Rehabilitation of totally atrophied maxilla by means of four zygomatic implants and fixed prosthesis: a 6–40-month follow-up

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Abstract. The zygomatic implant is an alternative to bone grafting in extremely resorbed maxilla. This study evaluates the results of a consecutive cohort of 20 patients (mean age 56 years) with extremely resorbed maxillas provided with four zygomatic implants. The first 10 patients had a two-stage procedure, the next 10 next patients benefited from a one-stage surgical procedure and one of them had flapless guided surgery with Nobelguide® in development and immediate function. The same surgical drilling protocol, according to Bränemark’s procedure, was applied to all the patients. Except for one patient who lost three implants, 18 patients received a fixed Procera® implant bridge and another an overdenture retained by a screwed bar fixed on the four zygomatic implants. The cumulative survival rate after 40 months is 96%. Although bone augmenting procedures such as onlay grafts and sinus grafts are popular and well-documented, the four zygomatic implants procedure results in less morbidity, shorter delays between anatomical reconstruction and functional rehabilitation and can provide immediate or early loading with immediate function. Four zygomatic implants and a fixed bridge seem to be a valuable technique for the rehabilitation of extremely resorbed maxillas.

Keywords: zygomatic implants; zygoma bone; zygoma implant; sinus graft; total edentulism; early loading; immediate loading.

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implant technique simplifies the treatment of the severely atrophic maxilla, allows less invasive surgery, low cost hospitalisation, reduction of treatment time and pain with a success rate comparable with that of conventional implants.\textsuperscript{13,6,15}

The most common treatment uses two zygomatic implants and two to four anterior standard implants. The success rate obtained with the standard implants in the anterior region is 91–93\%\textsuperscript{,4,16} Some maxilllas are so resorbed that the insertion of standard implants is impossible.

Following the success rates obtained with zygomatic implants, and knowing that if there is insufficient bone height in the anterior maxilla, bone grafting is necessary and increases the length of rehabilitation, the authors have devised a procedure whereby four zygomatic implants are inserted to support the fixed prosthesis. The aim of this retrospective study in a cohort of 20 consecutive patients is to evaluate the results obtained with four zygomatic implants inserted in a severely resorbed maxilla with a fixed prosthesis screwed on top of them.

### Material and methods

The patients’ general health was investigated clinically and radiologically. They were all edentulous in the upper jaw with extremely resorbed maxilla screened using panoramic radiography and spiral computed tomography (CT). The patients were given a choice between rehabilitation by means of bone grafting or the use of zygomatic implants; they chose zygomatic implants.

Postoperative controls were applied at 1 week, 1, 3, 6 and 9 months and then once per year after prosthesis placement. Prostheses were unscrewed and implants were separately tested for no pain, no mobility, and no infection.

### Patients

All 20 patients (19 women; one man) with a mean age of 56 years (range: 35–75 years), were provided with four zygomatic implants from the Branemark System\textsuperscript{16} (Nobel Biocare, Goteborg, Sweden). The criteria used for proposing the four zygomatic implants were total edentulism in the upper jaw classes D and E according to the Lekholm classification, with a bone height of <5 mm in the anterior and posterior region due to the pneumatization of the sinus and alveolar bone resorption.

There was no possibility of placing standard implants in the anterior region without bone grafting because the alveolar rim lacked the height, thickness and arch perimeter. No patient was treated by chemotherapy or radiotherapy. Two patients had hypertension, two had diabetes, one had Sjögren’s syndrome and three were taking antidepressants. There were no smokers. The only contraindication was acute or recurrent sinusitis. The CT scan confirmed the integrity of the sinus; no sinusitis, polyps or any unusual pathology was discovered in any patient.

### Pre-surgical procedures

All the patients had the same pre-surgical procedure. Radiological investigation consisted of orthopantograms (OPGs) and spiral CT. The CT scan involved the zygomatic arch. A digitalized tridimensional reconstruction of the entire maxilla was carried out with Procera\textsuperscript{11} software (Nobel Biocare AB, Goteborg, Sweden). The dimensions and localisation of the zygoma implants were defined on computerized pictures before surgery (Figs 1 and 2).

In one patient an additional impression was made for a surgical guide. The Nobelguide\textsuperscript{14} and teeth-in-an-hour\textsuperscript{11} procedures were used for one patient to make an ideal prosthesis regarding vertical dimension, phonetic and masticatory condition, occlusal balance, functional and aesthetic characteristics for the teeth before the surgery.

### Surgical procedures

Surgery was carried out by two different surgeons (CM, PD). Eighteen patients followed the same surgical protocol. A customized guide was used for one patient. One patient received a Nobelguide\textsuperscript{14} and flapless surgery with immediate loading.

Preoperative treatment was 1 g of amoxicillin with clavulanic acid the day before and 3 h before surgery. All surgery was carried out under general anaesthesia in the 1-day clinic and all the patients received corticoids (methylprednisolone 32 mg) during surgery to prevent excessive swelling of the lips and face.

