The posterior maxilla: clinical considerations and current concepts using Brånemark System™ implants

Bertil Friberg

Over a period of more than four decades oral implants have gradually become a substantial alternative in routine dental treatment planning and should today be looked upon as an indispensable part of a dentist’s everyday life. From being initially an exclusive treatment option for the totally edentulous patient (22), oral implants are today often considered the treatment of choice in partial edentulism, as well (10, 18, 72). For many years, strict standardized treatment protocols on implant site preparation and extension of healing periods were followed meticulously, according to the guidelines described by Adell et al. (3). With special reference to the Brånemark System™ implants (Nobel Biocare AB, Göteborg, Sweden), the surface was turned and the surgery was a two-stage procedure for all clinical situations. A number of prospective multicenter studies showed the excellent clinical behaviour of these implants (36, 49, 52, 56, 57, 106).

Over time, implant components were modified to facilitate and/or improve their performance. The implant macro-design was altered stepwise from a standard screw shape to a self-tapping and sometimes tapered geometry and the implant micro-design was altered from the turned to an oxidized, moderately rough surface (TiUnite™, Nobel Biocare AB). The latter was in line with the findings of Wennerberg (105), who stated that the early bone response was optimized when facing an implant surface roughness (Sa-value) of 1.0–1.5 μm. (Sa is the arithmetic mean of the absolute values of the surface departures from a mean plane within the sampling area.)

The surgical technique, especially in the mandible, has gradually become a one-stage procedure with early or immediate loading. The pioneering work in this context was performed by Schnitman et al. (88), who inserted additional implants to be loaded immediately. They used a two-stage procedure for the majority of implants, but to meet the patient demand of an immediate fixed construction, some extra implants were placed to be ‘at service’ during the healing period. Obviously the authors did not think of these as useful implants in the long term. However, the 10-year report (89) demonstrated an 85% survival rate for the immediately loaded implants. A similar approach was used by Tarnow et al. (94) and Wolfinger et al. (108). Today, a great number of publications demonstrate the 1- to 5-year results with Brånemark System™ implants that have been either early loaded (14, 27, 28, 34, 80) or immediately loaded (1, 20, 26, 47, 67) in fully edentulous mandibles. The clinical outcome is most encouraging for these procedures, which is why other treatment situations have been tested. For the fully edentulous maxilla, reports are showing survival rates of 93–100% during the first year of function for early (75) or immediately loaded implants (13, 68, 76, 98). In partially edentulous patients the corresponding figures are in accordance with those of the fully edentulous maxillae for early loaded (39, 65, 100) and immediately loaded implants (4, 25, 41, 86, 101).

In situations where there is a low bone density, i.e. quality 4 bone (59), the primary implant stability may be jeopardized; to overcome this problem various surgical techniques have been proposed, using osteotomes, narrow and/or half-way implant site preparations (4, 11, 30–33, 37, 66, 91, 93, 102). With the introduction of resonance frequency analysis...
(69), a diagnostic tool was at hand for the identification of poor implant stability, and one most important finding was the positive correlation with time, i.e. the increase in stability over time (38, 83, 90). Generously extended healing periods were obviously beneficial for the turned-surface implants when placed in soft bone textures (32). The use of the TiUnite™ surface with its early bone response (6, 40, 87), made the time factor less important. Today it may thus be stated that bone of poor density can host implants that are either loaded immediately (41) or after markedly shortened healing periods (Unpublished Results), and that implants placed under such conditions have a good prognosis, at least in the short-term.

Where there is a lack of bone volume, various augmentation techniques, using autogenous bone grafts as onlays/inlays together with titanium implants, have been described in numerous reports. Implant survival rates with up to 10 years of follow-up range roughly from 70 to 95% (2, 23, 58, 74, 83, 97, 107). Other bone materials, such as bovine hydroxyapatite (Bio-Oss™, Geistlich Pharma AG, Wolhusen, Switzerland), used alone or in combination with autogenous bone and placed mainly as sinus inlays, have shown their excellence (43, 48, 95, 110). Today it may thus be stated that small bone volumes can be augmented with various techniques and that implants placed in such bone have a safe long-term prognosis.

