A New Method to Eliminate the Risk of Maxillary Sinusitis with Zygomatic Implants

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Purpose: A new approach for zygomatic implant placement was proposed to eliminate the risk of maxillary sinusitis related to the procedure. Materials and Methods: A prospective study of this new approach was conducted, and consecutive patients treated between June 2007 and December 2008 were included. An extended sinus lift with retained bone window was performed, such that zygomatic implants were placed completely outside the displaced maxillary sinuses. All patients were followed up radiologically at regular intervals using cone beam computed tomography to evaluate the status of the zygomatic implants and the condition of the maxillary sinuses. Results: Sixteen patients (9 women and 7 men with a mean age of 60) were treated with 37 zygomatic implants. Within the period of investigation from 6 months to 24 months, there were no failed zygomatic implants, and no instances of maxillary sinusitis were reported. Conclusions: The new approach that combined the zygomatic implant placement with the extended sinus lift procedure was predictable and fulfilled the purpose of lowering the risk of maxillary sinusitis.

Key words: bone regeneration, maxillary sinusitis, sinus elevation, sinusitis, zygomatic implants

Branemark and coworkers introduced zygomatic implants to restore function in persons with severely atrophic edentulous maxillae.¹ Numerous studies have shown zygomatic implants to be a predictable treatment option with very few technical and biologic complications.¹⁻¹³ However, it was not uncommon to encounter maxillary sinusitis in zygomatic implant patients. The reported incidence of maxillary sinusitis after zygomatic implants ranges from 0% to 37.5%. In the present study, therefore, a new method was proposed to eliminate the maxillary sinusitis risk in zygomatic implants.

MATERIALS AND METHODS

Consecutive patients with severely atrophic maxillae who were treated with zygomatic implants between June 2007 and December 2008 were included in this study. Patients who required extraction of their remaining teeth were treated conventionally without the use of a surgical template; patients who were already edentulous were given the option of being treated by computer-assisted planning and template-based guided surgery.

All patients were free of signs and symptoms related to acute maxillary sinus infection at the initial consultation. All patients were assessed preoperatively for any medical contraindications that might prevent them from undergoing general anesthesia. Both smokers and nonsmokers were included. Patients who had sufficient bone volume for conventional implant placement were excluded.

Cone Beam Computed Tomography Imaging

Cone beam computed tomography (CBCT) was employed for preoperative imaging for every patient (Fig 1). The digital CBCT files were rendered for computer-based planning using Procera software (Nobel Biocare). In selected patients, stereolithographic templates were produced for guided zygomatic implant placement according to a previously published protocol.⁸ All patients were followed up with serial CBCT examinations. CBCT was performed immediately after implant placement and repeated at the 3-month, 6-month, and 12-month follow-up appointments.

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Zygomatic Implant Placement

All patients received general anesthesia for zygomatic implant placement. Vital signs of all patients were monitored, and all patients were observed for their depth of anesthesia using an electroencephalographic bispectral index. All patients received prophylactic amoxicillin clavulanate (1.2 g intravenously) after induction of anesthesia.

Patients were divided into two groups: one group received guided zygomatic implant placement and the other received conventional zygomatic implant placement. The patients who underwent guided zygomatic implant placement were treated with NobelGuide stereolithographic templates. The guided protocol, previously published, made use of SimPlant software (Materialise Dental) instead of Procura software (Nobel Biocare).

A crestal incision was made with vertical releasing incisions in the midline and second molar regions for patients undergoing conventional flap surgery. After the flap was raised and retracted, an extended rectangular bone window was cut according to the level of the sinus floor and sinus roof (Fig 2). The purpose of this bone window was to allow adequate exposure of the entry and exit points for zygomatic implants at the crestal/palatal level and the zygomatic bone, respectively. The bone window was retained on the underlying mucosa while the sinus membrane was slowly and carefully elevated from the sinus walls. The retained bone window acted as a shield that could protect the sinus membrane from direct damage by rotary instruments, such as the round bur and twist drills (Fig 3).
In patients treated with conventional flap surgery, zygomatic implant osteotomies were carried out starting with a round bur, followed by a 2.9-mm-diameter twist drill, 3.5-mm-diameter pilot drill, and finally a 3.5-mm-diameter twist drill. The entire osteotomy procedure was completed under direct visual control. In patients treated using the NobelGuide stereolithographic template, the zygomatic implant osteotomy was performed through the palatal drill sleeve on the surgical template (Figs 4a and 4b).

