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REHABILITATION OF SEVERELY RESORBED MAXILLAE WITH ZYGOMATIC IMPLANTS: A LITERATURE REVIEW

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Abstract

Background: The use of endosseous implants is a routine treatment modality for replacing missing teeth. However, the use of dental implants is limited by the presence of adequate bone volume permitting their anchorage. Several bone augmentation techniques have been applied to solve this problem. During the last two decades zygomatic implants have become a proposed alternative to bone augmentation procedures for the severely atrophic maxilla. The main advantages of this kind of rehabilitation could be that bone grafting may not be needed and a fixed prosthesis could be applied sooner.
Objective: The purpose of this review is to examine the evidence concerning the management of severely resorbed edentulous maxillae using implants placed in the zygomatic bone.
Data collection: The articles reported in this literature review were searched on pubmed/medline database, considering only the English-written scientific journals.
Outcomes: A Zygomatic Success Code, describing criteria to score the success of a rehabilitation anchored on zygomatic implants, is represented by the outcomes of these variables: implant stability, associated sinus pathology, peri-implant soft tissues condition and prosthetic results. Excellent results were observed for zygomatic implants. Many studies showed an implant survival rate of 100% combined to similar prosthetic results.The cumulative survival rate (CSR) and patients' satisfaction indicate that zygomatic implants could be an effective alternative for the management of an atrophic maxilla and, in some cases, be the only treatment solution. However, there are no well-defined criteria that help the clinician to evaluate this prosthetic rehabilitation.
Conclusions: Thus, further studies are necessary to assess the long-term prognosis of the zygoma implant and whether these implants offer some advantages over other techniques for treating atrophic maxillae.

Keywords: atrophic maxilla, zygomatic implants, dental implants, surgical technique, implants success criteria

BACKGROUND

The use of endosseous implants is currently a routine treatment modality for prosthetic reconstruction of the edentulous maxilla, allowing to achieve acceptable long-term results in patients with sufficient bone volume (1).
However, inadequate bone volume can be the result of a resorption process following teeth extraction, traumatic injuries, odontogenous infections and maxillary sinus pneumatisation (2-4), which present challenges to implant rehabilitation. Many techniques have been applied to increase the bone volumes. The most studied were sinus floor augmentation, onlay bone grafting, Le Fort I osteotomy with interpositional bone grafting and free revascularized flaps (5-14). However, these treatment protocols may extend the overall treatment time, the need for hospitalization and the inability to wear a pre-existing prosthesis during the healing period. Additionally, increased

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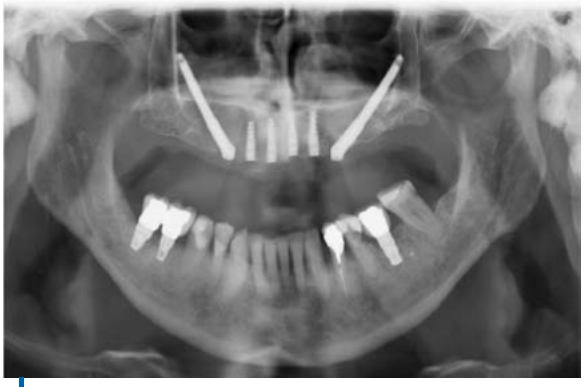

