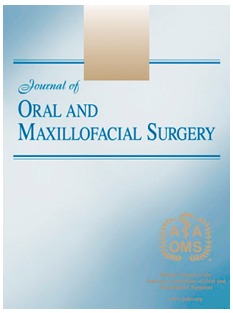
Accepted Manuscript



Survival and complications of zygomatic implants: an updated systematic review

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PII: S0278-2391(16)30446-3

DOI: 10.1016/j.joms.2016.06.166

Reference: YJOMS 57322

To appear in: *Journal of Oral and Maxillofacial Surgery*

Received Date: 21 January 2016

Revised Date: 1 June 2016

Accepted Date: 8 June 2016

Please cite this article as: Chrcanovic BR, Albrektsson T, Wennerberg A, Survival and complications of zygomatic implants: an updated systematic review, *Journal of Oral and Maxillofacial Surgery* (2016), doi: 10.1016/j.joms.2016.06.166.

Survival and complications of zygomatic implants: an updated systematic review

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Survival and complications of zygomatic implants: an updated systematic review

ABSTRACT

Purpose: To assess the survival rate of zygomatic implants (ZIs) and the prevalence of complications based on previously published studies.

Methods: An electronic search was performed in December/2015 in three databases and was supplemented by hand-searching. Clinical series of ZIs were included. Interval survival rate (ISR) and cumulative survival rate (CSR) were calculated. The untransformed proportion of complications (sinusitis, soft tissue infection, paresthesia, oroantral fistulas) was calculated, considering the prevalence reported in the studies.

Results: Sixty-eight studies were included, comprising 4556 ZIs in 2161 patients, with 103 failures. The 12-year CSR was 95.21%. Most failures were detected within the six-month postsurgical period. Studies (n=26) that exclusively evaluated immediate loading showed a statistically lower ZI failure rate than studies (n=34) evaluating delayed loading protocols (*P*=0.003). Studies (n=5) evaluating ZIs for the rehabilitation of patients after maxillary resections presented lower survival rates. The probability of presenting postoperative complications with ZIs was as follows: sinusitis 2.4% (95%CI 1.8-3.0), soft tissue infection 2.0% (95%CI 1.2-2.8), paresthesia 1.0% (95%CI 0.5-1.4), oroantral fistulas 0.4% (95%CI 0.1-0.6). However, these numbers may be underestimated, as many studies failed to mention the prevalence of these complications.

Conclusion: ZIs present a high 12-year CSR, with most failures occurring at the early stages postoperatively. The main observed complication related to ZIs was sinusitis, which may appear several years after ZI installation surgery.

INTRODUCTION

The combination of an increased maxillary sinus pneumatization with the advanced posterior alveolar resorption often results in insufficient bone for implant anchorage,[1] constituting a therapeutic challenge. Bone augmentation is usually required in these conditions, in order to enable the placement of sufficient numbers and lengths of implants.[2] Maxillectomy defects, maxillary sinus aplasia, and cleft deformities are even more challenging conditions.[3,4]

The installation of zygomatic implants (ZIs) is one of the various techniques described in the literature to treat the atrophic maxilla,[5] and several prospective studies[6-11] have showed successful outcomes. A previous review on the survival of ZIs[12] observed that most failures were detected until 6 months after surgery, with a high 12-year cumulative survival rate (CSR). The use of ZIs has several advantages, such as a considerable shortening of the treatment time, a reduced morbidity, as the technique eliminates the necessity of a graft (and consequently of a graft donor site), a reduced number of implants necessary to support fixed prostheses, and a reduction of the patients' costs. ZIs have enabled the surgeon to overcome the local osseous deficiency by engaging hard tissue at the distant zygomatic bone, allowing an increased retention and stability of a obturator or prosthesis.[13] The technique does have, however, some disadvantages. First, the installation of ZIs is a major surgical procedure and should be performed only by properly trained clinicians. There is a considerable risk of soft tissue complications around the abutments and of sinusitis. A more complex prosthetic design may be necessary when ZIs need to placed in a more palatal location. Furthermore, an eventual failure of a ZI may require a more complex and invasive treatment in comparison to failures of conventional implants.

The aims of the present systematic review was to report an updated survival rate of ZIs and the prevalence of complications based on previously published clinical studies. The present review is an update of a previously published article.[12]

MATERIALS AND METHODS

The present study followed the PRISMA Statement guidelines.[14]

Objective

The purpose of the present systematic review was to assess the survival rate of ZIs and the prevalence of complications based on previously published clinical studies. The focused question was elaborated by using the PICO format (participants, interventions, comparisons and outcomes): What are the clinical outcomes (survival rate and complications) of partially and totally edentulous patients undergoing prosthetic rehabilitation supported by at least one ZI?

Search strategies

An electronic search without time or language restrictions was undertaken in December 2015 in the following databases: PubMed/Medline, Web of Science, and the Cochrane Oral Health Group Trials Register. The following terms were used in the search strategies, refined by selecting the term:

{Subject AND Adjective}

{*Subject*: (zygomatic OR zygoma OR zygomaticus)

AND

Adjective: (implant OR implants OR fixture OR fixtures)}

An additional manual search of related journals was conducted. The reference list of the identified studies and the relevant reviews on the subject were scanned for possible additional studies.

Inclusion and exclusion criteria

The inclusion criteria comprised clinical human studies reporting clinical series of patients receiving ZIs. The patients could either have an atrophic maxilla bone, be partially or totally edentulous, or had undergone surgery for cancer ablation or radiotherapy. Randomized and controlled clinical trials, cross-sectional studies, cohort studies, case-control studies, and case series were considered. For this review, implant failure represents the complete loss of the implant. Exclusion criteria were case reports, technical reports, biomechanical studies, finite element analysis (FEA) studies, animal studies, *in vitro* studies, and review papers.

Study selection

The titles and abstracts of all reports identified through the electronic searches were read independently by the authors. For studies appearing to meet the inclusion criteria, or for which there were insufficient data in the title and abstract to make a clear decision, the full report was obtained. Disagreements were resolved by discussion between the authors.

Data extraction

Data were extracted from each of the identified eligible studies, including year of publication, number of patients, patients' age range and average, number of ZIs and additional conventional implants placed and failed, follow-up time, and the following four postoperative complications: sinusitis, soft tissue infection around the ZIs, paresthesia, and oroantral fistula formation.