The posterior maxilla with its soft bone texture and lack of bone structures may be a challenge for the implant team. The purpose of this report is to present treatment options and clinical considerations for the posterior maxilla situation, when using Brånemark System™ implants.

The use of short implants

Anterior/inferior expansion of sinuses in edentulous regions and age-related alveolar bone resorption may result in minimal bone volume in premolar/molar areas (Fig. 1A). Patients may find the suggested onlay/inlay grafting techniques too complex and ask for simpler treatment solutions. A remaining vertical bone height of 5–8 mm with a sufficient bucco-palatal width of 4–5 mm may harbor the short implants (Fig. 1B,C). In the study by Renouard & Nisand (84), a 2-year survival rate of 94.6% was reported for 96 implants of 6–8.5 mm length, placed with a one-stage technique in second premolar/molar regions of the maxilla. Four implants with the turned surface (4/54) and one implant with the TiUnite™ surface (1/42) failed, and only one of the 31 implants placed in quality 4 bone was lost. A sub-sample of the study material presented by Friberg et al. (33) consisted, as well, of

Fig. 1. (A) Lack of bone volume inferior to the left maxillary sinus; (B) placement of short regular and wide platform implants and abutments; (C) construction at 3-year follow-up.
96 implants of 6–8.5 mm length. All implants had a turned surface and most were placed in maxillae, using a two-stage surgical technique. The close to 3-year follow-up report revealed a survival rate of 93.8% (six failures) and only one implant out of 38 placed in quality 4 bone was lost. In a literature review on the impact of implant length on survival rates (85), figures on short implants were found to be comparable with those obtained with longer implants, i.e. when the implant site preparation was adapted to the bone density and textured-surface implants were used by experienced surgeons on carefully selected cases. Although a great number of publications conclude that short implants fail more often (10, 35, 52, 72, 92, 99, 109), such failure rates should be compared with, as correctly pointed out by Renouard & Nisand (85), implant survival rates of sinus inlay and crestal onlay grafting techniques, which are the treatments of choice when short implants are excluded. A clinical situation where short implants, preferably three in number, can be placed to support a posterior maxillary fixed construction must be regarded a relevant treatment option.

The use of tilted implants

One way to avoid short implants and/or sinus grafting procedures was described by Krekmanov et al. (54) and Aparicio et al. (9). By using tilted implants (>15° inclination with respect to the occlusal plane) in a mesiodistal direction, sometimes combined with a bucco-palatal angulation, the authors were able to use the severely resorbed posterior maxilla anterior to the sinuses (Fig. 2). This made it possible to insert longer implants and to extend fixed implant-connected prostheses further distally without performing bone grafting. Tilted implants were compared with nontilted/axial implants. The 5-year success rates were 98 (54) and 95.2% (9) for tilted implants and the corresponding figures for axial implants were 93 and 91.3%, respectively. In a subsequent report (7), comprising 295 implants (96 tilted) in 40 edentulous maxillae, the 5-year survival rates (mean 59 months) were 98.9 and 98.0% for tilted and axial implants, respectively. The marginal bone resorption at 5 years was reported to be within normal ranges and similar for axial and tilted implants. More recently, a comparable treatment approach of rehabilitating partially and totally edentulous maxillae, was described by Calandriello & Tomatis (24) and Malo et al. (68). They used one-stage surgery with mainly a direct loading concept and the 1-year implant success rates were 98.9% for tilted implants and 98.0% for axial implants.

Fig. 2. Bilateral placement of tilted implants. Photograph by courtesy of Dr. Carlos Aparicio, Spain.

Fig. 3. (A) Placement of one implant distal to the canine tooth, ‘peeping out’ in second bicuspid region; (B) implant in line with the anterior wall of the right maxillary sinus. Construction supported by canine tooth and implant.
cumulative survival rates for tilted implants were in the range of 95–96%.

