

# The Long-Term Use of Zygomatic Implants: A 10-Year Clinical and Radiographic Report

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## ABSTRACT

*Background:* The zygoma implant has been an effective option in the short-term management of the atrophic edentulous maxilla.

*Purpose:* To report on long-term outcomes in the rehabilitation of the atrophic maxilla using zygomatic (ZI) and regular implants (RI).

*Material and Methods:* 22 consecutive zygomatic patients in a maintenance program were included. Cumulative survival rate (CSR) of ZI, RI, prostheses, and complications were recorded during, at least, 10 years of loading. Implant mobility was tested using Periotest®. Sinus health was radiographically and clinically assessed according to Lund–Mackay (L–M) score and Lanza and Kennedy survey, respectively. A satisfaction questionnaire and anatomical measurements were also performed.

*Results:* Patients received 22 prostheses, anchored on 172 implants. Forty-one were ZI. Three RI failed (10 years CSR = 97.71%). Two ZI were partly removed due to perimplant infection (10 years CSR = 95.12%). All patients maintained functional prostheses. One patient fractured framework twice. Loosening or fracturing screws happened in 11 patients. Seven patients fractured occlusal material. Four ZI abutments in two patients were disconnected because of uncomfortable prostheses. Alveolar height at the ZI head level on the right and left sides was 2.64 mm and 2.25 mm, respectively. Mean distance of ZI head center to ridge center, on the right and left sides was 4.54 mm and 5.67 mm, respectively. Mean Periotest values (PTv) of ZI were –4.375 PTv and –4.941 PTv before prostheses placement and after 10 years, respectively. Six patients experienced sinusitis 14–127 months postoperatively. 54.55% of the L–M scores did not present opacification (L–M = 0) in any sinus. Osteomeatal obstruction happened in eight patients (two bilateral). Two (9.09%) were diagnosed with sinusitis. Eighty-four percent reported satisfaction levels above 80%. 31.81% reported maximum satisfaction score (100%).

*Conclusions:* The long-term rehabilitation of the severely atrophic maxillae using ZI is a predictable procedure.

**KEY WORDS:** cone beam CT, long-term retrospective study, maxillary atrophy, patient satisfaction, zygomatic implants

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## INTRODUCTION

Prosthetic rehabilitation with implant-supported dental bridges in the atrophic edentulous maxilla constitutes a challenge for the treatment team. The placement of implants in such cases often results in a biomechanically compromised situation due to the association of risk factors such as the presence of soft bone and high loads in the posterior regions.<sup>1–3</sup> During three decades, various bone augmentation techniques such as sinus floor augmentation and onlay bone grafting have been described with the common goal of enabling placement and integration of implants.<sup>4–22</sup> While most of these procedures have looked to directly augment a deficient

site, efforts have been made to pursue alternatives to grafting procedures in achieving osseointegrated implant anchorage using the remaining native bone. The use of existing anchorage sites in the tuberosities, pterygoid plates, or zygoma may obviate the need to graft. Some authors have suggested the use of the pterygo-maxillary suture as an alternative site for implant placement.<sup>23–26</sup> Implants can be effectively harbored in the cortical bone of the pterygoid process of the sphenoid bone and the pyramidal apophysis of the palatal bone, but this treatment modality is associated with a potential risk of vascular damage due to the presence of the descending maxillary artery.

The placement of implants in an angulated position has been proposed to avoid the use of bone grafts.<sup>27–32</sup> Aparicio and colleagues<sup>30</sup> compared angulated (>15°) and axially placed implants in the posterior maxilla during a 3- to 7-year follow-up period. The results showed no differences in the maintenance of the peri-implant marginal bone height; they suggested that angulated placement of implants can substitute most sinus lift procedures.

The use of zygomatic bone for anchorage of long oral implants was originally developed by Brånemark and colleagues and first described by Aparicio and colleagues<sup>33</sup> for rehabilitation of the atrophied maxillae. In 1997, Weischer and colleagues<sup>34</sup> cited the use of implants in the zygoma as retaining elements after hemimaxillectomy. Subsequently, Brånemark and colleagues<sup>35</sup> introduced a study with 77 patients and 156 implants, out of which 24 were called “zygomatic implants” (ZI) and presented lengths that were superior to the “standard model” and the rest responded to a specific implant design. The cumulative success rate of the ZI was 96.8%. No data for the prosthesis outcome were reported. More recently, other authors have reported good results on the use of ZI to stabilize a fixed prosthesis.<sup>36–38</sup> Despite the fact that ZI have been used for more than two decades, there are no randomized controlled trials evaluating their clinical effectiveness in relation to alternative means for rehabilitating patients with atrophic edentulous maxillae.<sup>39</sup> Moreover, there are insufficient prospective long-term studies published that endorse it. In this retrospective study, we present the results of a 10-year follow-up on the utilization of the zygomatic bone to provide anchorage for oral implants used to rehabilitate the severely atrophied maxilla. The reported material is considered as representative of the learning curve of a