Analyses

Implant survival was reported for each publication. The interval survival rate (ISR) of ZIs was calculated using the information for the period of failure extracted from the included studies, and the CSR was calculated over the maximal period of follow-up reported. Moreover, the

untransformed proportion of complications (sinusitis, soft tissue infection, paresthesia of infraorbital and/or zygomaticofacial nerves, oroantral fistulas) was calculated, considering the prevalence reported in the studies. The data were analyzed using the software OpenMeta[Analyst].[15]

RESULTS

Literature search

The study selection process is summarized in Figure 1. The search strategy resulted in 1414 papers. A number of 712 articles were cited in more than one research of terms (duplicates). The three reviewers independently screened the abstracts for those articles related to the focus question. Of the resulted 702 studies, 504 were excluded for not being related to the topic, resulting in 198 entries. Additional hand-searching of the reference lists of selected studies yielded 1 additional study. The full-text reports of the remaining 199 articles led to the exclusion of 131 because they did not meet the inclusion criteria (57 papers were case reports, 22 review papers, 15 FEA studies, 12 papers describing surgical techniques, 7 anatomical studies, 6 studies in cadavers of dry skulls, 4 papers were earlier follow-up of the same study, 2 papers not evaluating failures, 2 computed tomography studies, 1 phantom experiment, 1 orthodontic study, 1 repeated study published in another journal, 1 using ZIs for nasal prosthesis). Thus, a total of 68 publications were included in the review.

Description of the studies and analysis

One randomized clinical trial,[16] 16 prospective studies,[6-8,10,11,17-27] and 51 retrospective analyses[1,2,9,13,28-74] were included. The only randomized clinical trial[16] was randomized for the performance of inferior meatal antrostomy. One was study was a multicenter approach performed in several countries,[7] whereas the other 67 studies were performed in 15 countries: 13 in Spain, 9 in the United States, 8 in Sweden, 6 in Brazil, 5 each in China, Germany, and Italy, 4 in Portugal, 3 in

Belgium, 2 each in Colombia, South Africa, and United Kingdom, and 1 each in Japan, Norway, and Switzerland. Detailed data of the 68 included studies are listed in Table 1.

The publications included 2161 patients and 4556 ZIs, with a total of 103 ZI failures. According to the untransformed proportion, the probability of an event (a ZI failure) was 1.3% (95% confidence interval 1.0-1.6, standard error 0.2, $P < 0.001$; heterogeneity: $\tau^2 = 0.000$, $Chi^2 = 69.183$, df = 67, $I^2 = 3.155\%$, $P = 0.404$). Fifty-three studies provided information about the total number of placed and failed additional conventional implants in the maxilla, with a failure rate of 3.29% (182/5535). As not all studies reported the number of additional (standard) implants used, these figures might be underestimated. Fourteen studies were not included in the life-table analysis of ZIs because there was no information on when the ZIs failed in relation to the implant installation surgery and/or no information about the total number of ZIs followed up to the failure time point,[28,35,54,55,57,60,63,64,66,67,69,71,73] or because the life table survival of implants was reported at patient-level, not at the implant-level.[72] The 14 studies comprised 38 ZIs failures. Pooled data from the 54 articles reporting the time point when ZI failures occurred showed a total of 65 failures over varying time periods, with most failures (n = 40) occurring within 6 months after installation surgery or at the abutment connection, resulting in a 6-month ISR of 98.64%. The 12-year CSR was 95.21% (Table 2).

Of 68 studies, 26 exclusively assessed ZIs submitted to immediate loading,[8-11,18-21,23-25,27,39,44,45,47,48,50,56,59,61,62,65,69,71,72] showing a high survival rate (1074 patients, 2219 ZIs, 37 failures, 1.67%). Of the other 42 publications, 34 exclusively assessed ZIs with delayed function protocols,[1,2,6,7,13,17,26,28-38,40-43,46,49,51,52,55,57,60,64,67,68,70,74] with 1592 ZIs in 781 patients (50 failures, 3.14%). The difference of the ZI survival rates between the immediate and delayed protocols were shown to be statistically significant ($P = 0.003$; Pearson's Chi-square test). Eight studies[11,19,21,23,25,54,65,72] applied the so-called extramaxillary ZI, placing the implant completely outside the maxillary sinuses, comprising a total of 1241 ZIs in 592 patients (13 failures, 1.05%).

ZIs were used for the rehabilitation of patients with resected maxillae in five studies,[13,36,52,64,73] with a ZI survival rate ranging from 78.6 to 94.1%.

Altogether, the studies reported 127 cases of sinusitis (total of 3707 ZIs), 67 events of gingival infection around the implants (total of 2190 ZIs), 28 events of paresthesia, and 25 episodes of formation of oroantral fistulas (Table 3). According to the untransformed proportions, the probability of a maxillary sinus presenting sinusitis in case of a ZI placement was 2.4% (95% confidence interval 1.8-3.0, standard error 0.3, $P < 0.001$; heterogeneity: $\tau^2 = 0.000$, $Chi^2 = 72.533$, df = 52, $I^2 = 28.309\%$, $P = 0.031$), the probability of a ZI presenting a soft tissue infection around it was 2.0% (95% confidence interval 1.2-2.8, standard error 0.4, $P < 0.001$; heterogeneity: $\tau^2 = 0.000$, $Chi^2 = 83.511$, df = 41, $I^2 = 50.905\%$, $P < 0.001$), the occurrence of paresthesia of infraorbital and/or zigomaticofacialis nerves after a ZI surgery was 1.0% (95% confidence interval 0.5-1.4, standard error 0.2, $P < 0.001$; heterogeneity: $\tau^2 = 0.000$, $Chi^2 = 20.354$, df = 23, $I^2 = 0\%$, $P = 0.620$), and the formation of oroantral fistulas after a ZI surgery was 0.4% (95% confidence interval 0.1-0.6, standard error 0.1, $P = 0.002$; heterogeneity: $\tau^2 = 0.000$, $Chi^2 = 29.081$, df = 36, $I^2 = 0\%$, $P = 0.787$).

DISCUSSION

The 68 studies included in the present review totaled 4556 ZIs in 2161 patients, with only 103 failures, showing a CSR of 95.21% over a 12-year period. These numbers suggest that the technique has a high predictability with good clinical results.

Twenty-six studies assessed ZIs submitted to immediate loading.[8-11,18-21,23-25,27,39,44,45,47,48,50,56,59,61,62,65,69,71,72] The high survival rate presented in such conditions suggests that ZIs can successfully be submitted to immediate loading. However, these good results must be interpreted with caution, because few studies followed the patients for more than 5 years. Concern about primary stability and careful patient selection are the possible reasons for these high survival

rates. When a ZI is involved in an oral rehabilitation, there usually is a prosthetic connection of all maxillary implants with a rigid connector, which will result in a better distribution and sharing of the occlusal loading.[18] It was suggested that placing the implants in an arch form may counteract bending forces.[20]

There was a statistically significant lower survival rate of ZIs with delayed loading protocols than when the ZIs were immediately loaded, taken together all ZIs from the studies exclusively evaluating the distinct function protocols. This could be related to a general longer follow-up period observed in studies performing delayed loading protocols, since a longer follow-up can lead to an increase in the failure rate. Moreover, the immediate loading protocol was only adopted after 7-8 years of publications on ZIs clinical trials applying delayed loading protocols. Surgeons involved in more recent studies (mostly using immediate protocols) may have taken advantage of the enhancements and improvements of the surgical technique over the years, which could have increased the survival rates. Furthermore, most of the studies applying the use of ZIs in maxillary defects after resection surgery used delayed loading.

