The history of intraosseous implantology, as a whole, begins with the introduction of the Formiggini screw. Single-piece implants were subsequently derived from titanium bars. The intrinsic function of the emerging stump was immediate loading. The great stability of the implant in the bone thus demanded was eventually achieved by means of the self-tapping screw and bicortical support. Oblique implants were subsequently adopted to make the best use of the bone available and to avoid zones at risk, such as the maxillary sinus and the inferior alveolar nerve. Angled stumps on osseointegrated 2-stage implants were also described in the literature. There has since been a switch from sunken to single-stage implants in view of the usefulness of immediate loading. Recent articles have illustrated the use of inclined, nonbicortical implants; these are still placed in the spongy bone.

Key Words: oblique implants, parasinusal implants, palatine implants

INTRODUCTION

The history of intraosseous implantology, as a whole, begins with the introduction of the Formiggini screw. Single-piece implants were subsequently derived from titanium bars. The intrinsic function of the emerging stump was immediate loading. The great stability of the implant in the bone thus demanded was eventually achieved by means of the self-tapping screw and bicortical support. Oblique implants were subsequently adopted to make the best use of the bone available and to avoid zones at risk, such as the maxillary sinus and the inferior alveolar nerve. Angled stumps on osseointegrated 2-stage implants were also described in the literature. There has since been a switch from sunken to single-stage implants in view of the usefulness of immediate loading. Recent articles have illustrated the use of inclined, nonbicortical implants; these are still placed in the spongy bone.

MATERIALS AND METHODS

Conical titanium screws with a standard length of 30 mm and diameters ranging from 3.5 to 5.5 mm are used. Their bodies have 3 to 5 threads. Each thread has a triangular notch that removes small bone fragments and creates a precision housing. The shaft of the screw is a little more than 2 mm in diameter and can thus be bent without damaging the screw by means of a tool that exerts a countermovement to prevent injury to the bone.

Few surgical instruments are required (Figure 1), and they must be used with delicacy and precision. Overheating of the bone during perforation must be prevented by irrigation with a jet of water.

Technique

Drilling of the mucoperiosteum with a lanceolate cutter is followed by the use of 1- to 1.5-mm helical cutters. The screw is inserted with a circular or pipette spanner, and a dynamometric ratchet is used to assess the torque of the immediate loading.

The basal cortical bone is reached. After the stability of the screw is checked, it is bent parallel to the other pilasters and shortened to the length of the stump. If the screw is not stable, it is removed.
and positioned in another site. These screws display a good resistance to flexion without cracks or metal fractures. Their bending, indeed, is used as a test of their stability.

There is no need to use surgical templates. Mucoperiosteal flaps are required only for knife-blade ridges. Sharp ridges, however, are to be preserved because they act as a mesial and distal shoulder for the implants.

Bone saving is intrinsic to the method. It is not necessary to remove tissue cores. Instead, small bone fragments are compacted in the wall of the tunnel made by the helical cutters.

The method has also been validated photo-elastographically in experimental biomechanical studies (Figures 2 and 3). The loads (in Newtons) borne by 5 cylindrical implants are shown on the $x$-axes, and the stresses induced in the substrate on the $y$-axes. The straight lines indicate the behavior of the implants in response to changes in their inclination and length and the amount of the load. Stresses occur mainly around the apex of axially loaded cylindrical implants, whereas inclination of the load increases the area of bone involved, and the stresses are noticeably reduced. Long implants induce lower stresses than short implants do. Stress distribution is more uniform when conical screws are used.$^8,9$

Insertion of the implant is always followed by the immediate application of a fixed prosthesis, provisional at first and then, after 1–2 weeks, definitive by dental cement.

Radiographic assistance is usually confined to orthopantomography. Laterolateral or posteroanterior teleradiography are occasionally useful for assessing the position of an implant in relation to the sagittal and frontal planes, respectively (Figures 5 and 6). Computerized tomography (CT) is used to acquire precise images in areas at risk, such as the sinus and the inferior alveolar nerve.