In situations where more than one zygomatic implant was placed on the same side, the posterior zygomatic implant was placed first, followed by the anterior one. Conventional implants (NobelReplace or Brånemark System, Nobel Biocare) were placed in the anterior maxillary region between the zygomatic implants according to the standard protocols recommended by the manufacturer. All patients were given 5-day prescriptions for antibiotics, analgesics, and mouthwash (chlorhexidine 0.2%).

**Loading of the Zygomatic Implants**

All patients were given a fixed provisional prosthesis for immediate or early loading. When a fixed prosthesis was attached to the zygomatic implants for occlusal loading within 24 hours after the surgery, these zygomatic implants were considered immediately loaded implants. If the prosthesis was placed after this 24-hour period, zygomatic implants were considered to be early loaded.

When the guided surgery protocol was employed, a provisional prosthesis was prefabricated and connected immediately or shortly after surgery. In other patients, an impression was made immediately after surgery. A provisional prosthesis made of a cast cobalt-chromium framework and acrylic resin teeth was fabricated in the laboratory and was delivered to the patient within a few days.

Patients were seen on a regular basis for wound care and occlusal adjustment. All patients were advised to avoid hard or bony food during the initial healing period of 3 months. Zygomatic implants were examined individually for stability before the final impression was made.

**Success Criteria for Zygomatic Implants**

Zygomatic implants were considered successful when they met the following criteria: (1) asymptomatic function with a fixed prosthesis, (2) clinical stability without mobility when examined individually, and (3) no sinus infection as detected clinically and radiologically.

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Fig 4a A NobelGuide surgical template in place for guided implant placement. Two palatal drill sleeves are incorporated for zygomatic implants in the posterior region.

Fig 4b (Right) With the NobelGuide surgical template, a guided twist drill is placed through the drill sleeve and used to penetrate the crestal bone at the entry area for the zygomatic implant.
RESULTS

Sixteen consecutive patients were included (9 women and 7 men, ranging in age from 38 to 83 years, with a mean age of 60) and 37 zygomatic implants were placed (Tables 1 and 2). Nine patients were edentulous, while the others required extractions on the day of surgery. Four patients underwent guided implant surgery, while the remaining patients received conventional flap surgery. Two patients received their prostheses immediately after surgery, while the others were given their prostheses 1 to 8 days postoperatively. All zygomatic implants fulfilled the success criteria. None of the 16 patients developed any clinical signs or symptoms of maxillary sinusitis during the investigation period.

CBCT examinations were employed to evaluate the maxillary sinuses and the zygomatic implants. No radiologic signs of maxillary sinusitis were found. Incidentally, there were radiologic signs of new bone formation around the zygomatic implants in all patients. These radiologic signs (Fig 5) included the following: (1) existence of a radiopaque area surrounding the zygomatic implants and (2) thickening of the bone at the entry and exit areas of the zygomatic implants.

Table 1  Patient Data

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Table 2  Implant and Prosthetic Data for Patients

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DISCUSSION

Brånemark et al \(^1\) reported the 10-year results of 56 zygomatic implants in 28 patients. The authors conducted regular clinical and radiographic examinations of this group of patients and concluded that zygomatic implants were predictable, with a long-term survival rate exceeding 94.3%. Since the zygomatic implants were placed via a transantral approach, an otolaryngology specialist was asked to investigate the tissue response of the sinus membrane to the exposed titanium surface. In the 11 cases examined by Petruson, \(^{14}\) the sinus membrane was healthy and normal. Despite these favorable findings, Brånemark and coworkers nevertheless encountered four patients with recurrent maxillary sinusitis that required surgical intervention. Although the etiology of the maxillary sinusitis was unknown, Brånemark et al stated that the sinus infection could be adequately treated without causing zygomatic implant failure.