single surgeon in the original intra-sinus zygoma technique. The reported experience is considered also as the grounding for the development of a refinement of the original technique: the anatomy-guided approach (Zygoma Anatomy-Guided Approach).<sup>37,40,41</sup> The mentioned new approach for the placement of the ZI is not “internal,” nor “external” to the sinus wall, but promotes the placement of the ZI according to the anatomy of the patient instead. In other words, the entrance point is located depending on the vertical and horizontal resorption of the alveolar/ basal process and according to the anterior maxillary wall curvature.

## MATERIAL AND METHODS

The study was conducted in accordance with the ethical principles which originated in the Declaration of Helsinki. It has been reported according to the Strengthening the Reporting of Observational Studies in Epidemiology statement (<http://www.strobe-statement.org/>). This clinical study was approved by an independent ethical committee (School of Medicine University of Barcelona). All patients received thorough explanations and signed a written informed consent prior to the zygoma surgery. The clinical part of this prospective study was conducted in a single center (Clinica Aparicio, Barcelona, Spain); all surgeries were performed by the same operator (C.A.). For the assessment of the sinus health, an independent otorhinolaryngological center was used (Clinica Claros, Barcelona, Spain). An independent investigator (K.F.) fully explained the nature of the study, along with the aims, methods, potential hazards, and discomfort that participation might entail. The patient was given the opportunity to read and ask questions about the Patient Information Leaflet prior to signing the informed consent form to enroll in the survey. Albrektsson and Isidor's<sup>42</sup> implant success criteria were used to evaluate implant condition.

## Patients

Twenty-two patients who participated in a previously published prospective study<sup>38</sup> with severely atrophic edentulous maxillae ( $n = 22$ ) or partially dentate atrophic maxillae ( $n = 0$ ), restored with ZI and regular implants (RI), and with at least 10 years of follow-up, were included in the study. An inclusion criterion for this study was the patient agreement to participate in a maintenance program at our dental office twice a year.

Of these patients, eight were male and 14 were female aged between 48 and 80 years (m = 63 years). Seventeen patients were nonsmokers, two patients smoked between 11 and 20 cigarettes a day, and three patients smoked 20 or more cigarettes a day.

Patients were contacted for a final radiological and clinical evaluation and were invited to answer two specific questionnaires, to assess implant and sinus health status and their degree of satisfaction regarding the treatment received.

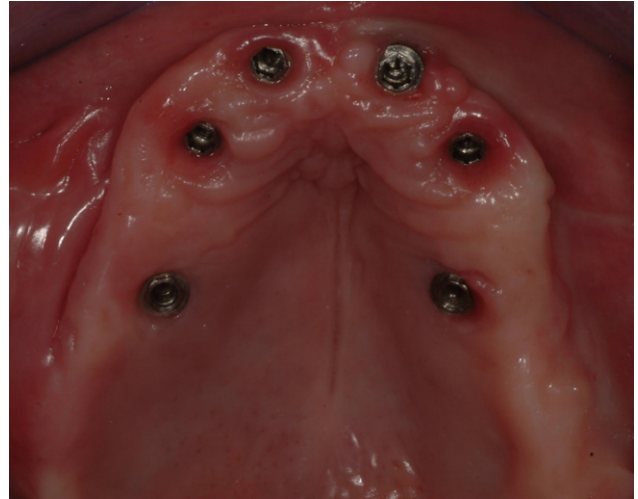
### Implant Surgery

The main inclusion criterion for treating patients with ZI was the presence of a residual alveolar crest less than 4 mm in width and height, immediately distal to the canine pillar. The exclusion criteria were general and local health conditions that prevented the use of general anesthesia and/or intraoral surgery.

Between November 1998 and June 2002, a single surgeon (C.A.) placed a total of 172, machined surface titanium implants (Nobel Biocare AB, Göteborg Sweden) in the maxillary bone of 22 patients. One hundred thirty-one were regular, machined surface implants (Nobel Biocare AB) with lengths from 7 to 18 mm and diameters from 3.3 to 4 mm. In total, 41 zygomatic, machined surface implants (Nobel Biocare AB) with lengths from 30 to 50 mm were positioned.