**Figure 1.** Photos of instruments.

![Figure 1](http://meridian.allenpress.com/doi/abs/10.1563/AAID-JOI-D-09-00121.1)

**Figure 2 and 3. Figure 2.** The blue line shows the mean of the stresses imposed by 5 long cylindrical implants subjected to loads of 0 to 450 N at zero inclination. Modified from Calderale et al. $^7$

**Figure 3.** Application of the load at 45° greatly reduces the stresses imposed by the long implants. These stresses are also lower than those imposed by short implants of the same type (red line). Modified from Calderale et al. $^7$
Method

The method consists of self-tapping conical screws inserted obliquely along the major axis of the alveolar process to draw the most benefit from the height and thickness of the bone and to reach the basal bone lamina of the maxilla or the deep cortical of the jaw; from here, the term bicortical is derived. Cortical bone, in fact, withstands the loads imposed by mastication better than spongy bone.

In an atrophic alveolar process, the slope of the implant is increased to offset bone reabsorption. In the lateroposterior quadrants of the jaw, implants are inserted obliquely until they reach the deep cortical to straddle the inferior alveolar nerve. The slope is accentuated in areas at risk, such as the sinus and the inferior alveolar nerve (Figures 4, 5, and 11).

Parasinusal implants are inserted obliquely close to the maxillary sinus, usually in the mesial direction. However, if there is not much room, a distal approach is adopted, and the implant is inserted as far as the tuberosity (Figures 14 and 15).

Cases of severe bone atrophy are treated with palatine implants. The screw passes through the alveolar process and is included in the palatine process of the maxilla. In the lateroposterior quadrants, care must be taken to support the implant to the floor of the maxillary sinus and not to go inside it (Figures 9, 18, 19, and 20).

Results

Our series consists of many hundreds of cases of implantoprosthetic rehabilitation and follow-ups over the course of more than 20 years. The 3 main aspects of the method, namely, the use of (1) oblique bicortical implants, (2) parasinusal implants, and (3) palatine implants, are individually illustrated in radiographs and photographs from the following clinical cases.

Figures 4–13 document the implantoprosthetic rehabilitation of a 46-year-old man. Figures 4 and 5 show the situation at the end of the operation on May 11, 1999. The others are the subsequent CT scans and the axial and coronal projections. The last figures illustrate the findings at a follow-up after 8
Figures 10–12. Follow-up after 8 years. Slight accentuation of bone reabsorption of the right mandibular distal implant.

Figures 13–16. Figure 13. The metal-ceramic implant-prosthesis. Figures 14–16. No. 9 oblique bicortical implants. One of the 2 parasinusal implants on the left is mesial; the other is inserted into the tuberosity and not bent.
years and the prosthesis. Reworking of the bone is evident and slightly more accentuated at the site of the right inferior distal implant owing to its shorter length. This case encompasses nearly all of the oblique implant varieties. Note should be made of the slopes of the implants, their anchorage to the basal bone, their typical umbrella pattern, and the straddling over the inferior alveolar nerve.

The second case (Figures 14–17) illustrates the use of parasinusal implants in a 65-year-old woman. The distal implant was inserted obliquely into the tuberosity and was not bent.

The third case (Figures 18–21) is an example of the use of palatine implants in a 45-year-old man.

**DISCUSSION**

Our implants are conical and self-tapping screws. A statistical assessment has also been made of the length and area of the intraosseous portion of a sample of 200 conical screw implants. The mean length (17.1 mm) was equal to the percentage maximum incidence of the implants. The maximum area was comparable to the roots of a molar tooth.10

Physics corroborated the clinical premises: (1) if an implant is compared with a lever, one can readily understand that if the intraosseous arm is longer than the external arm, the moment of the forces is favorable to the bone; and (2) the pressure exerted by the implant, given the same masticatory force, decreases appreciably in function of the increase in the area of the implant in contact with the bone ($P = F/A$).