The use of tooth-connected implants

In the case of a canine being the most distal residual tooth, the available bone between this tooth and an anteriorly extended sinus may not infrequently only host one implant. Instead of placing the implant parallel to the canine in the first bicuspid region and allowing for a single tooth construction, one may consider the use of the aforementioned tilted implant placement. Thereby, the implant will ‘peep out’ in the second bicuspid region and, together with the canine, support a three-unit fixed construction with an intermediate pontic (Fig. 3A,B). This procedure has

Fig. 4. (A) Patient in need of unilateral rehabilitation in right maxilla and left mandible; (B) insertion of one zygoma implant (52.5 mm long); (C) bone site preparation for two short intra-oral implants; (D) a total of three implants in position; (E) radiograph showing a fixed prosthesis supported by the three implants.
been executed routinely over the last decade at the Brånemark Clinic (Göteborg, Sweden), for patients who accept that the occlusion will end with the second premolar. Within-subject comparison reports on tooth-implant-supported prostheses and freestanding implants showed no difference with regard to implant failures (51, 60). In the Lindh et al. (60) study, 26 posterior maxillae (95 implants) were treated, while in the Hosny et al. (51) study there was a mixture of jaw situations (78 implants). When reviewing the literature on tooth-connected Brånemark System™ implants, various study and treatment concepts were described for both maxillae and mandibles, and the implant survival rates after up to 15 years of follow-up varied between 88 and 100% (42, 51, 60, 61, 71, 73). There seems to be a consensus that the prognosis of a tooth/implant splinted construction is mainly determined by the prognosis of the involved tooth/teeth and a rigid connection helps significantly in avoiding unwarranted tooth intrusion.

The use of zygoma implants

Zygoma implants have mainly been used in the rehabilitation of severely resorbed or partially resected maxillae in combination with short anteriorly placed implants, as an alternative to grafting procedures. Although all follow-up reports deal with the totally edentulous patient, substantial unilateral tooth and bone loss may allow one zygoma implant to be connected to one or two short anterior implants (Fig. 4A–E). In the report by Brånemark et al. (21), 28 patients with 52 zygoma implants were followed for 5 years or more and three implants were lost during the study period. Numerous publications deal with the outcome during the first years (6–69 months) and zygoma implant survival rates vary between 82 and 100% (5, 8, 15, 17, 29, 50, 55, 64, 78, 111). The one-stage approach with immediate loading of zygoma implants together with shorter premaxillary implants has been reported with no losses of 28 zygoma implants after at least 12 months of follow-up (16).

Sinuscopy was executed in 14 patients with zygoma implants after more than 1 year of function (79) and there were no signs of infection or inflammation in the mucosa around the implants. Recent sinusitis/chronic infections have, though, been reported in relation to these implants (15, 21, 55) and infections have even caused the loss of some zygoma implants (15, 55). Smokers should perhaps be informed to stop their habit. Nevertheless, all of these studies conclude that zygoma implants constitute an acceptable to an excellent treatment option in the compromised maxilla.
The use of inlay/onlay augmentation techniques

Augmentation of the sinus normally implies elevation of the Schneiderian membrane and placement of autogenous bone and/or alloplastic materials either alone or in combination. It seems, though, that membrane elevation alone, without any grafting material, is sufficient to create new bone (63). This coincidental finding caused Lundgren et al. (62) to initiate a prospective study on sinus membrane elevation in 10 patients, all of whom presented radiographic evidence of ossification in the elevated sinuses. In an experimental study in primates (77) it was shown that the amount of augmented bone tissue in the maxillary sinus after sinus membrane elevation, with or without adjunctive autogenous bone grafts, did not differ after 6 months of healing.