Fifty-five of the RI were anchored in the residual bone at the canine areas, 42 were intentionally anchored in the subnasal crest penetrating the bone forming the nasal floor, previous raising of the nasal floor epithelium, and five implants were sited in the anterior nasal spine. Twenty-nine RI were located in the pterygoid process of the sphenoid bone and the pyramidal process of the palatine bone. All 41 ZI were placed according to the original technique<sup>36,43</sup> in the zygomatic bone following an intra-sinus path starting at the residual alveolar or basal bone. All the ZI, except for two, achieved good primary stability at insertion time.

A two-stage procedure with 5–6 months of healing between placement and abutment connection was used.<sup>44</sup> One week after surgery, sutures were removed, and patients were controlled monthly in follow-up appointments to both assess the soft tissue health and to adjust the provisional prosthesis. Twenty to 27 weeks later, healing abutments were screwed in (Nobel Biocare AB) in a second-stage surgery, and these were finally



**Figure 1** Clinical occlusal view of an edentulous maxilla rehabilitated with six implants, two of them placed in the zygomatic bone.

substituted by final standard abutments (Nobel Biocare AB) after soft tissue healing (Figure 1).

### Prosthesis

The 22 implant-fixed bridges, anchored on 41 ZI and 131 standard implants, were completed approximately 4 weeks after second-stage surgery using a technique previously described to achieve passive fit of metal structures.<sup>45</sup> Nineteen bridges were screw retained (Figure 2) and three were cemented. None of the 22 patients received a partial prosthesis. Regarding denture material, 10 dental prostheses were full-arch metal-resin designed and 12 were metal-porcelain bridges.



**Figure 2** Occlusal view of a clinical situation of a screw retained bridge on six implants according to the original intra-sinus protocol. Note the palatal emergence of the zygomatic implants.



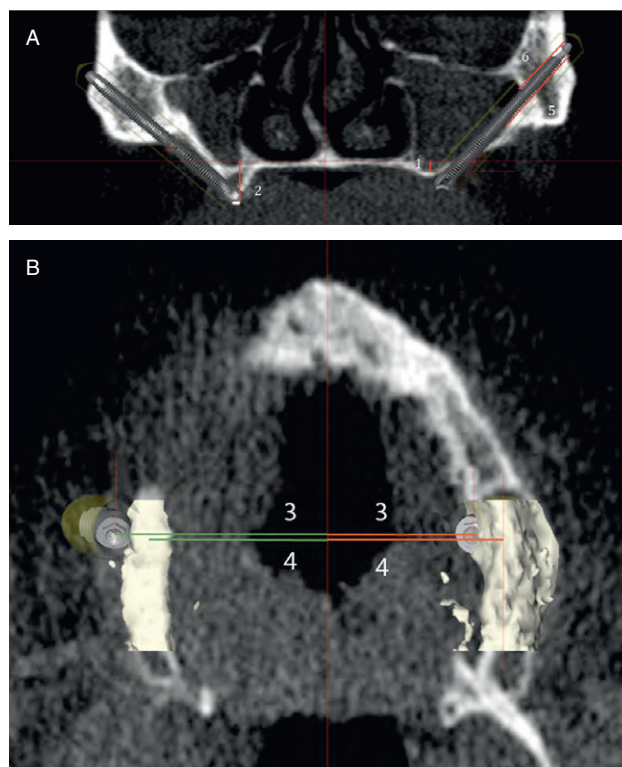
Fifteen patients had an implant-supported prosthesis on the opposite mandible and three patients had their natural dentition. The other four patients had a combination of implants and natural dentition on the opposite mandible.

### Follow-Up Maintenance and Periotest Measurements (PTv)

Patients were scheduled for control after 1, 2, and 3 months after the prostheses delivery and thereafter every 6 months. A checkup of occlusion and a verification of the status of the prostheses and soft tissue was performed in every visit. Implant stability was measured individually using the Periotest® device (Siemens AG, Bensheim, UK) according to Olive and Aparicio.<sup>46</sup> Measurements were made on the day of bridge delivery, after 1, 2, and 3 months, and annually thereafter. The aim of the measurements was to compare the Periotest values (PTv) obtained before prosthesis placement and the stability of the same implants after a period of loading. A panoramic radiograph was obtained annually in a different visit from the PTv.