Figure 1. Postoperative panoramic x-ray

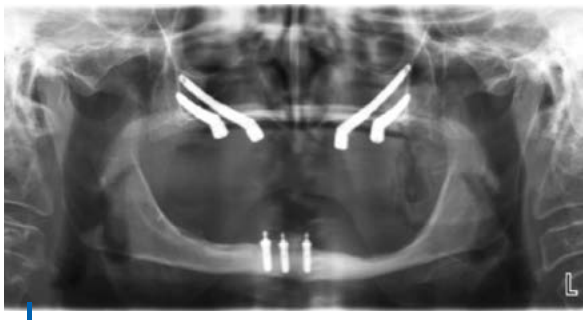

Figure 2. Postoperative panoramic x-ray

failure rates have been experienced in situations with inadequate bone volume and density in edentulous patients (4, 15, 16).
These problems reduce the patient's compliance and may lead to refusal of treatment. Therefore, during the last two decades the placement of dental implants in the zygomatic bone process has become a proposed alternative to bone augmentation procedures.
The clinical procedure for placement of zygomatic implants was first described by Brånemark (Nobel Biocare, Göteborg, Sweden) to provide the clinician with an alternative to grafting procedures. After their initial clinical use in patients with maxillary resection for malignant diseases (17), the indication of zygomatic implants was expanded to completely edentulous patients with severe maxillary atrophy (18). The bone of the zygomatic arch was used for anchorage of a long implant and, together with conventional implants, could be used as an anchor for epistheses, prosthesis and/or obturators (19).
In clinical practice, zygomatic implants have been used in association to conventional implants or alone. The first protocol proposed involved the placement of a minimum of 2 premaxillary implants in the canine position, or ideally 4 premaxillary implants in the canine and the central incisor positions, allowing for the fabrication of fixed hybrid prostheses (20). After that, Bothur et all. (21) proposed the use of prosthesis full supported by multiple zygomatic implants (Fig. 1-2).
The technique provides many patients with a restored function, improving their esthetic and social life. Bedrossian (22) distinguished three zones in the upper maxilla to provide a decisional flowchart: zone 1, the premaxilla: zone 2, the premolar area: zone 3, the molar area (Table 1).
In case of an adequate bone in zone 1 and bilateral lack of bone in zones 2 and 3, two to four conventional implants are distribuited in the anterior maxilla plus one zygomatic implant on each premolar/molar side. This is the so-called mixed technique (Fig. 3). Conventional implants placed in the premaxilla probably reduce the load applied to the zygomatic implants and the effectiveness of this mixed rehabilitation is dependent on a rigid connection between implants (18). Particularly, there is a significant biomechanical disadvantage regarding the long lever arm and the small amount of bone integration and the biomechanics of these implants could be improved by inserting angled implants connected to conventional fixtures (23) and reducing the distal cantilever (24) . Moreover the angle head of the zygomatic implant is designed to allow the placement of the prosthesis at 45° to the long axis of the implant, minimizing the lever effect (20).
Instead, in case of lack of bone in all three zones of the maxilla, four zygomatic implants can be used for the rehabilitation. In this option, the "QUAD technique", zygomatic implants are used alone and placed in an arch form to counteract the bending forces (25). Four implants, two on each side, can restore the entire dental arch: the anterior ones rehabilitate the incisor-canine region, whereas

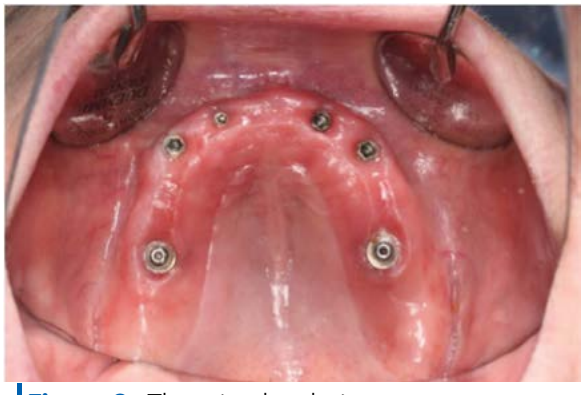

Figure 3. The mixed technique

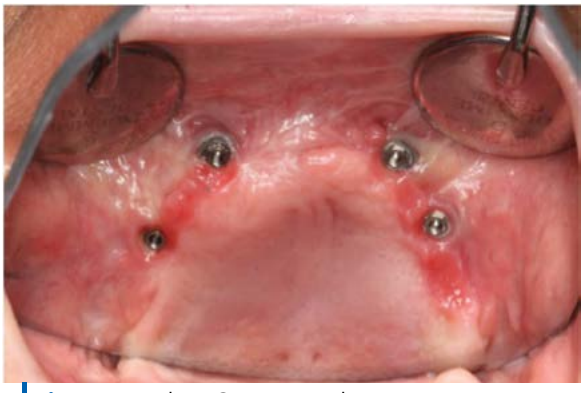

Figure 4. The "QUAD" technique

Table 1. Treatment recommendations based on the presence of bone in the different zones of the maxilla

Presence of bone	Surgical approach
Zones I, II and III	Traditional, axial, implants
Zones I and II	Four traditional implants,tilted
Zones I only	Zygomatic implants plus two or four traditional implants
Insufficient bone	Four zygomatic implants

Table 2. Zygomatic Success Code

Criteria	Condition I Success grade I	Condition II Success grade II	Condition III Success garde III	Condition IV Failure
Criterion A: zygomatic implant stability	No mobility No pain	Light clinical mobility No pain	Clear clinical mobility = no evidence of disintegration of the apical part of the implant or rotation No pain	Clear clinical mobility = evidence of disintegration of the apical part of the implant Rotation and/or pain
Criterion B: Associated sinus pathology	Lanza & Kennedy test - Lund-Mackay score = 0	Lanza & Kennedy test - Lund-Mackay score = 0	Lanza & Kennedy test - Lund-Mackay score > 0	Lanza & Kennedy test + Lund-Mackay score > 0
Criterion C: peri-implant soft tissue condition	No recession	Light recession Implant head is visible = yuxta-gingival No exposed threads	Recession Up to seven exposed threads	Recession. More than seven exposed threads
Criterion D: prosthetic offset	0 mm ≤D≤6mm -3mm≤D≤0mm	6mm<D≤10mm -4mm≤D<-3mm	10mm<D≤15mm -5mm≤D<-4mm	D>15mm D<-5mm

the posterior zygomatic implants can restore the second premolar/first molar (Fig. 4).