Recurrent infection, overgrowth of soft tissue surrounding the implant impairing the abutment connection, overloading leverage in extensive maxillectomies, and tumor recurrence are all factors that may contribute to a lower survival rate of ZIs used in patients with resected maxillae.[36] The use of ZIs in large maxillary defects after tumor resection can be considered a drawback, due to the biomechanical disadvantages of a long lever arm, the 30- to 60-degree angle relative to occlusal forces, and the small volume of available bone for anchorage and osseointegration.[13] The soft tissue around the implant head and abutment may create deep peri-implant pockets, predisposing the site to infections.[36,52] Radiotherapy may also have an impact on the success of ZIs and impairs the bone reparative capacity.[75,76] The survival rate of standard implants is negatively affected by irradiation of the maxillofacial region.[77] All these factors may have influenced the survival rates of ZIs placed in patients after the ablation of neoplasias.[13,36,52,64,73] Schmidt et al.[13] reported 78.6% of survival, Landes[36] 89.3%, Landes et al.[52] 91.7%, Huang et al.[64]

88.9%, and Pellegrino et al.[73] 94.1%. On the other hand, higher survival rates are reported with ZIs placed in patients with no resected maxillae. One reason seems to be that in such cases there is the engagement of more cortical bone - the palatinal alveolar crest and sinus floor cortical portions are also used – in comparison to fewer cortical portions (one or two) when conventional implants are installed.[78] The anchorage of an implant in more portions of cortical bone provides a great deal of stability and has been considered as an important factor influencing the survival of implants.[79]

The literature reported several complications related to ZI surgery, including sinusitis and infections in the maxillary sinus,[1,2,6-8,10,16,17,19,26,27,34,35,40,41,44,46,47,49,51-53,60,61,63,65-67,69,70,72] intraoral soft tissue infection,[2,7,10,11,17,26,27,34,36,40,47,49,52,53,58,61,66,67] removal of ZIs due to recurrent sinusitis[2] or continued pain,[59] formation of an oroantral fistula,[2,7,10,17,26,27,33,47,58,61,63,65,72] facial/periorbital hematoma,[26,61,69,74] gingival hyperplasia,[74] orbital cavity penetration,[27,45,59] temporary sensory nerve deficits,[6-8,16,26,43,53,61,63,69,70] moderate nasal bleeding for 1–3 days,[6] and subcutaneous malar emphysema.[16,63] Not so many events of complications were reported. However, the prevalence of these complications is probably underestimated, as several publications did not report either the presence or the absence of these conditions.

The problem of oroantral fistula is believed to be caused by the weak sealing between the thin and compromised alveolar bone and the implant head, which may results in a communication between the maxillary sinus and the oral cavity.[6] Extensive countersinking preparations must be avoided, as well as fracturing of the thin alveolar crest during implant installation.[20] It was hypothesized that a hole for the abutment screw in the machined Brånemark ZI could also lead to oroantral communication.[2,51,80] Some suggested that connecting the definitive abutments together with the implants in a one-stage procedure could decrease the risk of oroantral communication by establishing a better soft tissue barrier.[47,51]

Concerning sinusitis, virtually all operated maxillary sinuses will fill up with blood and become radiopaque for some time after surgery,[81] and the protrusion of implants into the maxillary sinus can cause thickening of the sinus membrane around the implants but without clinical signs of

sinusitis,[82] fact that was observed by several studies.[80,82,83] This could be explained by the absence of mobility of these implants, consequently not causing irritation of the sinus mucosa and/or obstruction of the meatal complex.[84] However, three clinically stable ZIs had to be removed in the study of Becktor et al.[2] because of recurrent sinusitis. Events of sinusitis after ZI surgery still do occur, and they can be attributed to several factors[2] such as the presence of postsurgical debris inside the sinus causing blockage of the maxillary ostium,[8] perforation of the sinus membrane bringing bacteria from the mouth,[53] and a lack of osseointegration at the marginal level in the palatal area, resulting in transversal mobility of the ZI and a pump effect during function.[2] Thus, it is suggested that sinusitis may be more related to oroantral communications rather than to exposed implant threads.[2]

The prevalence of sinusitis may be underestimated, due to lack of information provided and to short-term follow-up studies. Sinusitis may be established years after ZI surgery.[34] Another important point is the fact that there is no consensus how to report sinusitis diagnosis in the dental literature.[61] In most of the studies, using ZIs, the term used to describe the sinus pathology is sinusitis, without clarifying the type, the associated signs and symptoms, or whether a CT scan or endoscopy was performed to confirm the diagnosis. For these reasons, it was not possible to determine sufficient useful details of the sinusitis described.[61] Furthermore, there are difficulties to establish any clear relationship between the sinus infection and the implant,[80] as several studies[1,2,6,9,25,26,34,41,46,61-63,67-69,74] did not report the pre-existing clinical and radiological conditions of the sinus. Although there seems to be a higher risk of maxillary sinus infections when rehabilitating patients with a previous diagnosis of maxillary sinusitis,[72] there is still no scientific evidence supporting a cause-and-effect relation between ZIs and the development of maxillary sinusitis. A study[80] analyzed the CT scans of the maxillary antrum before and after the placement of ZIs, and found that 46% (12 out of 26) of the patients showed a thickening of sinus mucosa around the implants, but there was no clinical consequence. However, thickening of the mucosa was already present before the installation of ZIs in 8 of these 12 patients. As isolated sinusitis without

the occurrence of an oroantral fistula has not been associated with loosening of the implant in several studies,[1,6,10,16,27,34,40,44,46,49,51,53,60,63,65-67,69,70,72] it seems that sinusitis might not be a significant factor to impair the osseointegration of ZIs.[80]

Eight studies[11,19,21,23,25,54,65,72] preferred extramaxillary placed ZIs, a surgical technique first proposed by Migliorança et al.[85] in 2006, which aimed to decrease the prevalence of problems in the maxillary sinus. Although there were no episodes of sinusitis in 7 of these studies (Maló et al.[65] reported 5 cases, all with previously diagnosed sinusitis prior to surgery, and in all a maxillary sinus membrane rupture occurred during the surgical procedure), there were no cases of sinusitis in several studies applying intrasinus ZIs.[9,20,24,37,46,55,58,62,68,74]

Sensitivity disorders after ZI installation surgery were reported in several studies.[6-8,16,26,43,53,61,63,69,70] As a reflection of the soft tissues in the malar region is expected, a damage of the zygomaticofacial and infraorbital nerves is likely to occur during the clinical procedure of implant placement.[78]

