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REVIEW ARTICLE

Possible surgical complications of the zygomatic implant in oro-facial reconstructive surgery: A systematic review

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ABSTRACT

Dental implants are widely used in oro-facial rehabilitation. They are considered effective and acceptable in the replacement of lost teeth and, with an implant-supported prosthesis, oro-facial soft and hard tissues configuration. A zygomatic implant is a class of dental implant, which is different from the conventional one, mainly, because it is much longer and attached to the zygomatic bone instead of the maxillary bone. This systematic review was aimed at identifying the possible frequent surgical complications of zygomatic implants in oro-facial reconstructive surgery. A review of published literature with no time limitation was conducted in November 2019. An electronic search of PubMed, ISI Web of Science, Cochrane, and Google Scholar databases was conducted to obtain information for this review. A total of 29 prospective and retrospective studies, which contained relevant information, were considered for data extraction and analysis. Based on the information obtained from the included articles, a total of 3613 zygomatic implants were placed in 1679 study participants. This translates to 2.2 implants being placed per single cohort. After an average follow-up period of 3.5 years, the most frequently reported surgical complications were sinus infection (65.5%), soft tissue trauma (8%), mucositis (7%), hematoma (5%), paraesthesia (4%), and non-osteointegration (3%). Peri-implantitis, oroantral communication, fistula, and sinus membrane perforation comprised of 2%, 1.2%, 1.1%, and 1% reported complications respectively. Intracerebral penetration, aspergillosis, rhinosinusitis, otitis, orbital cavity penetration, and persistent pain together comprised 2.2% of all the reported zygomatic implant-related surgical complications. The ZI procedure is associated with various complications which, although rare, may jeopardize the treatment plan. The set of complications identified in this study may underestimate the overall situation. Therefore, the installation of more studies with longer follow-up periods and larger study participants may be necessary to enhance the scientific evidence of the possible surgical complications of this treatment modality.

INTRODUCTION

Dental implants are widely used in oro-facial rehabilitation. The replacement of lost teeth and oro-facial soft and hard tissues configuration with implant-supported prosthesis is an effective and acceptable treatment modality. Zygomatic implants (ZI) are among classes of dental implants which are different from the conventional implants mainly in that they are much longer and attached to the zygomatic bone rather than the maxillary bone (Davo et al., 2010).

In the 1990s, zygomatic implants were designed by the Swedish scientist Per-Ingvar Brånemark to allow for implant-supported prosthesis placement where maxillary bony support for prosthetic rehabilitation is inadequate (Chrcanovic et al., 2017; Chow et al., 2010). The cheekbone was used as an anchorage point for the zygomatic implant. In the year 2003-2004, documentation and data began to be published revealing the success rates of zygomatic implants.

The success rates (SR) were found to be as good as with conventional implants.

The technique of zygomatic implants has been developed over the last quarter-century, and, as such, those implants are not a point of debate. They do not rely on the alveolar jaw bone anchorage, as do conventional implants, but rely solely on the zygoma anchorage. Those implants are much longer (3.5 to 5 cm) than the regular dental implants (0.7 to 1.5 cm) (Annibali et al., 2012).

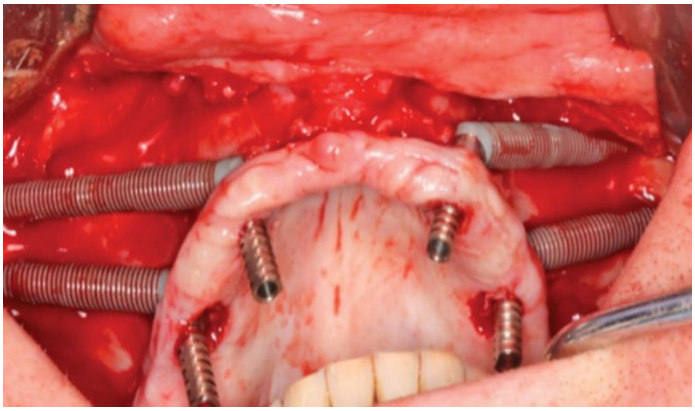
Rehabilitation of oro-facial function with dental implants can be achieved with predictable success in various clinical situations, and acceptable long-term results have been reported in patients with sufficient bone volume. However, the presence of inadequate bone quantity poses a problem for implant placement (Bertolai et al., 2015). The treatment of major maxillary atrophy with a zygomatic implant is challenging because difficult bone grafting techniques or micro vascularized flaps with long healing time and severe discomfort for the patients may require to enable placement of a sufficient number and length of implants (Pellicer-Chover et al., 2016). Advanced posterior alveolar resorption combined with increased maxillary sinus pneumatization often leaves insufficient bone for implant anchorage (Yates et al., 2014). Conditions such as cleft deformities and post-surgery maxillary defects, which present a discontinuity in the musculoskeletal facial complex are more challenging. Various techniques have been described to treat the atrophic maxilla, including the use of angled implants in the parasinus region, extensive bone grafting surgical procedures like iliac bone harvesting, implants in pterygoid apophysis, maxillary sinus floor elevation with bone substitute or graft, short and wide implants, and zygomatic implants (Bertolai et al., 2015). The use of zygomatic implant after ablative tumor surgery with resection of the maxillary bone, gangrenous facial condition like cancrum oris, trauma, congenital defects, unsuccessful autogenous bone grafts, gunshot wounds, and in patients who refuse autogenous bone grafting is alternative in providing thick zygomatic bone that plays a key role in the reconstruction of the midface and oral rehabilitations deficits (Fernández et al., 2014).