The incision, on the maxillary crest or 5 mm palatally to the crest, depending on the residual anatomy, went from one tuberosity to the contralateral tuberosity. A vertical releasing incision was performed bilaterally at the posterior end of the first incision as well as in the midline.\textsuperscript{14} The periosteal elevation of this flap exposed the entire maxillary process up to the zygomatic buttress. The infraorbital nerve was identified. With a round bur a horizontal bony window was made at the
upper limit between the zygoma and the sinus to visualize the insertion of the zygoma implants in the zygoma bone. The classical protocol for drilling proposed by Bränemark was then followed. The implant length was verified with the depth indicator and the tip of the implant was observed by the surgeon at the top of the zygoma.

The anterior implant was first inserted with a low speed motor and with the manual driver to give the desired fixture head position in accordance with the prosthetic work. The emergence point of the first implant was at the level of the second incisor or canine. The posterior zygomatic implant was installed following the same sequence. The emergence point of the second implant was at the level of the second premolar–first molar. All the zygomatic implants were stable at the time of the placement.

After implant insertion, either a cover screw was placed on top of the implants and the soft tissue closed (two-stage procedure; 10 cases) or an abutment (one-stage procedure) for performing early or immediate loading (10 cases).

In the case in which the Nobelguide® was used, no flap was raised following the Nobelguide® protocol. The four zygomatic implants were inserted and a permanent prosthesis screwed on the implants on the day of surgery (teeth-in-an-hour®). The distribution lengths of implants was 30–52.5 mm.

All patients received antibiotic prophylaxis (2 g of amoxicillin with clavulanic acid per day for 4 days) and analgesics (codeine phosphate and paracetamol) to minimize postoperative pain. Patients had to rinse their mouths carefully with chlorhexidine after each meal.

In the two-stage procedure, the delays before the second stage were 2, 3, 4 and 5 months.

Prosthetic procedures

For the two-stage procedure (10 cases), the abutments were placed at the second-stage surgery and an immediate (same day) provisional fixed prosthesis was provided for seven patients. Three patients were not provided with provisional fixed prosthesis but with a removable re-adapted one for 2–3 months.

For those undergoing the one-stage procedure (10 cases), an acrylic provisional fixed prosthesis was provided the day of surgery or a couple of weeks later.

One patient received an immediate definitive prosthesis at the time of surgery with the teeth-in-an-hour® concept (Nobel Biocare AB, Goteborg, Sweden).

All the patients benefited from a definitive fixed prosthesis with a titanium frame Procera® implant bridge (Nobel Biocare AB, Goteborg, Sweden) and acrylic, except for one patient who received an overdenture retained by a rigid bar (Fig. 3).

Follow-up procedures

OPGs (Fig. 4) or X-rays were not taken systematically because they do not provide much information because of superimposition of the bony structures, deformation of the zygoma implants (OPG), and difficulty in standardising retroalveolar X-rays. Only clinical investigations were performed.

Clinical investigations to assess pain, infection, stability of the implant, control of plaque and inflammation, and occlusal adjustment were performed after 1 week, 1, 3, 6 and 9 months and 1 year during the first year and then once a year after prosthesis placement. Only survival rates were proposed because of the lack of information given by radiological examination.

Results

The survival rate of the implants after 3 years is 96% (77 implants of 80). The failure rate is shown in Table 1. The
cumulative failure rate was calculated using the following formula:

$$NCFR = PCFR + \left( \frac{IFR \times \left( 100 - PCFR \right)}{100} \right)$$

where NCFR is new cumulative failure rate; IFR is interval failure rate (failed fixtures during interval/number fixtures present at the beginning of the interval).

Three implants (failure rate 4%) were lost in the same patient. In this case, a customized surgical guide was fabricated in the department laboratory but due to technical problems, it could not be placed in the right position and consequently implants were not inserted in the correct position. The three implants were diagnosed as failures and removed but not replaced.

All other patients received a fixed prosthesis (Procera® implant bridge) on four zygomatic implants, except for one who received an overdenture retained by a bar fixed on the four zygomatic implants.

Only one patient had a unilateral sinusitis, which was successfully treated with antibiotics. One case presented a definitive cheekbone hypoaesthesia. Three patients had soft tissue inflammation around the abutments due to problems with oral hygiene. These patients received more instruction on good hygiene and one had soft tissue resection.

In this study of 20 consecutive patients, only one patient lost three implants due to technical problems and no fixed prosthesis was provided for the patient. The other patients showed satisfying mechanical, aesthetic and functional results.

**Discussion**

Reconstruction of the atrophic edentulous maxilla is a challenge. Many procedures, such as sinus lift, sinus graft, onlay graft and apposition graft with or without Le Fort I osteotomy are well-documented and have a success rate of 60–90%, but they often involve invasive and lengthy surgery, a long treatment time and some morbidity.

Zygomatic implants have survival rates of 98–100% when two zygomatic implants are added to two to four anterior standard implants. This procedure is suitable for treating atrophic maxilla with enough bone in the anterior region to place standard implants.

Although no randomized clinical trials have been conducted comparing sinus grafts or onlay grafts and zygomatic implants, the survival rates show that zygomatic implants should be considered as an alternative to bone grafting and applied in routine rehabilitation of the totally edentulous patient with high resorption of the maxilla.