Atypical complications of ZI surgery reported in isolated reports include an infection by aspergillosis,[86] orbital cavity penetration,[27,45,59] and intracerebral penetration.[87] Concerning the case of aspergillosis infection, the sinus membrane was perforated, leading the authors[86] to consider that the sinus was possibly infected by airborne fungus during surgery. With regard to accidental cavity penetrations, a small drilling angular error may result in significant positional errors at the end of the tool trajectory, especially when custom-made drill guides are used.[17,88] In the particular case of orbital penetration, if a second ZI is planned to be placed on the same zygoma, there is a risk that the anterior ZI could involve the orbital wall.[7]

Limitations of the present study. The results of the present study have to be interpreted with caution because of its limitations. First, all confounding factors may have affected the outcomes. When very long implants are inserted in the zygomatic buttress, the impact of these variables on the implant survival rate is difficult to estimate if these confounding factors are not identified separately in order to perform a meta-regression analysis. The real fact is that individual patients sometimes

present with more than one risk factor, and groups of patients are typically heterogeneous with respect to risk factors and susceptibilities so the specific effect of an individual risk factor could be isolated neither for individual studies nor for the present review.[89] Second, most of the included studies had a retrospective design, manifesting problems such as gaps in information and incomplete records. Third, some of the included studies are characterized by a low level of specificity, where the assessment of ZIs was seldom the main focus of the investigation. In addition, much of the research in the field is limited by small cohort sizes and short follow-up periods. Taken together, the ISRs and the 12-year CSR are encouraging but there are not so many studies including a reasonable number of ZIs where the patients were followed for at least 5 years. A longer follow-up period may lead to an increase in the failure rate, especially if it extended beyond functional loading, because other prosthetic factors can influence implant failure from that point onward. This might have led to an underestimation of actual failures in some studies. More studies including a greater number of ZIs followed up for longer periods are needed, in order to draw more definitive conclusions on these matters.

CONCLUSION

Most ZIs failures were occurred within the six-month postsurgical period or at the abutment connection. The 12-year CSR was 95.21%. ZIs submitted to immediate loading presented a statistically significant higher survival rate than ZIs submitted to delayed loading protocols. Studies applying ZIs in patients with resected maxillae showed the lowest survival rates among all clinical series. The main complication which seems to occur with ZIs is sinusitis, which may develop several years after their placement.

ACKNOWLEDGEMENTS

The authors would like to thank Dr. Miguel de Araújo Nobre, Dr. Roberto Bertolai, Dr. Rubén Davó, and Dr. Constantin Landes for having sent us their articles.

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FIGURE LEGENDS

Figure 1. Study screening process.

TABLES

Table 1. Clinical series of zygomatic implants: study details and implant failures.

Study	Published	Study design / setting / country	Patients (n)	Patients' Age Range (Average) (years)	Follow-up Period Range (Average) (months)	Antibiotics / mouth rinse (days)	Healing period / loading	Zygomatic implant surface modification (brand)	Prosthetic rehabilitation	Observations	Zygomatic Implants		Conventional Implants	
											Failed /Placed (% survival)	Failure period	Failed /Placed	Failure period
Brånemark[28]	1998	RA / UC / Sweden	81	NM	12-120 (NM)	NM	6 months	Turned (Nobel Biocare AB, Göteborg, Sweden)	FAP	-	4/164 (97.6)	NM	NM	-
Parel et al.[29]	2001	RA / UC / Sweden	27	NM	12-144 (NM)	NM	5-6 months	Turned (Nobel Biocare AB, Göteborg, Sweden)	FAP	-	0/65 (100)	-	NM	-
Bedrossian et al.[30]	2002	RA / UC / USA	22	NM	34 (34)	NM	6 months	Turned (Nobel Biocare AB, Göteborg, Sweden)	FAP	-	0/44 (100)	-	7/80	NM
Boyes-Varley et al.[31]	2003	RA / UC / South Africa	45	NM	6-30 (NM)	1 / NM	6 months	Turned (n=42; Nobel Biocare AB, Göteborg, Sweden), sandblasted/acid-etched (n=35; Southern, Irene, South Africa)	FPP, FAP, OD	-	0/77 (100)	-	NM	-
Nakai et al.[32]	2003	RA / UC / Japan	9	37-73 (54.2)	17–47 (NM)	NM	6-8 months	Turned (Nobel Biocare AB, Göteborg, Sweden)	FAP, OD	3 men, 6 women	0/15 (100)	-	NM	-
Vrielinck et al.[17]	2003	PS / UC / Belgium	29	37-71 (56.4)	3–24 (15)	10 / Yes	6 months	Turned (Nobel Biocare AB, Göteborg, Sweden)	FPP/FAP (n=10), OD (n=19)	9 men, 20 women	3/67 (95.5)	at stage II implant surgery (6 months)	5/71	at stage II implant surgery (6 months)
Al-Nawas et al.[33]	2004	RA / UC / Germany	24	NM	11-30.5 (19.9)	NM	Mean 189 days (range 100-288)	NM	NM	3 smokers, grafts in 13 implant sites (iliac crest)	1/37 (97.3)	Lost in the loading phase	NM	-
Brånemark et al.[34]	2004	RA / UC / Sweden	28	39-79 (58.3)	60-120 (NM)	14 / NM	Mean 204 days (range 145-295)	Turned (Nobel Biocare AB, Göteborg, Sweden)	FAP	Grafts in 17 patients, 12 men, 16 women	3/52 (94.2)	2 lost at the abutment connection phase (6 months), 1 at the 6-year follow-	29/106	NM