The importance of the functional load on implants is confirmed by clinical findings and numerous histologic investigations.11 Following are specific findings:

1. Function shapes bone, directs its growth, and steers the internal trabeculae.12
2. An implant inserted in a toothless socket reduces bone reabsorption.
3. After the union of fractures, limbs are mobilized at an early stage to stimulate bone repair.
4. According to Feigel and Makek,13 “Bone only forms where and when it is required by mastication.” Histologic examination has also revealed the formation of alveolus-like compact bone at the implant areas most exposed to loading.14 This provides further corroboration of the need for bicortical support and immediate implant loading.
5. The amount of bone in contact with the implant is greater in loaded as opposed to resting implants and varies from 20% to 50%\textsuperscript{15–17}

6. Implants inserted in the maxillary sinus after the floor is elevated are surrounded by bone that remains devoid of structural and functional soundness for a long time\textsuperscript{18,19}

Insertion of an implant triggers reparative osteogenesis until the bone is shaped and functionally adapted to the implant. Shaping takes place through reabsorption and consolidation, which lead to the mature bone structure, which in turn will be directly dependent on the pressure applied\textsuperscript{20,21}. This mechanism is thought to explain cases of peri-implantitis due to masticatory overloading.

In the event of excessive pressure, reabsorption prevails over osteogenesis. Fibroblast differentiation prevails over osteoblast differentiation, and fibrous connective tissue is formed instead of bony tissue\textsuperscript{20,21}. Another possible complication is the trespass of the screw in the maxillary sinus. In these cases, the implant is extracted and inserted on the other side.

Oblique bicortical screw fractures are rare. They are regarded as fatigue fractures and occur some time after insertion, usually at the surface threads of screws implanted and in sclerotic bone. Fractures are more frequent in upright as opposed to oblique implants. This observation is in line with biomechanical studies performed at Milan Polytechnic: the ultimate loading point is higher if the implant is oblique.
Conclusion

The method of oblique implants is suitable for rehabilitation with a fixed prosthesis and immediate loading. The basic requirements are the following:

1. Self-tapping bicortical screws of appropriate diameter and length,
2. Primary stability of the implant obtained by means of its bicortical support in a precision housing, and
3. Constant checking of the balanced occlusion.

Oblique implants do not usually require the cutting of mucoperiosteal flaps and rarely break. Palatine implants alone allow rehabilitation with a fixed prosthesis in dental arches with serious bone atrophy. Parasinusal implants are a preferential alternative to operations such as raising the floor of the maxillary sinus, bone distraction, expansion of the ridge, and the harvesting of autologous bone, which are burdensome for the patient and not free from complications. In addition, their outcome is uncertain, and long waiting times are required.

Bone and implant constitute an inseparable biomechanical entity whose efficiency is wholly dependent on sufficient implant size and the quality and quantity of the surrounding bone.

Oblique implants also make a substantial contribution to balancing the compressive and extractive forces of mastication. Use of oblique bicortical implants is in line with the tenets of Italian intraosseous implantology, whose practitioners have been appreciatively termed enlightened empiricists by ZARP.

We may rightly end with the words of Chercheve: “Italy has been the cradle of intraosseous implantology. . . . There is no safeguard for implantology without the lesson of its past.”

Summary

The bicortical oblique implants method stems from and is fine-tuned by clinical experience. Self-tapping, tapered screws are used to create a precision housing in the bone. They are inserted obliquely to reach the lamina of basal cortical bone. Once inserted, they are bent and shortened to fit the length required by the stump. They are used at steeper angles in areas at risk, such as the sinus and the inferior alveolar nerve.

Parasinusal implants are a preferential alternative to burdensome operations, such as raising the floor of the maxillary sinus and the harvesting of autologous bone. In the presence of severe bone atrophy, the only possibility is to use oblique palatine implants inserted into the palatine process of the maxilla.

Biomechanics confirms the validity of oblique implants, and radiographic images illustrate the method. The basic requirements are bicortical screws, primary stability of the implant, and balanced occlusion.

Abbreviation

CT: computerized tomography

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