### Anatomical Measurements

Cone Beam Computer Tomography (CBCT) scans (Kodak 9500 Cone Beam 3D System; Kodak, Carestream Health, Rochester, NY, USA) were performed, at least 10 years postloading, on the 22 patients and analyzed by an independent fellow researcher (K.F.). Images in the oblique-coronal, coronal, and horizontal axial planes were obtained for each of the ZI studied. The oblique-coronal planes were used to identify the ZI path along the zygomatic bone. Special emphasis was devoted to the coronal views, where the status of both right and left osteomeatal complex permeability and the height of the alveolar ridge at the location of the head of the ZI were assessed. Moreover, the axial planes relating the distance from the ZI head to the bone crest on each side were examined (Figure 3). Anatomical measurements (numbered 1–4 in Table 1) were performed to assess: (i) the height of the alveolar ridge at the location of the head of the ZI (measurement 2 minus 1); (ii) the position of the head of the ZI with regard to the center of the crest of the alveolar ridge in the horizontal axial dimension (measurement 4 minus 3). A positive value on this implant head position to the alveolar ridge relationship indicates a palatal position of the implant, whereas a negative value indicates a buccal emergency.



**Figure 3** A, In this figure, the anatomical measurements performed on each patient CT scan are graphically represented. The number 1 value represents the distance between the tangent to the floor of the nose and sinus floor at the entrance of the zygoma implant. Number 2 represents the distance between the tangent to the floor of the nose and the crest of the alveolar ridge at the entrance of the zygoma implant. B, Number 3 represents the distance between the midline of the palate and the center of the zygoma implant head. Number 4 represents the distance between the midline of the palate and the center of the alveolar ridge.

### Lund–Mackay Score

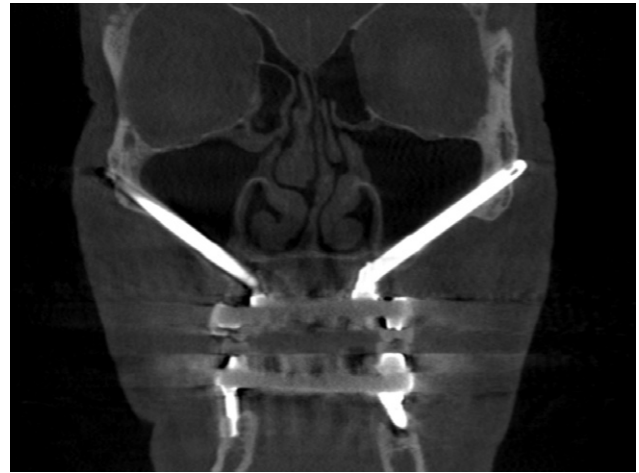
Each CBCT scan was scored by an independent, otolaryngological researcher (P.C.). The Lund–Mackay (L–M) staging system, a validated scoring system recommended by the Task Force on Rhinosinusitis (TFR) for research outcomes, was used<sup>47–49</sup> (Table 2 and Figure 4). The test includes six regions: anterior ethmoid, posterior ethmoid, maxillary, frontal, sphenoid, osteomeatal complex. Each region is given a score of 0, 1, or 2: 0 representing normality, no opacification; 1 partial opacification; and 2 total opacification. Osteomeatal complex can only be scored 0 or 2. Total scores range from 0 to 24. For purposes of this study, a normal or “negative” scan was defined as any scan with a L–M score of 0. Any scan with a score >0 was considered an abnormal or “positive” scan.

**TABLE 1 CBCT Anatomical Measurements Worksheet for Right and Left Zygomatic Implants**

Measurements	Right Z (mm)	Left Z (mm)
1. Perpendicular distance between the tangent to the floor of the nose and sinus floor at the entrance of the zygoma implant level.		
2. Perpendicular distance between the tangent to the floor of the nose and the crest of the alveolar ridge at the entrance of the zygoma implant level		
3. Distance between the midline of the palate and the center of the zygoma implant head.		
4. Distance between the midline of the palate and the center of the alveolar ridge.		

### Questionnaire for Sinusal Reactions

A patient questionnaire developed by Hwang and colleagues<sup>50</sup> (Table 3) to identify the presence of sinusitis symptoms, as specified by the TFR diagnostic criteria (Table 4), was given to each patient. Each symptom question is answered by YES or NO. Diagnosis of sinusi-



**Figure 4** Example of L–M 0. Coronal cuts like this were employed to assess the different anatomical measurements and the Lund and Mackay score. Observe the permeability of the osteomeatal complex.

tis requires a YES answer in: two or more major criteria, one major and two or more minor criteria, or purulence on nasal examination.