Ferrara and Stella[35]	2004	RA / UC / USA	16	40-65 (NM)	NM	NM	6 months	Turned (Nobel Biocare AB, Göteborg, Sweden)	FPP, FAP	-	1/25 (96.0)	up NM	0/80	-
Malevez et al.[1]	2004	RA / UC / Belgium	55	22-79 (57) ♀ 40-76 (62) ♂	6–48 (NM)	5 / NM	6 months	NM (Nobel Biocare AB, Göteborg, Sweden)	FAP	Grafting in 7 patients, 14 men, 41 women	0/103 (100)	-	16/194	NM
Schmidt et al.[13]	2004	RA / UC / USA	9	47-85 (68.7)	0-84 (NM)	NM	6 months	NM	FAP, OD	All patients with maxillary defects after resection surgery, 1 patient irradiated	6/28 (78.6)	at stage II implant surgery (6 months)	3/10	at stage II implant surgery (6 months)
Becktor et al.[2]	2005	RA / UC / Sweden	16	29-77 (61.1)	9–69 (46.4)	7 / NM	Mean 6.4 months (range 5-8)	Turned (Nobel Biocare AB, Göteborg, Sweden)	FAP	6 men, 10 women	3/31 (90.3)	2 at 6 months 1 at 37 months	3/74	between the abutment connection surgery and definitive prosthetic loading
Landes[36]	2005	RA / UC / Germany	12	24-79 (58)	14–53 (28.9)	1 / NM	6 months	Turned (Nobel Biocare AB, Göteborg, Sweden)	FPP (n=2), OD (n=10)	Patients with maxillary defects after resection surgery, 6 patients irradiated, 2 men, 10 women	3/28 (89.3) [a]	1 within 1 year 2 at 2 years	NM/23	NM
Peñarrocha et al.[37]	2005	RA / UC / Spain	5	29-75 (50.4)	12–18 (15)	7 / 7	3 months	NM (Nobel Biocare AB, Göteborg, Sweden)	FAP	2 men, 3 women, 1 smoker	0/10 (100)	-	0/18	-
Ahlgren et al.[38]	2006	RA / UC / Norway	13	49-73 (59)	11-49 (NM)	3-6 / NM	6 months	NM (Nobel Biocare AB, Göteborg, Sweden)	FAP (n=4), OD (n=9)	11 smokers, grafting in 3 patients, 2 bruxers, 6 men, 7 women	0/25 (100)	-	NM	-
Aparicio et al.[6]	2006	PS / UC / Spain	69	38-82 (56)	6–60 (25.1)	NM	5-6 months	NM (Nobel Biocare AB, Göteborg, Sweden)	FAP	27 smokers, 22 men, 47 women	0/131 (100)	-	2/304	1 month after abutment connection, 27 months in function
Bedrossian et al.[39]	2006	RA / UC / USA	14	NM (54.2)	12–34 (NM)	1 / Yes	Immediate	NM (Nobel Biocare AB, Göteborg, Sweden)	FAP	6 men, 8 women	0/28 (100)	-	0/55	-
Chow et al.[18]	2006	PS / UC / China	5	43-60 (49.8)	6-10 (NM)	NM	Immediate	Turned (Nobel Biocare AB, Göteborg, Sweden)	FAP	4 men, 1 woman, use of a surgical guide	0/10 (100)	-	0/20	-

Farzad et al.[40]	2006	RA / UC / Sweden	11	41-72 (57.6)	18-46 (33.1)	7 / 7	6-11 months	NM (Nobel Biocare AB, Göteborg, Sweden)	FAP	7 smokers, 1 man, 10 women	0/22 (100)	-	1/42	6 months
Zwahlen et al.[41]	2006	RA / UC / Switzerland	18	NM (63)	≥ 6 (NM)	Yes / NM	Mean 8 months	NM (Nobel Biocare AB, Göteborg, Sweden)	FAP	9 men, 9 women	2/34 (94.1)	postoperative	NM	-
Aghabeigi and Bousdras[42]	2007	RA / UC / United Kingdom	4	52-74 (60)	9-24 (NM)	NM	6 months	NM (Nobel Biocare AB, Göteborg, Sweden)	FAP, OD	1 smoker, 1 augmentation with Bio-Oss	0/8 (100)	-	2/14	NM
Boyes-Varley et al.[43]	2007	RA / UC / South Africa	20	12-82 (56)	Maximum 96 (NM)	NM	8 weeks	NM	FPP, FAP, fixed-removable prosthesis	All patients with maxillary defects after resection surgery, 5 patients irradiated, 14 men, 6 women	0/40 (100)	-	3/66	NM
Davó et al.[44]	2007	RA / UC / Spain	18	44-74 (58)	6-29 (14)	NM	Immediate	NM (Nobel Biocare AB, Göteborg, Sweden)	FAP	6 men, 12 women	0/36 (100)	-	3/68	NM
Duarte et al.[45]	2007	RA / UC / Brazil	12	NM	30 (NM)	NM	Immediate	Turned (Nobel Biocare AB, Göteborg, Sweden)	FAP	-	2/48 (95.8)	1 at 6 months 1 at 30 months	0/0	-
Kahnberg et al.[7]	2007	PS / MC / Australia, Belgium, Finland, Germany, Italy, Spain, Sweden, USA	60	35-77 (58)	36 (36)	NM	6 months	NM (Nobel Biocare AB, Göteborg, Sweden)	FAP, OD	15 smokers, 19 men, 57 women (of the original 76 patients)	5/145 (96.6)	3 failures before the prosthetic restoration (6 months) 1 at 2 years 1 at 3 years	NM	-
Peñarrocha et al[46]	2007	RA / UC / Spain	21	31-75 (54.1)	12-45 (29)	7 / 7	4-6 months	NM (Nobel Biocare AB, Göteborg, Sweden)	FAP	3 smokers, 10 men, 11 women	0/40 (100)	-	2/89	1 at 1 month 1 at 2 months
Davó et al.[47]	2008a	RA / UC / Spain	42	34-79 (57)	12-42 (20.5)	NM	Immediate	Oxidized (Nobel Biocare AB, Göteborg, Sweden)	FPP (n=5), FAP (n=37)	19 men, 23 women	0/81 (100)	-	4/140	3 months
Maló et al.[19, b]	2008	PS / UC / Portugal	29	32-75 (52.4)	6–18 (13)	4 / chlorexidine gel	Immediate	Oxidized (Nobel Biocare AB, Göteborg, Sweden)	FAP	8 men, 21 women	1/67 (98.5)	12 months	0/57	-
Mozzati et	2008	RA / UC /	7	52-64 (56.8)	24 (24)	5 / 4	Immediate	Oxidized (Nobel	FAP	4 men, 3 women	0/14 (100)	-	0/34	-