In previous cases with two zygomatic implants and two, three or four anterior standard implants, the failure rate of the standard implants was quite high at 8–27%. Success rates obtained using the two zygomatic implants suggest that the zygoma anchorage was very strong.

Owing to its strong, thick cortical layer, the zygoma bone offers a solid and extended anchorage in a region situated at a large distance from the occlusal level that can support the masticatory forces applied to the occlusal level. The mean volume and the possibility of a tricortical anchorage could be the reason

<table>
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<tr>
<th>Table 1</th>
<th>Life-table analysis showing failure rates of zygomatic implants.</th>
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<tr>
<td>Patients at beginning of study</td>
<td>Fixture at beginning of study</td>
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<tr>
<td>0–3 months</td>
<td>20</td>
</tr>
<tr>
<td>4–6 months</td>
<td>20</td>
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<tr>
<td>7–9 months</td>
<td>19</td>
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<tr>
<td>12–24 months</td>
<td>19</td>
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<td>24–36 months</td>
<td>16</td>
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<td>&gt;36 months</td>
<td>13</td>
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Absolute success rate: 96%.
for the high success rate. The width of the zygoma offers the possibility of inserting two implants. The solution could be the use of four zygomatic implants in cases of extreme resorption to avoid invasive and lengthy onlay graft surgery and to permit immediate loading with early rehabilitation of mastication and comfort for the patient.

Posterior implants merge in the region of the second premolar and first molar, and anterior implants merge in the region of the canine and lateral incisor. This configuration seems to offer steady support for fixed screwed prosthesis. The position of the apex of the implants in zygomatic bone allows distribution of axial and lateral loads in a structure of excellent anatomical quality.\textsuperscript{10,18}

Few studies\textsuperscript{10,17} have been published concerning a consecutive series of totally edentulous patients with four zygomatic implants. A technical note proposed three zygomatic implants in a dry skull\textsuperscript{5} showing the amount of bone available in the zygoma region.

In the cases of four zygomatic implants, the anterior one comes out at the level of the second incisor or canine and the posterior one at the level of the second premolar or first molar assuring anterior and posterior support and tripod stability.

A fixed prosthesis avoids the relative motion of zygomatic implants. The micro motion of zygomatic implants can destroy all the inter implant bone between the two zygomatic implants on the same side and can result in an invasive complication. This complication has not been reported in any published article nor in the present study, but may appear after a prolonged period of time.

The results obtained with four zygomatic implants are comparable with the long-term results presented in onlay grafting studies\textsuperscript{4,8} with or without Le Fort I osteotomy.

One potential advantage of the zygomatic implants is that the morbidity of the donor site is eliminated. Additional advantages include a reduction in treatment time as well as lower hospital costs.

Immediate loading with a fixed prosthesis, which allows mastication, is an important psychological factor for the patient, improving quality of life.\textsuperscript{4,8}

Some authors report soft tissue inflammation around the abutments.\textsuperscript{1} The depth of the palatal mucosa at the level of the posterior implant is normally 5 mm consisting of parakeratinized epithelium that is not comparable with the normal pocket depth around standard implants placed on the crest (Fig. 5). With good hygiene no inflammation is recorded around the implant.

Sinusitis has been reported by some authors. The incidence is 14–30\%. In some cases, patients with an oro-antral fistula may develop suppuration with or without sinusitis\textsuperscript{3,7,15,17}. In these cases, treatment is the administration of antibiotics and/or meatotomies and repositioning the soft tissue without the removal of the stable zygomatic implant. No recurrence of sinusitis was seen\textsuperscript{15,17}. The reason for the sinusitis could be perforation of the sinus membrane, leakage at the level of the maxilla due to a hole in the zygomatic implant leading to migration of bacteria from the mouth to the sinus. Sinusitis could be caused by a foreign body in the sinus or by a two-stage procedure at a level of weakness due to the small amount of bone at the maxilla. Sinuscopies show healthy sinus\textsuperscript{22}.

A modification of the implant placement technique could reduce this problem with an extra-maxillary implant. The advantage of this technique is that it can avoid introducing a foreign object into the sinus\textsuperscript{17}. More care should be paid to sinus health and ventilation. In the study of four zygomatic implants\textsuperscript{10} no sinusitis occurred but there was only one case of sinusitis, which appeared after 6 months.

In conclusion, this retrospective study of 20 consecutive patients shows the benefits of inserting four zygomatic implants in the zygoma providing a steady anchorage for a fixed prosthesis and a prosthesis retained on a screwed fixed bar. Zygomatic implants have been developed for compromised maxillary situations and extremely resorbed maxilla and seem to offer a reliable solution. Four zygomatic implants permit the rehabilitation of severely atrophied maxilla without bone grafting, reducing procedure time, costs and morbidity with early rehabilitation of mastication and comfort for the patients. More studies are necessary to evaluate the masticatory loads supported by the zygoma bone and the possibility of flapless surgery with longer-term follow-up.

\textbf{Competing interests}
None declared.

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Ethical approval
Not required.

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References

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