### Satisfaction Questionnaire

The satisfaction level and the masticatory capacity were evaluated by means of the questionnaire Oral Health Impact Profile Edentulous Patients (OHIP-EDENT).<sup>51</sup> Patients answered questions regarding their ability or lack of ability to comminute hard and soft

**TABLE 2 Lund–Mackay CT Staging System**

		No Abnormality	Partial Opacification	Total Opacification
Ant. ethmoid:	R	0	1	2
	L	0	1	2
Post. ethmoid:	R	0	1	2
	L	0	1	2
Maxillary:	R	0	1	2
	L	0	1	2
Frontal:	R	0	1	2
	L	0	1	2
Sphenoid:	R	0	1	2
	L	0	1	2
			Not-Obstructed	Obstructed
Osteomeatal complex:	R		0	2
	L		0	2
Total score:	–			

Lund–Mackay<sup>41</sup> staging worksheet. Each region is scored 0, 1, or 2, 0 representing no abnormality, 1 partial opacification, and 2 total opacification. OM complex can only be scored 0 or 2. The minimum possible score is 0 (negative CT), and the maximum score is 24.

**TABLE 3 Task Force on Rhinosinusitis Criteria for the Diagnosis of Rhinosinusitis**

Major Criteria	Minor Criteria
Facial pain or pressure	Headache
Facial congestion or fullness	Fever (all non-acute)
Nasal obstruction	Halitosis
Purulent discharge	Fatigue
Hyposmia or anosmia	Dental pain
Purulence on examination	Cough
Fever (acute only)	Otalgia or aural fullness
Diagnosis on rhinosinusitis requires:	
– 2 or more major criteria	
– 1 major and 2 or more minor criteria	
– purulence on nasal examination	

From Lanza and Kennedy.<sup>62</sup>

foods relating it to the discomfort and instability of the dentures, their perception of satisfaction in relation to the esthetics, pleasure when eating, level of comfort, and to self-assurance. Patients answered nine questions about their dentures, the answer scale ranging from 0 to 4 (0 complete satisfaction, 4 complete dissatisfaction, or 0 never, 1 hardly, 2 occasionally, 3 fairly often, 4 very often)<sup>51,52</sup> (Table 4). The highest scores represent the worst satisfaction levels and the minimum scores represent the best satisfaction levels. The maximum score is 36. Results were translated into percentage values of satisfaction, 0% representing worst possible satisfaction level and 100% best possible satisfaction level.

## RESULTS

### Anatomical Measurements

Anatomical measurements performed on the 22 CBCT scans showed a mean height of the alveolar ridge at the entrance of the ZI of 2.64 mm (SD = 0.79 mm) on the right side and 2.25 mm on the left side (SD = 1.16 mm). In all cases, the residual alveolar crest showed less than 4 mm in height (range 1.1–3.7 on the right side and 0.4–4 on the left side).

The position in which the center of the head of the implant emerges related to the center of the alveolar crest in the horizontal plane had a mean value of 4.54 mm (SD = 2.40 mm) for the right side and 5.67 mm (SD = 2.29 mm) for the left side. In all cases,

the head of the implant emerged at the palatal side of the crest except in three patients who showed a vestibular buccal emergency (ranges –0.2 to –1.6) to the center of the ridge (range +9.3 to –1.6 mm).

### Survival Rate and Cumulative Survival Rate of RI and ZI

Three RI failed during the study period. One implant placed in the subnasal area failed 1 month after abutment connection, another RI failed after 3 years of function in the same patient. An implant placed in the pterygoid area failed previous to prosthesis installation

**TABLE 4 OHIP-EDENT Questionnaire**

	0	1	2	3	4
1					
2					
3					
4					
5					
6					
7					
8					
9					

Satisfaction level questionnaire.<sup>45,46</sup> Nine questions in a scale ranging from 0 to 4, 0 representing total satisfaction and 4 total dissatisfaction (0 = never, 1 = hardly ever, 2 = occasionally, 3 = fairly often, 4 = very often). The maximum score is 36 and the minimum is 0, this representing the best satisfaction level and masticatory ability.