The main indications for this type of implant are:

1) Patients with extensive defects of the maxilla caused by tumour-resections (17, 26);
2) History of periodontitis (27);
3) Traumatic injuries , cleft lip and palate and congenital defects (20, 27-29);
4) Failure of previous maxillary rehabilitations (30).

Contraindications to the use of zygomatic implants include (19):

1) Acute sinus infections;
2) Maxillary or zygoma pathology;
3) Uncontrolled or malignant systemic disease.

Relative contraindications are:

1) Chronic infectious sinusitis
2) The use of bisphosphonates
3) Smoking more than 20 cigarettes a day

For these reasons, accurate pre-surgical evaluations are required before the placement of the zygomatic implants.

DATA COLLECTION

The articles reported in this literature review were searched on pubmed/medline database, considering only the English-written scientific journals; case reports and review studies were excluded.

The keywords selected were "Zygoma Implants", "Rehabilitation", "Survival" and "Results". After this research only 17 works presented the characteristics described above.

Table 3. Sinus complications in studies in which zygomatic implants were placed using the two-stage protocol

Two-stage protocol	Patients (n)	Follow-up period (months)	Survival rate of zygomatic implants %	Sinusitis %
Malevez et al.(2004)	55	6-48	100	5 (9)
Hirsch et al.(2004)	76	12	98	3 (4)
Becktor et al.(2005)	16	9-69	90.3	6 (26.6)
Farzad et al.(2006)	11	18-56	100	1 (9.1)
Davo et al.(2009) (53)	24	60	97.4	5 (20.8)
Stièvenart et al.(2010) (54)	10 (of 20)	40	96.3	1 (1.3)
Aparicio et al.(2012)	22	120	97.7	2 (9.1)

Table 4. Sinus complications in studies in which zygomatic implants were placed using the immediate function protocol

Immediate function protocol	Total number of patients	Follow-up period (months)	Survival rate of zygomatic implants %	Sinusitis %
Aparicio et al. (2004)	20	6-48	100	0
Mozzati et al. (2008)	7	24	100	0

OUTCOMES

The severely atrophied maxilla constitues a therapeutic problem for a restorative dentist, especially when previously performed rehabilitations result in failure and patients' dissatisfaction. The zygomatic implants were introduced to solve prosthetic reconstruction problems in fully edentulous patients.
The zygomatic implant is a titanium endosteal implant ranging from 30 mm to 52.5 mm in length. The apical two thirds of the implant is 4 mm in diameter and the alveolar one third is 5 mm in diameter. The surgical technique for inserting zygomatic implants has been the subject of modification during the last years, with today essentially two major variations existing: the internal and the external approach. In the first option, the sinus membrane is carefully dissected and the implant is inserted internal to the maxillary sinus as reported by Brånemark and colleagues (31). The extrasinusal technique is characterized by inserting the implant external to the maxillary sinus before anchoring in the zygomatic bone. In this case the implant is covered only by soft tissue along its lateral maxillary surface. The decision for an "external" rather than an "internal" placement of the zygomatic implant must be the result of accurate anatomic assessments. For this reason Aparicio et al. (32) proposed a classification for zygomatic implant patient based on the zygoma anatomy guided approach: the ZAGA approach. It is a modification of the original zygomatic implant technique and it focuses on interindividual anatomic differences. Thus, the path of the implant body can vary from being totally intrasinus to being totally extrasinus, depending on the relationship between the different anatomic components.
Keller et al. (10) and Branemark et al. (31) suggested that zygomatic implants may be used as an alternative to bone grafts in case of severe maxillary resorption, because the insertion of these implants does not require additional surgery. This major surgical technique requires a proper training and many studies were conducted in an institutional environment, such universities or specialty clinics. The presurgical protocols provide for the selection and preparation of patients in order to allow promising results. Once the clinical examination is complete, radiographic examinations are performed to ensure appropriate treatment planning of the zygomatic implants.
The presurgical exams recommended are following:

Table 5. Peri-implant diseases in studies in which zygomatic implants were placed using the immediate function protocol or the two-stage protocol