Malevez et al \(^2\) reported retrospective data on 103 zygomatic implants placed in 55 patients with severe maxillary bone resorption. Among these 55 patients, six developed maxillary sinusitis during the investigation period. These patients’ infections resolved after they received antimicrobial treatment, and none of them required surgical intervention. The authors admitted that it was difficult to evaluate the status of osseointegration in the zygomatic region; however, they reported a 100% survival rate of these zygomatic implants based on their clinical stability.

In a multicenter study, \(^3\) Hirsch et al evaluated 66 patients with 124 zygomatic implants 1 year after treatment. The authors reported a 97.9% survival rate after the loss of three zygomatic implants in two patients. In addition, an additional three patients presented with signs and symptoms related to sinus infection. In a later report on the same group of patients, \(^4\) 14 of the 60 remaining patients had experienced sinus-related complications during the 3-year investigation period, and one patient actually presented with maxillary sinusitis at the 3-year follow-up. There was no loss of zygomatic implants related to the sinus infection, however. These two studies showed that maxillary sinusitis can be a delayed problem in zygomatic implants and can happen at any time during follow-up.

Aparicio et al \(^6\) recently conducted a prospective study to investigate the clinical outcome of 131 zygomatic implants in 69 consecutively treated patients. No failures of zygomatic implants were reported, but three patients presented with acute sinusitis at different times during the investigation period. One of them suffered from recurrent sinusitis. These sinusitis episodes were managed with oral antibiotics, without surgical treatment. The authors suggested that the lack of crestal bone contact around the zygomatic implants was the explanation for maxillary sinusitis in these patients.

Becktor et al \(^5\) retrospectively evaluated 31 zygomatic implants in 16 patients and reported a 90.3% survival rate after a mean follow-up period of 46.4 months. Six patients presented with recurrent sinus infection and three of them developed bilateral sinusitis. Despite the fact that oral antibiotics were given and surgical interventions were performed, three zygomatic implants in three patients had to be removed as a consequence. To explain the occurrence of maxillary sinusitis in zygomatic implant patients, the authors postulated that the design of the zygomatic implant, with an internal threaded chamber perforating the implant head, along with the thin palatal bone surrounding the long flexible zygomatic implants, might increase the risk of oroantral communication.

In general, the maxillary sinusitis risk associated with zygomatic implants has been reported as low to moderate (Table 3). Except for a few instances, \(^4,7\) maxillary sinusitis seldom resulted in the loss of the zygomatic implants. Etiologic factors such as preexisting

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Fig 5a Preoperative CBCT of a patient.
Fig 5b Postoperative CBCT at 3 months of the same patient. Radiopaque areas around the zygomatic implants can be seen, in addition to thickening of the bone palatal to the zygomatic implant at the entry and exit locations.
Fig 5c Postoperative CBCT at 6 months of the same patient.

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sinus pathology, perforation of the sinus membrane, marginal bone loss around zygomatic implants, and inadequate oral hygiene at zygomatic implant sites have been suggested, without scientific proof.

The original protocol \(^1\) for zygomatic implant placement did not emphasize the importance of the integrity of the sinus membrane. The subsequent endoscopic study by Petruson\(^{14}\) strengthened the general belief that titanium zygomatic implants were compatible with sinus mucosal health and normal sinus function. In the literature, there have been interesting observations about how to manipulate the maxillary sinus membrane during zygomatic implant placement. In many studies, the sinus membranes were always perforated\(^{3,9,10,15}\). Many other studies provided no information about the integrity of the sinus membrane during zygomatic implant placement. Although many clinicians attempted to preserve the sinus membrane, others believed that it was better to remove the sinus membrane to avoid possible trapping of soft tissue remnants between the implant and the zygoma\(^{3,10}\).

Because maxillary sinusitis in zygomatic implant patients has been a common observation, various techniques have been proposed to prevent sinus infection. Peñarrocha et al\(^{15}\) employed the “slot technique” to place 40 zygomatic implants in 21 patients. The advantages of this technique included the elimination of a sinus window while preparing the zygomatic implant osteotomy.\(^{16}\) However, in spite of this advantage, the authors stated that sinus membrane perforation could not be avoided. The sinus membranes in all 21 patients were invariably perforated, and postoperative sinusitis was reported in two patients. However, there was no evidence in the literature suggesting that sinus membrane perforation was associated with postoperative sinusitis in zygomatic implant patients.