The outcome of an inlay procedure may be affected by several factors, e.g. the chosen surgical technique, immediate versus delayed implant insertion, the residual bone height under the sinus, the graft material etc. In a review article on sinus augmentation by Wallace & Froum (104), published clinical studies were selected and included if they comprised a minimum of 20 interventions and a minimum follow-up period of 1-year. The implant survival rate varied between 61.7 and 100%, with an average of 91.8%. The latter outcome is equal to the result reported by Raghoebar et al. (82), who followed 392 Brånemark System™ implants placed in 99 individuals after sinus augmentation with autogenous bone. Both immediate and delayed implant insertion were performed and 8.2% of implants failed (32/392) during the study period of 12–124 months.

In the Wallace & Froum study (104) it was further stated that grafts consisting of either 100% autogenous bone or a mixture of bone and various bone substitutes did not affect implant survival. Hallman et al. (43, 44) reported on the outcome of placing bovine hydroxyapatite (Bio-Oss™, OsteoHealth, Shirley, NY) solely or in combination with autogenous bone into the sinus (Fig. 5A–C). The 5-year outcome with turned Brånemark System™ implants placed into a mixture of autogenous bone and bovine hydroxyapatite was 86% (46). A more recent study (45) showed that grafting the sinus with bovine hydroxyapatite indicated no risk for sinusitis and that preoperative and 3-year post-operative radiographs showed similar rates of healthy sinuses (ca. 70%).

Wallace & Froum (104) concluded that there was insufficient evidence to recommend the use of platelet-rich plasma together with sinus graft surgery, a statement in accordance with more recent investigations of various jaw situations (70, 81, 96).
In a 5-year comparative longitudinal study by Wiltfang et al. (107), the outcome of buccal-crest onlay (Fig. 6A–D) and sinus inlay augmentations was evaluated. They focused specifically on implant survival and bone resorption of the posterior alveolar crest. The overall majority of implants were of the Branemark System™. Implant survival rates at 5 years were 91.5 \(\frac{215}{235}\) implants and 94.6\% \(\frac{330}{349}\) implants for the onlay and inlay techniques, respectively, and the difference was statistically significant. Bone resorption was initially more pronounced in the onlay group, but leveled out in the further course of the study.

It may be concluded that implants placed in augmented posterior maxillae show survival rates that compare favorably with the reported survival rates in nongrafted bone.

The use of exceptional extractions

Just by their presence, residual teeth may sometimes complicate treatment planning. As shown in Fig. 7(A), conus crowns and a removable prosthesis were the chosen solution in the maxilla, but at the 7-year follow-up the female patient ‘demanded’ a fixed construction. A conventional fixed prosthesis on the four remaining teeth, together with left-side sinus augmentation for placement of implants to support a separate implant bridge, was suggested. For various reasons, though, the patient refused a grafting procedure and instead it was decided to use the right-side second bicuspid and canine to support a three-unit construction. The left-side incisors were extracted and a total of four implants were placed to

Fig. 7. (A) Patient rehabilitated in maxilla with four conus crowns and a removable prosthesis, ‘demands’ a fixed construction; (B) after removal of left central and lateral incisors, four implants have been placed: view at abutment operation; (C–E) tooth-supported construction from second right bicuspid to right canine, implant-supported construction from right lateral incisor to left second bicuspid.
support a construction from right lateral incisor to left second bicuspid (Fig. 7B–E). This treatment has so far (8 years) been successful. Removal of teeth that have severe caries defects, apical lesions, or periodontal disease is justified, while extraction of teeth without signs of obvious pathology is more problematic. However, such teeth may, on rare occasions, be considered for extraction based on prosthetic indications.

**Concluding remarks**

This article deals with implant treatment alternatives of the posterior maxilla without claiming a total perspective. There are further options, such as the use of pterygoid implants (7, 8, 12, 78, 103) and distraction osteogenesis, although the latter has mainly been used in the anterior maxilla (19, 53). It may be stated that patients of today are offered a panorama of treatment procedures of the posterior maxilla, which ought to satisfy most needs and demands.

**References**

Using Brånemark System™ implants


103. Vrieling L, Politis C, Schepers S, Pauwels M, Naert I. Image-based planning and clinical validation of zygoma and pterygoid implant placement in patients with severe