Study (reference)	Patients (n)	Zygoma implants (n)	Follow-up period (months)	Patients affected by peri-implant pathology	Number of zygomatic implants with peri-implant diseases	Patients in which the situation was resolved	Treatment
Al-Nawas et al.(2004)	14	20	20	?	9	?	?
Hirsch et al.(2004)	76	124	12	8 especially on the palatal surface	?	?	?
Miglioranca et al.(2011)	75	150	≥12	?	2	?	?
Rodriguez et al.(2014)	29	67	20	?	4	?	?
Malò et al.(2015)	352	747	6-84	54	54	43	Scaling+CHX/ antibiotics or surgery

Table 6. Prosthetic results reported in studies in which zygomatic implants were placed using the immediate function protocol or the two-stage protocol

Study (reference)	Patients (n)	Follow-up (months)	Prosthetic survival rate %
Becktor et al.(2005)	16	9-69	100
Farzad et al.(2006)	11	18-56	100
Mozzati et al.(2008)	7	24	100
Miglioranca et al.(2011)	75	≥12	100

- Cone Beam Computed Tomography (CBCT)
- Panoramic images
- Intraoral radiographs
- Lateral cephalograms

Especially, computed tomography is crucial for the evaluation of the zygomatic implant site,the sinus status and the implant path (19).

In literature different surgical protocols were reported and Le Fort I, crestal and palatal incisions resulted the most commonly applied approaches. These techniques provided excellent prosthetic stabilization (33, 34).

Analysing complications described in literature, (1, 22, 35-41) the main adverse reactions related to zygomatic implants were caused by sinus pathologies, poor oral hygiene, implant mobility and inadequate prosthetic rehabilitation. Specifically a Zygomatic Success Code (Table 2), describing criteria to score the success of a rehabilitation anchored on zygomatic implants, is represented by the outcomes of the previous variables (19): implant stability, associated sinus pathology, peri-implant soft tissues condition and prosthetic results. The success grade of the implant is determined by the worst condition of the four criteria.

The percentage of sinus pathology in clinical studies has been reported by many authors (Table 3-4). In particular, Becktor et al. (1) in a 3 years and 10 months study, reported on 16 patients consecutively treated with 31 zygomatic implants and 74 additional dental implants. Six patients were affected by sinusitis. Three patients had bilateral sinus infection and another three unilateral. It occurred both early and later in the period after the abutment connection surgery. They were treated with antibiotics and sinus rinses. Three zygomatic implants failed because medications have did not solve the infection. One patient was treated for sinusitis throughout the observation periods. Farzad et al. (42) described experiences of 11 patients treated consecutively who received zygomatic implants. Two patients reported a maxillary sinus discomfort after surgery, but it resolved spontaneously.

Table 7. Reported zygomatic implant outcome

Study (reference)	Follow-up (months)	Patients (n)	Zygoma implants	Conventional implants	CSR% Zygoma implants	CSR% Conventional implants
Bedrossian et al. (2002)	34	22	44	80	100	91.25
Hirsch et al. (2004)	12	76	145	?	97.9	?
Malevez et al.(2004)	6-48	55	103	194	100	91.75
Becktor et al.(2005)	46.4	16	31	74	90.3	95.9
Farzad et al.(2006)	18-46	11	22	42	100	97.7
Aparicio et al.(2006)	60	69	131	304	100	99
Peñarrocha et al.(2007)	12	23	44	?	97.7	?
Fernández et al.(2014)	27	95	244	?	99.5	?
Aparicio et al.(2010)	7-38	25	47	127	100	100
Fernández et al.(2014)	27	95	244	?	99.5	?
Malò et al.(2015)	6-84	352	747	795	98.2	97.9

However, with a third patient this sinus problem was not resolved spontaneously and a nasal antrostomy was performed. After surgery, the patient did not complain of any symptoms anymore. Bedrossian et al. (43) did not observe sinusitis during their study. As discussed in literature, it is likely that problems with sinusitis are related more to the extreme thinness of the palatal bone tissue and the consequent oro-antro communications, than to exposed implant threads , to the surgical procedure and to the micro-movement of the functioning zygomatic implant (1, 39, 44-46).