al.[48]		Italy						Biocare AB, Göteborg, Sweden)					
Pi Urgell et al.[49]	2008	RA / UC / Spain	54	38-75 (56)	1–72 (NM)	10 / 15	6 months	Turned (Nobel Biocare AB, Göteborg, Sweden)	FAP, OD	9 smokers, grafting in 25 patients, 19 men, 35 women	4/101 (96.0)	2 at 6 months (2nd phase) 1 at 18 months post-loading 1 at 43 months post-loading	15/221	NM
Balshi et al.[50]	2009	RA / UC / USA	56	38-84 (60)	9–60 (NM)	NM	Immediate	NM (Nobel Biocare AB, Göteborg, Sweden)	FAP	27 men, 29 women	4/110 (96.4)	3 at 0-3 months 1 at 3-6 months	11/391	NM
Davó[51]	2009	RA / UC / Spain	21 (24)[c]	36-72 (51.4)	60 (60)	NM	6 months	NM (Nobel Biocare AB, Göteborg, Sweden)	FPP (n=2), FAP (n=19), OD (n=3)	Graft in 1 patient (iliac crest), 8 men, 16 women	1/39 (97.4)	1 month	11/109	6 months (abutment connection)
Landes et al.[52]	2009	RA / UC / Germany	15	24-79 (58)	13-102 (65)	NM	6 months	NM (Nobel Biocare AB, Göteborg, Sweden)	OD	Patients with maxillary defects after resection surgery, 7 irradiated patients, 5 men, 10 women	3/36 (91.7)[d]	1 at 11 months 2 at 24 months	0/24	-
Aparicio et al.[21, b]	2010a	PS / UC / Spain	20	44-62 (52)	36–48 (41)	Yes / NM	Immediate	Turned (Nobel Biocare AB, Göteborg, Sweden)	FPP, FAP	12 smokers, 6 bruxers, 11 men, 9 women	0/36 (100)	-	0/104	-
Aparicio et al.[20]	2010b	PS / UC / Spain	25	34-78 (48)	24–60 (NM)	Yes / NM	Immediate/early	Turned (Nobel Biocare AB, Göteborg, Sweden)	FPP, FAP	13 smokers, 12 bruxers, 13 men, 12 women	0/47 (100)	-	1/129	52 months of loading
Bedrossian[8]	2010	PS / UC / USA	36	NM	6-84 (NM)	Yes / NM	Immediate	NM (Nobel Biocare AB, Göteborg, Sweden)	FAP	14 men, 22 women	2/74 (97.3)	6 months	0/98	-
Bothur and Garsten[22]	2010	PS / UC / Sweden	7	51-82 (63.9)	7-13 (10)	NM	NM	NM (Nobel Biocare AB, Göteborg, Sweden)	FAP	1 smoker, 1 bruxer, 2 men, 5 women	0/28 (100)	-	0/5	-
Chow et al.[23,b]	2010	PS / UC / China	16	NM (60)	6–24 (NM)	5 / 5	Immediate/early	NM (Nobel Biocare AB, Göteborg, Sweden)	FAP	2 smokers, 1 diabetic patient, 7 men, 9 women, use of a surgical guide	0/37 (100)	-	NM	-
Stiévenart and Malevez[53]	2010	RA / UC / Belgium	20	35-75 (56)	6-40 (NM)	5 / Yes	Immediate (n=10) 2-3 months (n=10)	NM (Nobel Biocare AB, Göteborg, Sweden)	FAP (n=19), OD (n=1)	2 diabetic patients, 1 man, 19 women	3/80 (96.3)	7-9 months	0/0	-
Miglioranza	2011	RA / UC /	75	32-81 (52)	≥ 12 (NM)	7 / 7	Immediate	NM (Nobel Biocare AB,	FAP	58 smokers, 27 men, 48	2/150 (98.7)	NM	2/286	NM

et al.[54,b]		Brazil					(n=27) 6 months (n=48)	Göteborg, Sweden)		women			
Schiroli et al.[55]	2011	RA / UC / Italy	4	NM	4-39	NM	Delayed	NM	FAP	Use of surgical guide, graft in 1 patient	0/7 (100)	-	2/18	NM
Balshi et al.[56]	2012	RA / UC / USA	77	33-80 (59)	Until 120	NM	Immediate	NM (Nobel Biocare AB, Göteborg, Sweden)	FPP, FAP	31 men, 46 women	6/173 (96.5)	1: 0-3 months 3: 3-6 months 1: 9-12 months 1: 1 year	The exact number was not reported	-
Bothur et al.[57]	2012	RA / UC / Sweden	7	51-82 (64)	NM	NM	Mean 8.2 months (range 3.9-11)	NM	FAP	2 men, 5 women	0/28 (100)	-	0/5	-
Degidi et al.[24]	2012	PS / UC / Italy	10	NM (62.3)	12 (12)	5 / NM	Immediate	Oxidized (Nobel Biocare AB, Göteborg, Sweden)	FAP	4 men, 6 women	0/20 (100)	-	0/20	-
De Moraes[58]	2012	RA / UC / Brazil	8	46-69 (57)	Mean 24.6 (range 15-42)	7 / 7	Immediate (n=18), delayed (n=4)	Turned (Conexão, São Paulo, Brazil)	FAP	8 men	0/22 (100)	-	0/20	-
Migliorança et al.[25,b]	2012	PS / UC / Brazil	21	43-69 (55.1)	96 (96)	7 / 14	Immediate	NM	FAP	14 smokers, 8 men, 13 women	1/40 (97.5)	4 months	3/74	NM
Sartori et al.[9]	2012	RA / UC / Brazil	16	38-63 (NM) ♀ 44-77 (NM) ♂	≥ 12 (NM)	NM	48 hours	NM (Neodent, Curitiba, Brazil)	FAP	2 smokers, 1 diabetic patient, 6 men, 10 women	0/37 (100)	-	0/58	-
Davó et al.[10]	2013a	PS / UC / Spain	42	34-79 (57.4)	60 (60)	7 / 14	Immediate	Oxidized (n=37), turned (n=44) (Nobel Biocare AB, Göteborg, Sweden)	FAP (n=37), FPP (n=5)	19 men, 23 women	1/69 [e] (98.6)	3 years	6/118 [e]	4: 3 months 2: 4 years
Hinze et al.[59]	2013	RA/ UC / Germany	10	56-69 (61.5)	6 (6)	7 / 14	Immediate	NM (Nobel Biocare AB, Göteborg, Sweden)	FAP	Sinus graft in all patients, 3 smokers, 3 men, 7 women	2/22 (90.9)	1: after surgery 1: 6 months	0/23	-
Landes et al.[60]	2013	RA/ UC / Germany	4	41-72 (57)	37-99 (62)	5 / NM	6 months	Turned (n=2), oxidized (n=2) (Nobel Biocare AB, Göteborg, Sweden)	OD	2 men, 2 women	0/9 (100)	-	0/0	-
Aparicio et	2014a	PS / UC /	22	48-80 (63)	120 (120)	NM	5-6 month	Turned (Nobel	FAP	5 smokers, 8 men, 14	2/41 (95.1)	10 years	3/131	2 at 7 months