**TABLE 5 Life Table for Regular Implants**

Follow-Up (Years)	Number of Implants	Failures	Survival Rate	Cumulative Survival Rate
0-Prost. placement	131	2	98.47	98.47
Prost. placement-1	129	0	100	98.47
1-2	129	0	100	98.47
2-3	129	0	100	98.47
3-4	129	1	99.22	97.71
4-5	128	0	100	97.71
5-6	128	0	100	97.71
6-7	128	0	100	97.71
7-8	128	0	100	97.71
8-9	128	0	100	97.71
9-10	128	0	100	97.71%

Actuarial life table for regular implants ( $n = 131$ ).

in another patient. The final 10-year cumulative survival rate (CSR) for RI was 97.71% (Table 5).

None of the ZI were removed because of disosseointegration. However, in 2010, two ZI were cut through the surgical maxillary window and partially removed (both in the same patient, a heavy smoker) due to extreme peri-implant infection with complete dissolution of the palatal bone. The final 10-year CSR for ZI was 95.12% (Table 6).

### Prosthetic Survival Rate and Mechanical Complications of Prosthetic Restorations

All patients maintained the fixed arch bridge in good function during the study period, except for

one patient whose framework fractured twice. Few mechanical problems were observed during the 10-year follow-up. Some of these problems were: loosening of gold ZI screws (four patients), fracture of gold screws (four patients), loosening of the abutment screw (three patients), fracture of ceramic prosthetic teeth (five patients), and fracture of resin prostheses (two patients). Four abutments in two patients were disconnected from their ZI due to uncomfortable bulky prostheses. Due to the existence of distal implant pterygoid support, the maneuver was performed with minor modifications of the original prosthesis framework. As a result, the prostheses became less bulky (Table 7).

**TABLE 6 Life Table for Zygomatic Implants**

Follow-Up (Years)	Number of Implants	Failures	Survival Rate	Cumulative Survival Rate
0-Prost. placement	41	0	100	100
Prost. placement-1	41	0	100	100
1-2	41	0	100	100
2-3	41	0	100	100
3-4	41	0	100	100
4-5	41	0	100	100
5-6	41	0	100	100
6-7	41	0	100	100
7-8	41	0	100	100
8-9	41	0	100	100
9-10	41	2	95.12%	95.12%

Actuarial life table for zygomatic implants ( $n = 41$ ).

**TABLE 7 Record of Biological and Prosthetic Complications**

	Follow Up (Years)	Prost. Placement										Total				
		0-Prost. Placement	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10		10-11			
Biological	Facial hematoma/edema	6														6
	Lip laceration	5														5
	Cheek and/or paranasal paresthesia (temporary)	6														6
Mechanical	Suppuration of regular implant		1											1		1
	Acute/chronic sinusitis			1					1							6
	Oro-sinusal communication (per implant)						1									3
	Fracture coating material: acrylic.									1						4
	Fracture coating material: porcelain.		2	1	2	1	3	6	4	1	2	3				25
	Fracture of metal framework				1			1								2
	Fracture screws				1					1						6
Loosening of screws or abutment		1	1	2		1	2	2							9	

Number of complications during the 10 year follow-up period. Failures of implants are not included. 90% of biological late complications belong to 2 patients; and 74% of prosthetic complications occurred in five patients.

**Periotest Measurements**

Mean Periotest measurements of ZI showed decreased Periotest values (PTv) with time, indicating increased stability (-4.375 PTv vs. -4.941 PTv before and after 10 years of prosthesis placement, respectively) (Table 8).

**Sinusal Records**

Five patients suffered from acute sinusitis postoperatively, which could be treated with antibiotics. One additional patient experienced extreme peri-implant infection around all the implants, acute sinusitis and oro-sinusal communication, 10 years postoperatively and the ZI were cut on their intrasinus path and partially removed. These and other biological complications among the 10-year follow-up period for all patients are recorded in Table 8.

**L-M Score<sup>47</sup>**

After 10 years of function, 12 patients (54.55%) did not show any opacification in any of their sinuses (L-M = 0). All the patients with a positive scan presented a certain degree of opacification in the maxillary sinus, either on the right or on the left, or both. Also, an osteomeatal complex obstruction, at least on one side, was observed in eight patients. Two of them experienced bilateral obstruction. Four patients had positive scores on anterior ethmoid but only two on posterior ethmoid. Only one patient presented obstruction in the frontal and sphenoid regions. These patients also had the highest scores in the other regions considered in the test (Figure 5).