Complications in the soft tissues may occur with this type of implants (Table 5). Malò et al. (47) reported the outcome of rehabilitating 352 patients with complete edentulous atrophied maxillae using 747 zygomatic implants. Peri-implant pathology, such as higher probing pocket depths together with bleeding on probing and/or presence of dental plaque, were observed in 54 patients and 54 implants. The situations were resolved for 43 patients by means of non surgical or surgical interventions. With 11 patients the inflammation persisted. As discussed by Aparicio (19), one concern may be the long-term effect of having exposed threads towards the soft tissues at the lateral aspect of the zygomatic implants. However, Miglioranca (18) did not report irritation or inflammation of the soft tissues despite a dehiscence in the cervical portion of the implant was observed. This was directly related to the strict control protocol with periodic professional hygiene in which every patient enrolled in that study was included. Based on anatomic reasons, especially the lateral aspect of the zygomatic implant body in the coronal and middle thirds covered only with soft tissue, the maintenance of a good standard of oral hygiene was suggested in most studies.

Another zygomatic implant complications may be the clinical mobility. Aparicio et al. (19) described slight mobility when extra-sinusally placed implants are tested individually. This non-rotational movement is due to the elastic modulus of the zygomatic bone when bent by a remotely applied force and it disappeared when implants were splinted together. In case of a rotational movement an implant failure should be considered.

The success of the zygomatic prosthesis and the patients' satisfaction described in literature were encouraging (1, 42, 48) (Table 6).

However, anatomic measurements to assess the position of the head of the zygomatic implant with regard to the middle of the crest of the alveolar ridge should be included (1, 19). The posterior palatal position seems to create difficulties in upholding hygiene by patients and a bulky dental bridge sometimes can lead to discomfort and/or speech problems.
A particular advantage of this type of implants is the possible shortening of the treatment time which could be achieved with immediate or early loading . Studies that used immediate zygomatic implant loading reported decreased treatment times and increased acceptance of the treatment by the patient (35, 40, 44) . However, owing to the small number of patients enrolled and the short follow-up times, further studies are necessary to confirm these results (24).
One of the prerequisites for immediate or early loading is high initial implant stability (24). The special properties of treated-surface implants,TiUnite Nobel Biocare, may have contributed to the favorable results of many studies (49) . Their micropores and properties similar to ceramics ensure a high osteoconductivity and rapid anchoring to the newly bone formation (50).
The failure rate described in literature was not related to the number of zygomatic implants but, probably, to poor oral hygiene and soft tissue contamination surrounding the abutments (1, 48). A strict control protocol is important to observe because the soft tissues may act as a bacterial reservoir (38). Furthermore, Al Nawas et al. reported that the probing pocket depth increased even in absence of bleeding and pathological colonization. This indicates a non-infectious cause of the soft tissue alteration probable.
Finally, an excellent survival rate was observed for zygomatic implants in cases of prosthetic rehabilitation of patients with maxillary resorption (Table 7). Many studies showed an implant survival rate of 100% combined to similar prosthetic results (20, 24, 42, 44, 47, 48, 51, 52).

CONCLUSIONS

In conclusion, the cumulative survival rate and patients' satisfaction indicate that zygomatic implants could be an effective alternative for the management of an atrophic maxilla and, in some cases, be the only treatment solution.
The survival rates of these particular implants may be related to suitable presurgical examinations and surgical procedures, whereas their failures reported in some studies are more related to local infection than the number of zygomatic implants.
Particularly, if a zygomatic rehabilitation is used a proper skilled surgical technique is required and regular recalls are essential to allow long term successful results.
However, despite numerous positive zygomatic implants outcomes, there are no well-defined criteria that help the clinician to evaluate the success of a rehabilitation supported by these implants.
Thus, further studies are necessary to assess the long-term prognosis of the zygoma implant.

Conflict of Interests
The authors declare that there is no conflict of interests regarding the publication of this paper.

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In 1986 he received his Medical Doctor degree at the University of Verona with the highest honours. In 1989 he specialized in Dentistry.
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Questions

In the Zygomatic Success Code, criterion D, which of the following represents the Condition III?:

- ❑ a. 0 mm ≤D≤6mm
- ❑ b. 6mm<D≤10mm
- ❑ c. 10mm<D≤15mm
- ❑ d. D>15mm

What was the survival rate shown by many studies?:

- ❑ a. 100%
- ❑ b. 80%
- ❑ c. 60%
- ❑ d. 40%

In the management of an atrophic maxilla zygomatic implants are ...?:

- ❑ a. The only treatment solution
- ❑ b. Not an effective alternative
- ❑ c. Not a therapeutic choice
- ❑ d. An effective alternative and, in some cases, the only treatment solution

In the Zygomatic Success Code, criterion A, which of the following represents the Condition I?:

- ❑ a. Light clinical mobility
- ❑ b. Clear clinical mobility = no evidence of disintegration of the apical part of the implant or rotation
- ❑ c. Clear clinical mobility = evidence of disintegration of the apical part of the implant
- ❑ d. No mobility