al.[26]		Spain					s	Biocare AB, Göteborg, Sweden)		women				1 at 3 years
Aparicio et al.[61]	2014b	RA / UC / Spain	80	NM (53)	NM (55)	NM	Immediate	Turned (Nobel Biocare AB, Göteborg, Sweden)	FAP	24 smokers, 25 men, 55 women	5/157 (96.8)	4: 4-5 years 1: 5-6 years	0/529	-
Butura and Galindo[62]	2014	RA / UC / USA	15	53-80 (66)	12 (12)	NM	Immediate	Oxidized (Nobel Biocare AB, Göteborg, Sweden)	FAP	-	0/40 (100)	-	0/112	-
Fernández et al.[63]	2014	RA / UC / Colombia	80	25-75 (55.5)	6-48 (27)	NM	NM	NM	FAP	40 men, 40 women	1/244 (99.6)	NM	NM	-
Huang et al.[64]	2014	RA / UC / China	24 (6 received zygomatic implants)	28-66 (45.2)	18-137 (99.1)	NM	4-6 months	NM (Nobel Biocare AB, Göteborg, Sweden)	Fixed (n=18), movable (n=6)	All patients with maxillary defects after resection surgery, grafts in all patients, 18 men, 6 women	1/9 (88.9)	NM	9/79	NM
Maló et al.[65,b]	2014	RA / UC / Portugal	39	32-77 (53.5)	60 (60)	4 / chlorexidine gel	Immediate	Oxidized (Nobel Biocare AB, Göteborg, Sweden)	FAP	4 smokers, 9 men, 30 women	1/92 (98.9)	46 months	0/77	-
Rodríguez-Chessa et al.[66]	2014	RA / UC / Brazil	29	35-69 (NM)	10-40 (20)	Yes / NM	Immediate (n=10) Mean 6.7 months (n=19)	Treated (Conexão, São Paulo, Brazil)	FAP	3 smokers, 11 men, 18 women	8/67 (88.1)	NM	NM/84	.
Yates et al.[67]	2014	RA / UC / United Kingdom	25	42-84 (64)	60-120 (NM)	NM	6 months	Turned (Nobel Biocare AB, Göteborg, Sweden)	FPP, FAP	6 smokers, 12 men, 13 women	6/43 (86)	1: 1 week 1: 3 months 3: 6 months 1: 9 months	NM	-
Zou et al.[68]	2014	RA / UC / China	25 (5 received zygomatic implants	17-28 (NM)	60 (NM)	NM / Yes	3-6 months	NM (Nobel Biocare AB, Göteborg, Sweden)	FAP (n=24), OD (n=1)	All patients with ectodermal dysplasia, grafting in 17 patients, 13 men, 12 women	0/10 (100)	-	5/169	-
Bertolai et al.[69]	2015	RA / UC / Italy	31	52-82 (62)	20-60 (NM)	NM	Immediate	NM (Nobel Biocare AB, Göteborg, Sweden)	FAP	20 men, 11 women	2/78 (97.4)	NM	0/74	-
Bothur et al.[70]	2015	RA / MC / Sweden	14	51-78 (60)	Mean 112 (range 70-144)	NM	4-11 months	NM (Nobel Biocare AB, Göteborg, Sweden)	FAP	3 smokers, 5 men, 9 women	2/58 (96.6)	Early stages	1/13	Early stage
Davó and Pons[27]	2015	PS / UC / Spai	17	41-78 (57.7)	60 (60)	8 / 14	Immediate	Oxidized (n=64), turned (n=4)	FAP	4 smokers, 7 men, 10 women	0/68 (100)	-	0/0	-

		n						(Nobel Biocare AB, Göteborg, Sweden)					
De Araújo Nobre et al.[11, b]	2015	PS/ UC / Portugal	40	31-82 (56.6)	12 (12)	4 / chlorexidine gel	Immediate	Oxidized (Nobel Biocare AB, Göteborg, Sweden)	FAP	7 smokers, 3 bruxers, 9 men, 31 women	1/72 (98.6)	2 months	3/88	2: 4 months 1: 1 year
Fernández Olarte et al.[16]	2015	RCT [f] / UC / Colombia	44	25-75 (55.4)	3 (3)	7 / NM	Not loaded	NM	No prostheses	21 men, 23 women	1/137 (99.3)	< 3 months	NM	-
Jensen et al.[71]	2015	RA / MC / USA	44	42-88 (NM)	12-36 (NM)	NM	Immediate	Oxidized (Nobel Biocare AB, Göteborg, Sweden)	FAP	20 men, 24 women	2/16 (87.5)	NM	4/163	NM
Maló et al.[72,b]	2015	RA / UC / Portugal	352	17-85 (55.2)	6-84 (NM)	NM	Immediate	Oxidized (Nobel Biocare AB, Göteborg, Sweden)	FAP	66 smokers, 16 diabetic patients, 85 bruxers, 71 men, 281 women	7/747 (99.1)	4: 3 months 1: 9 months 1: 14 months 1: 46 months	17/795	NM
Pellegrino et al.[73]	2015	RA / UC / Italy	5	51-83 (61.8)	10-29 (12)	NM	Immediate (n=4) Delayed (n=1)	NM (Southern Implants, Irene, South Africa)	FPP, FAP, OD	All patients with maxillary defects after resection surgery, 1 irradiated patient	1/17 (94.1)	8 months	0/0	-
Wu et al.[74]	2015	RA / UC / China	10	NM (20.1)	36 (36)	NM / Yes	6 months	NM (Nobel Biocare AB, Göteborg, Sweden)	FAP	Grafting in all patients, all patients with ectodermal dysplasia, 7 men, 3 women	0/20 (100)	-	9/80	NM

NM – not mentioned; RA – retrospective analysis; PS – prospective study; RCT – randomized controlled trial; UC - unicenter; MC – multicenter; FPP - fixed partial prosthesis; FAP – full-arch prosthesis; OD – overdenture

[a] Kaplan–Meier cumulative 4-year zygoma implant survival/in situ rate was 82%

[b] The authors used the so-called ‘extramaxillary implants’ or ‘extrasinus zygomatic implants’

[c] 3 patients were not reviewed throughout the follow-up period

[d] Kaplan-Meier cumulative 9-year telescoped zygoma implant survival/in-situ rate was 89%

[e] Of the original 81 zygomatic and 140 conventional implants, respectively 69 and 118 were reviewed at the 5-year follow-up

[f] Randomized for the performance of inferior meatal antrostomy

Table 2. Life-table survival analysis showing the cumulative survival rate of zygomatic implants for 54 studies combined.*

Intervals in months	Number of implants in each interval	Number of failures in each interval	Survival rate within each interval (%)	Cumulative survival rate (%)
0-6	2949	40	98.64	98.64
7-12	2734	8	99.71	98.35
13-18	2274	0	100	98.35
19-24	2154	6	99.72	98.07
25-30	1896	1	99.95	98.02
31-36	1694	2	99.88	97.90
37-42	1279	1	99.92	97.82
43-48	1206	2	99.83	97.65
49-54	1026	0	100	97.65
55-60	993	1	99.90	97.55
61-66	488	0	100	97.55
67-72	473	2	99.58	97.13
73-84	360	0	100	97.13
85-96	202	0	100	97.13
97-108	123	0	100	97.13
109-120	104	2	98.08	95.21
121-132	36	0	100	95.21
133-144	17	0	100	95.21

* Fourteen studies were not included because the time point when these failures occurred was not reported and/or the authors could not extract the total number of implants that were followed-up to the time of failure, [28,35,54,55,57,60,63,64,66,67,69,71,73] or because the life table survival of implants was reported at patient-level, not at the implant-level.[72]

Table 3. Clinical series of zygomatic implants: other complications.