In a recent publication, Aparicio and coworkers\(^{17}\) reported their experience with extrasinus placement of zygomatic implants in 20 patients. All patients presented with pronounced buccal concavities lateral to the maxillary sinuses. The contour of the maxillary walls allowed the authors to perform zygomatic implant placement without creating an opening into the maxillary sinuses. In addition to 100% success after a follow-up of 18 months, the authors did not encounter a single case of maxillary sinusitis.

In another study, Maló et al\(^{18}\) described an original method of using extramaxillary implants with a new design to avoid the maxillary sinus while obtaining direct bone anchorage in the zygomatic region. Maló et al presented 29 patients who had received 67 extramaxillary implants and reported a 2-year survival rate of 98.4%. Four patients who had developed postoperative maxillary sinusitis were treated successfully by medical or surgical intervention. Maló reported that it was not possible to keep the sinus membrane intact in some patients because of anatomical factors. It would seem that when the maxillary sinus was perforated during the implant surgery, the risk of maxillary sinusitis in conjunction with extramaxillary implants could not be ignored.

Although there is no evidence in the literature confirming a cause-and-effect relationship between zygomatic implants and maxillary sinusitis, it is reasonable
to think that the passage of a long and flexible zygomatic implant through the thin crestal/palatal bone could increase the risk of oroantral communication. This risk of oroantral communication could be related to the residual bone thickness at the zygomatic implant entry point. However, no information is available regarding residual bone thickness in the literature for further analysis.

Theoretically, it is logical to try keeping the zygomatic implants outside the maxillary sinuses. The extrasinus placement technique\(^1\) was promising, but it only worked in patients with certain extreme anatomic characteristics. The new use of implants for extramaxillary anchorage by Maló et al\(^2\) was an interesting attempt; however, there was a concern regarding the long-term stability of the soft tissue seal surrounding the implant heads.

In this study, an extended sinus lift was performed with a retained bone window. In leaving the bone window attached to the sinus membrane, the membrane was kept intact during the zygomatic implant osteotomy. This short-term study showed promising results in avoiding maxillary sinusitis in zygomatic implants. The extrasinus position of the zygomatic implants was crucial for this success.

In addition to eliminating the risk of maxillary sinusitis in zygomatic implant patients, the new approach revealed the possibility of new bone formation around the zygomatic implants underneath the elevated maxillary sinus. CBCT images obtained after 3 and 6 months suggested that new bone had been formed around the zygomatic implants. These radiologic features included a radiopaque area surrounding the zygomatic implant bodies and increased thickness of bone at the palatal entry and exit areas of the zygomatic implants. These features were seen in every patient, but they were more pronounced in some patients. It was not possible to confirm that these radiologic features were mineralized tissues; however, several clinical and experimental studies\(^19,20\) could provide some insight regarding the probable bone formation underneath the elevated maxillary sinus.

Lundgren and coworkers\(^19\) conducted a prospective investigation of the potential of bone formation around dental implants underneath an elevated sinus without using any graft material in 10 patients. This study demonstrated that new bone formation around dental implants could be predictably achieved inside a space created by sinus membrane elevation without grafting. In an experimental study, Palma et al\(^20\) provided histologic evidence of de novo bone formation underneath the elevated sinus with or without simultaneous implant placement. The study also showed that bone formation was more pronounced around titanium implants with an oxidized surface. Although this information could not be extrapolated directly to the current study, it is reasonable to expect that zygomatic implants with a similar surface may promote bone formation underneath an elevated maxillary sinus.

The potential advantages of the new method are: (1) elimination of the risk of maxillary sinusitis in zygomatic implants, and (2) increased zygomatic implant stability through the promotion of spontaneous bone formation underneath the elevated maxillary sinus membrane.

**CONCLUSION**

The risk of maxillary sinusitis related to zygomatic implant placement can be avoided by performing an extended sinus lift with a retained bone window before placing the implants. Follow-up studies are required to evaluate long-term outcomes of this new method. Moreover, clinical and experimental research is needed to further investigate the probable bone formation around zygomatic implants underneath the elevated sinus membrane.

**REFERENCES**