**Questionnaire for Sinusal Symptomatology<sup>50</sup>**

Six patients experienced postsurgical acute sinusal infection. The infection was positively treated with antibiotics and antihistamines in five patients. These five patients answered the questionnaire for sinusal symptomatology positively. Two of them (9.09%) had positive diagnosis for sinusitis, according to the diagnostic criteria of the symptomatology questionnaire (TFR criteria), at the time of the final checkup.

**Satisfaction Test: OHIP-Edent Questionnaire<sup>51</sup>**

Eighty-four percent of the patients reported being satisfied with the treatment (scores above 80% in the total satisfaction score). In addition, 31.82% of the patients



**TABLE 8 PT Values for Zygomatic Implants**

PT Values	Right	Ranges	Left	Ranges	Mean
PTv (mean) before prostheses placement	-4.4	0/-7	-4.35	0/-7	-4.38
PTv (mean) 10 years after prostheses placement	-5.18	-1/-7	-4.71	-1/-7	-4.95

Stability measurements, (Periotest® values), of zygomatic implants before prosthesis placement and after 10 years of follow-up. Decrease of PTv mean values indicates increased stability.

reported the maximum satisfaction score (100%) (Figure 6).

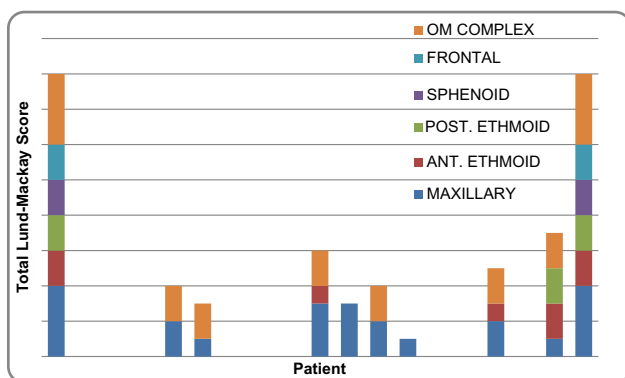
## DISCUSSION

All the patients underwent a two-step surgery, following an intra-sinus protocol for the implant placement that included the opening of a window-shaped osteotomy on the anterior sinus wall to control implant direction. All the used RI and ZI had a relatively smooth, machined titanium surface. This retrospective study showed that ZI, as described in the original technique, can be used for long-term successful rehabilitation of patients with severe atrophic maxillae. The last statement is of special relevance because this period represents the learning curve of the original zygoma technique for a single surgeon (C.A.).

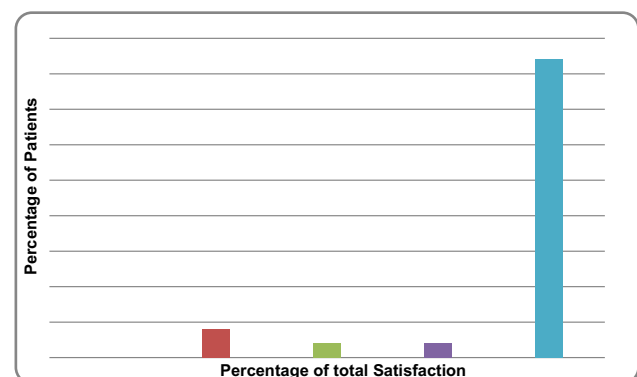
Since the anatomical measurements performed on the 22 CBCT scans showed a mean height of the alveolar ridge at the entrance of the ZI of 2.64 mm (SD = 0.794 mm) on the right side and 2.25 mm on the left side (SD = 1.155 mm), the inclusion criterion for the surgical procedure of having less than 4 mm height was fulfilled.

The ZI technique results in a different biomechanical situation compared to conventional implants: (i) the ZI is much longer (35–52.5 mm) and the main anchorage is located far away from the loading point; (ii) the implant has to be angulated 40–60° to engage the zygomatic process; and (iii) the implant head has a 45° angle correction. All of these factors result in an unfavorable biomechanical situation when they are considered in an isolated manner. In other words, it would be fairly simple to overload a solitary implant in an angulated position. Nevertheless, various authors, including ourselves, have shown the effectiveness of tilted implants provided that they are connected with other implants.<sup>27–32,53–55</sup> For this reason, a rehabilitation that includes the use of ZI must be conceived as a one piece, rigid bar that includes two to four RI in the anterior maxilla.

