differences in anteroposterior angulation (sagittal view) of this region among different patients.

In the present study, the buccopalatal axis (frontal view) average angulation was 81.3 ± 2.8 degrees relative to Frankfort plane. Several authors have suggested placement of the implant in a buccal direction about 75 to 80 degrees relative to Frankfort plane and to the sagittal view.^{5,6,13-16} The results of this study were consistent with this approach. The small standard deviations seen in the present study suggest that there are few differences in the buccopalatal angulation (frontal view) of this region among different patients. Most of the palatine bone is made up of compact bone tissue. The angulation of the implant axis toward the palatine bone would allow the use of the palatal cortical bone

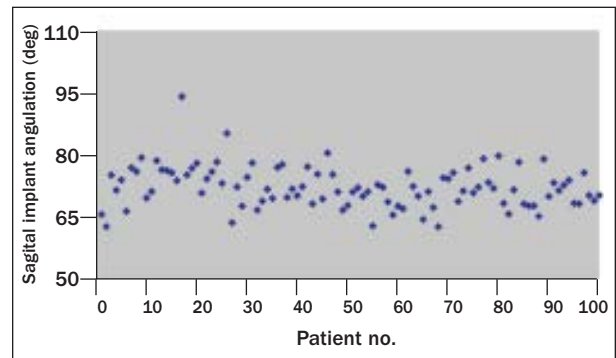


Fig 4 Scatter plot of the anteroposterior axis (sagittal view) angulation relative to the Frankfort plane.

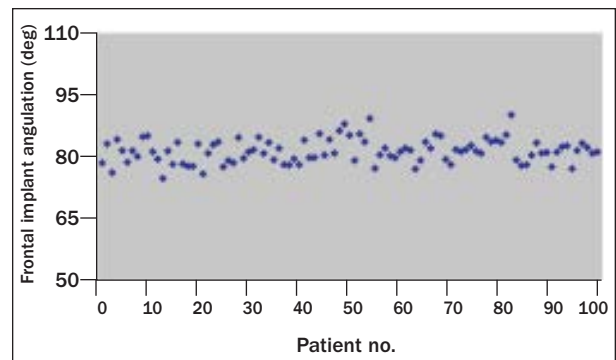


Fig 5 Scatter plot of the buccopalatal axis (frontal view) angulation relative to the pterygomaxillary vertical bone.

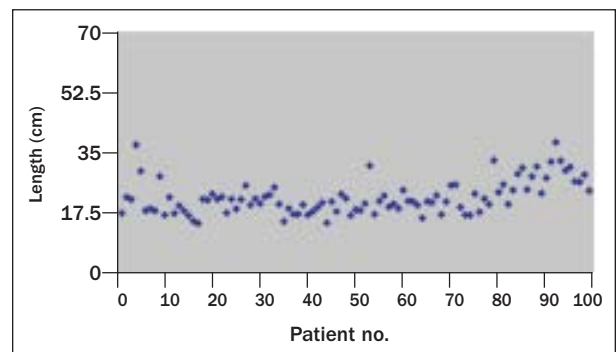


Fig 6 Scatter plot of the length from the tuberosity alveolar ridge to the pterygoid apophysis.

to achieve good primary stability, which would also improve bone-implant contact.

In the present study, the bone column average length was 22.5 ± 4.8 mm. The authors who described this technique stated that, in 80% of their patients, an implant at least 13 mm long could be placed.^{5,6} The results of the present study considered the placement of a 13- to 20-mm implant, following the examples of the aforementioned studies. The width of the pterygomaxillary suture is influenced by the pyramidal apophysis of the palatine bone. Thus, the pterygomaxillary suture in its lower half consists of three different structures: the maxillary tuberosity, the pyramidal apophysis of

the palatine bone, and the pterygoid apophysis of the sphenoid bone.¹⁸ When the side view of the cranium is analyzed, it is possible to distinguish four different types of pterygomaxillary suture, depending on the form and size of the pyramidal apophysis of the palatine bone.¹⁹

However, when the caudal image of the jawbone is considered, four different groups may be distinguished.¹⁹ According to Lee et al, the mean length of the pterygomaxillary suture, or the height of the pyramidal process of the palatine bone, was 13.1 mm, and 83% of the cases showed a pyramidal apophysis more than 10 mm high.¹⁹ In the present study, the length of the pterygomaxillary area was 22.5 ± 4.8 mm. Some authors have recommended supracrestal placement of implants in posterior regions to reduce bone resorption, because this allows the establishment of a biologic width.^{20,21} Tulasne and others suggested placing implants no shorter than 13 mm in the pterygoid region, because this length would increase primary stability, allow supracrestal implant placement, and prevent damage to nearby vascular structures.^{5,6,22,23} The verticalization of the long axis of the pterygoid implant would allow it to reach the distalmost bone area, minimizing the horizontal forces over the rehabilitation.

The present study was limited by the small number of CBCT scans obtained. More clinical and radiologic studies are needed to corroborate this result.

CONCLUSIONS

The mean position of the pterygomaxillary buttress axis was 72.5 ± 4.9 degrees to the distal direction and 81.3 ± 2.8 degrees to the palatal direction relative to Frankfort plane. Placement of a pterygoid implant following these inclinations may increase surgical accuracy. The average length from the tuberosity alveolar ridge to the most apical distance of the pterygoid apophysis was 22.5 ± 4.8 mm. This result may suggest that an implant 15 to 18 mm in length would fit in the pterygomaxillary area in most patients to engage the cortical bone.

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