Study	**Complications**							
	Sinusitis	PO	Soft Tissue Infection	PO	Paresthesia (cheek, paranasal zones)	PO	Oroantral fistula formation	PO
Brånemark[28]	NM	-	NM	-	NM	-	NM	-
Parel et al.[29]	NM [a]	-	NM	-	NM	-	NM [a]	-
Bedrossian et al.[30]	NM	-	NM	-	NM	-	NM	-
Boyes-Varley et al.[31]	NM	-	NM	-	NM	-	NM	-
Nakai et al.[32]	0		NM	-	NM	-	NM	-
Vrielinck et al.[17]	2	NM	2	NM	0	-	1	NM
Al-Nawas et al.[33]	NM	-	NM	-	NM	-	1	12 months after restoration
Brånemark et al.[34]	4	NM	2	6 years 9 years	0	-	NM	-
Ferrara and Stella[35]	1	NM	NM	-	NM	-	NM	-
Malevez et al.[1]	6	1 before and 5 after prosthesis (installed at 4-6 months)	NM	-	NM	-	NM	-
Schmidt et al.[13]	NM [a]	-	NM	-	NM	-	NM [a]	-
Becktor et al.[2]	6	3 at 1-6 months	9	From 1 to 19	NM	-	5	After abutment connection (6

		1 at 33-37 months 1 at 18 months		months				months)
Landes[36]	0 [a]	-	3	Coincident with implant losses	0 [b]	-	0 [a]	-
Peñarrocha et al.[37]	0	-	0	-	0	-	0	-
Ahlgren et al.[38]	NM	-	NM	-	NM	-	NM	-
Aparicio et al.[6]	3	14, 23, and 27 months	NM	-	6	Subsided 3–8 weeks postoperatively	NM	-
Bedrossian et al.[39]	NM	-	NM	-	NM	-	NM	-
Chow et al.[18]	0	-	0	-	NM	-	0	-
Farzad et al.[40]	3	postoperative	14	NM	NM	-	NM	-
Zwahlen et al.[41]	2	postoperative	NM	-	NM	-	NM	-
Aghabeigi and Bousdras[42]	0	-	0	-	0	-	0	-
Boyes-Varley et al.[43]	0	-	0	-	1	NM	0	-
Davó et al.[44]	1	10 days	0	-	NM	-	0	-
Duarte et al.[45]	0	-	0	-	NM [c]	-	0	-
Kahnberg et al.[7]	14	1 patient at 3-years follow-up	10	8: NM 2: 3-years follow-up	3	1 patient: still present after 3 years. 2 patients: spontaneously resolved	5	3 before or at abutment connection, 2 following prosthesis insertion. No persisting fistula at the 3-year follow-up
Peñarrocha et al[46]	2	NM	NM	-	NM	-	NM	-
Davó et al.[47]	1	4 months	1	10 days	NM	-	1	At the surgery
Maló et al.[19,d]	4	1 at 2 months 2 at 6 months 1 at 12 months	NM	-	NM	-	NM	-
Mozzati et al.[48]	0	-	0	-	NM	-	NM	-
Pi Urgell et al.[49]	1	NM	1	18 months post-loading	NM	-	NM	-
Balshi et al.[50]	NM	-	NM	-	NM	-	NM	-
Davó[51]	5	NM	0	-	NM	-	0	-
Landes et al.[52]	3 [a]	Coincident with implant losses	3	Coincident with implant losses	[b]	-	NM [a]	-
Aparicio et al.[21,d]	0	-	0	-	0	-	0	-

Aparicio et al.[20]	0	-	0	-	NM	-	0	-
Bedrossian[8]	3	NM	NM	-	4	All resolved within 7 weeks	NM	-
Bothur and Garsten[22]	EE NM	-	NM	-	NM	-	NM	-
Chow et al.[23,d]	0	-	NM	-	NM	-	NM	-
Stiévenart and Malevez[53]	1	NM	3	NM	1	NM	NM	-
Migliorança et al.[54,d]	0	-	0	-	NM	-	NM	-
Schiroli et al.[55]	0	-	0	-	0	-	0	-
Balshi et al.[56]	NM	-	NM	-	NM	-	NM	-
Bothur et al.[57]	NM	-	NM	-	NM	-	NM	-
Degidi et al.[24]	0	-	0	-	0	-	0	-
De Moraes[58]	0	-	2	NM	NM	-	2	NM
Migliorança et al.[25,d]	0	-	0	-	NM	-	0	-
Sartori et al.[9]	0	-	0	-	0	-	0	-
Davó et al.[10]	1	4 months	1	1 week	NM	-	1	1 week, closed spontaneously after 5 months
Hinze et al.[59]	0 [f]	-	0	-	NM	-	0	-
Landes et al.[60]	1	3 months	0	-	0	-	0	-
Aparicio et al.[26]	6	6: postoperative	1	10-11 years	6	6: postoperative	3	1: 6-7 years 2: 10-11 years
Aparicio et al.[61]	3	1: 1-2 years 2: 3-4 years	5	2: postoperative 2: 1-2 years 1: 2-3 years	1	postoperative	2	2: postoperative
Butura and Galindo[62]	0	-	0	-	0	-	0	-
Fernández et al.[63]	6	NM	NM	-	1	NM	1	NM
Huang et al.[64]	NM [a]	-	NM	-	NM	-	NM [a]	-
Maló et al.[65,d]	5	2: 2 months 1: 6 months 1: 1 year 1: 2 years	0	-	NM	-	1	12 months
Rodríguez-Chessa et al.[66]	4	NM	4	NM	NM	-	0	-
Yates et al.[67]	1	3 months	2	1: 3 months 1: 9 months	NM	-	NM	-

Zou et al.[68]	0	-	0	-	NM	-	0	-
Bertolai et al.[69]	2	2-4 months	0	-	3	All solved within 2 weeks	0	-
Bothur et al.[70]	5	NM	0	-	1	NM	0	-
Davó and Pons[27]	2	1: 24 months 1: 30 months	1	24 months	0	-	1	1 month
De Araújo Nobre et al.[11,d]	0	-	3	1: 2 months 1: 6 months 1: 1 year	0	-	0	-
Fernández Olarte et al.[16]	3	NM	0	-	1	NM	0	-
Jensen et al.[71]	NM	-	NM	-	NM	-	NM	-
Maló et al.[72,d]	26	NM	NM	-	NM	-	1	1 year
Pellegrino et al.[73]	NM [a]	-	NM	-	NM	-	NM [a]	-
Wu et al.[74]	0	-	0	-	NM	-	0	-
Total	**127**	**-**	**67**	**-**	**28**	**-**	**22**	**-**

PO – period of occurrence after the zygomatic implant surgery
NM – not mentioned
[a] Most patients underwent (hemi) maxillectomy due to tumor ablation. Due to that, no separation between maxillary sinus and oral cavity was present when the zygomatic implants were placed
[b] Some patients had nerve impairment (5 in infraorbital and 1 in zygomaticofacial – Landes[36]; 6 in infraorbital and 2 in zygomaticofacial - Landes et al.[52]) due to tumor ablation (they had primary nerve resection when tumor ablation was performed), not due to the implant placement surgery
[c] The authors reported the presence of paresthesia in their cases in the discussion section. However, the number of cases with paresthesia was not reported
[d] The authors used the so-called ‘extramaxillary implants’ or ‘extrasinus zygomatic implants’
[e] The authors only evaluated speech problems. Other complications were not mentioned
[f] Sinus graft in all patients