The success criteria for the evaluation of osseointegrated implants include the maintenance of the marginal bone height during loading.<sup>42,56</sup> With respect to ZI, intraoral periapical radiographs could not be used to assess marginal bone levels in a standardized manner. This is due to the difficulty of placing an intraoral film



**Figure 5** Results for the Lund-Mackay CT staging system. Nine of the patients (47.4%) did not show any opacification in none of their sinus. All the patients having a positive scan presented a certain degree of opacification in the maxillary sinus, either on the right or on the left, or both. A common finding was to observe osteomeatal complex obstruction, at least on one side.



**Figure 6** Percentage of satisfaction. Distribution of total satisfaction among patients. Eighty-four percent of the patients reported to be satisfied above 80% of the total satisfaction score regarding the received treatment. Forty-four percent reported the maximum satisfaction score (100%).

correctly, because of: (i) the lack of palate curvature in these patients whose residual alveolar crest had literally disappeared; and (ii) because of the tilted placement of the ZI together with the angulated design of its head. Moreover, since the stability of the ZI is mainly achieved by engagement of the zygomatic arch bone, the importance of integration in the residual alveolar bone is not known.

When reporting success rates of ZI, it is important to use universally accepted criteria to evaluate the sinus status. In this report, we are using widely employed criteria on the Ear, Nose, and Throat literature. These are the L–M score radiological examination together with a questionnaire for sinus symptomatology specified by the TFR diagnostic criteria.

From the available data, sinusitis rates for the classic two-stage protocol are approximately 6.6%.<sup>37</sup> The present study showed few incidences with infections in the maxillary sinus after more than 10 years of ZI installation. The vast majority of patients treated using ZI do not experience sinus pathology.<sup>37</sup> Furthermore, it is not clear if sinusitis rates in patients with ZI are higher than rates in the general population.<sup>57</sup> A few studies have analyzed sinus reactions to ZI,<sup>58</sup> and, usually, a low rate of early sinus complications is described, probably associated with implant placement surgery.<sup>37</sup> The majority of reports of sinus problems were of complications in ZI that had been in place for a certain time. Other authors have reported more extensive problems with intraoral soft tissue<sup>59</sup> as well as the removal of ZI due to recurrent sinusitis.<sup>60</sup> The problem may be due to lack of contact between the residual alveolar crest and the implant, thereby creating communication between the oral and sinus cavities. However, it was not possible to determine the origin of the infection. Sinus complications have empirically been associated with the original technique that used machine-surfaced ZI installed using the classic two-stage protocols and an intra-sinus path.

It is important to understand that for purposes of interpretation of this study, a normal or “negative” scan was defined as any scan with a L–M score of 0. Any scan with a score >0 was considered an abnormal or “positive” scan. Because the L–M grading scale does not specify a cutoff score for a “positive” or “negative” scan, we chose to adhere to the strictest possible definition of a negative scan. The symptoms of rhinitis and sinusitis overlap. Moreover, sinusitis rarely occurs in

the absence of rhinitis. Many authors,<sup>61,62</sup> therefore, use the term rhinosinusitis. Acute rhinosinusitis is defined as up to 4 weeks of purulent (not clear, but cloudy or colored) nasal drainage (anterior, posterior, or both), accompanied by nasal obstruction, congestion, blockage, or stuffiness, facial pain/pressure/fullness, or both. It normally starts as viral rhinosinusitis caused by an upper respiratory tract infection.

If the problem persists for more than 7 to 10 days, the sinusitis can become acute bacterial rhinosinusitis (ABRS). Generally speaking, ABRS remains mainly a clinical diagnosis. So a positive scan does not imply the presence of rhinosinusitis but only connotes the presence of radiologically evident mucosal abnormalities.<sup>61</sup> However, because of the relative opacity of objective measures for evaluating rhinosinusitis, we chose to use CT scans as standard reference for evaluating TFR criteria. The fact that after 10 years of function, nine patients (47.4%) did not present any opacification in any of their sinuses (L–M = 0) is a good indication of the benevolence of the procedure. Another factor to keep in mind when evaluating a 10-year L–M positive result is that, in any case, we did have presurgical control of all sinuses and osteomeatal complex to compare with. Since the ZI situation is unique with parts of the implant exposed to the maxillary sinus, controlling of the health of the maxillary sinus should be part of the maintenance program.

## CONCLUSIONS

It is concluded that long-term rehabilitation of the severely atrophic maxillae by means of fixed implant-supported bridges anchored on ZI and RI is a predictable procedure. However, prospective randomized controlled studies are needed to assess the long-term prognosis for this technique in comparison with augmentation procedures.

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