ZIs can still be considered a relevant alternative to short implants and implants of conventional length placed following sinus floor elevation. The zygomatic implant placement procedure does not require any adjunctive procedures. Furthermore, the ability to immediately use existing dentures and the lack of need for bone grafting and prolonged hospitalization makes this treatment modality more acceptable to the patient. Extraoral bone harvesting necessitates increased hospital admission, more money cost, donor site morbidity, different complications, and functional limitations. Depending on the anatomical situation and the kind of rehabilitation needed ZIs can be used unilaterally or bilaterally with one or two zygomatic implants in each side of the zygomatic buttresses. The use of short implants and/or wide-diameter implants might be also considered but the failure rate is reported to be high. Different designs and sizes of zygomatic implants have developed since the introduction of the technique. The implant length is ranging in length from 30 mm to 52.5 mm. The surgical procedure is carried out under general anesthesia or intravenous sedation as described elsewhere (Annibali et al., 2012). Briefly, following the bilateral elevation of the buccal mucoperiosteal tissue, removal of the lateral sinus bony window posteriorly, and reflection of the antral mucosal lining, two zygomatic implants are inserted engaging the dense bone of the body of the zygomatic arch, emerging intraorally in the upper premolar region just palatal to the alveolar crest. Each implant is introduced into the second premolar area, traversing the maxillary sinus, and is placed into the body of the zygomatic bone (Romeed et al., 2014).

Surgical placement of a minimum of four dental implants in the canine and the central incisor maxillary area allows for the fabrication of a fixed hybrid prosthesis. Alternatively, the placement of two zygomatic implants and at least two standard dental implants at the pyriform buttresses allows the construction of a bar to support a maxillary overdenture without the need for any bone grafting. In case more root form dental implants can be placed in the pre-maxilla, a fixed prosthesis could be fabricated (Mozzati et al., 2015). See **Figures 1 and 2**.

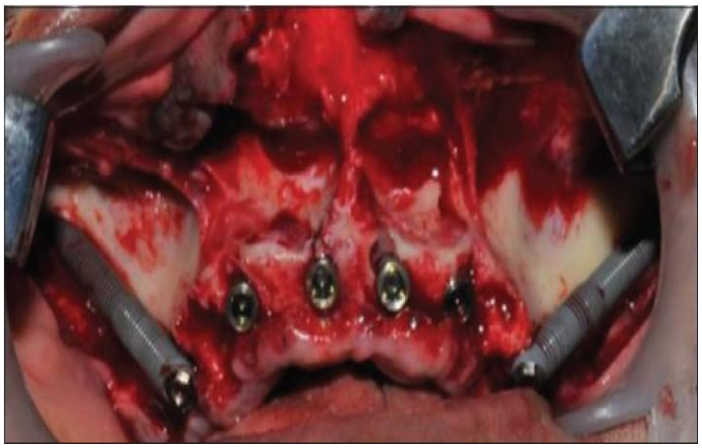
Since the classical description of surgical placement of ZIs in 1998 by Brånemark, some authors have made improvements and modifications to the original technique. (Brånemark et al., 2009). This systematic review aimed to identify the possible frequent surgical complications of zygomatic implants in oro-facial reconstructive surgery.

Figure 1 :
Quad zygomatic implant clinical



(Kuabara et al., 2010)

Figure 2:
Single bilateral maxillary implant clinical



(Aparicio et al., 2010)

Surgical Procedures

There are various types of surgical approaches applicable in practice for the placement of zygomatic implants to treat patients depending on the clinical situations. Patient's bony and soft tissue anatomy, the health status of the neighboring organs, and the technical skill of the surgeon are the main determinant factors in the selection of the surgical technique (Corvello et al., 2011; Dawood et al., 2015; González-García et al., 2016; Gasparini et al., 2017).

When the maxilla is severely resorbed, the concavity formed by the ridge crest is small, and the original classical technique should be used. When maxillary resorption generates a large concavity, it would be better to exteriorize the zygomatic implant. The externalized technique has fewer surgical steps than the classical and sinus slot methods, is less invasive, and reduces surgical time. It is recommended that utilization of the sinus slot technique together with the CT-based drilling guide would enhance the final results (Esposito et al., 2017). Although the technique that uses the computer-aided surgical navigation system approach may improve precision in the clinical procedure, its use is expensive, prolongs the operation time, and is limited to centers that have the necessary equipment for the surgery (Chrcanovic et al., 2017).

MATERIALS AND METHODS

A systematic review of published literature with no time limitation was conducted to identify the potential surgical complications of the zygomatic implant. This review analyses the data extracted from the reviewed literature and depicts the possible surgical complications of the zygomatic implant.

Search Strategy

An electronic initial search was undertaken on 11 November 2019 on PubMed (U.S. National Library of Medicine, National Institute of Health), ISI Web of Science (Institute for Scientific Information), Cochrane, and Google Scholar databases. The keywords zygoma, zygomatic, and zygomaticus were used as Subjects. The survival rate, success rate, failure rate, complications, and combination of these terms were used as adjectives. For searching the PubMed database, the terms were used as Medical Subject Headings (MeSH). This work adhered to the PRISMA guidelines (``PRISMA`` 2009) and all included articles were assessed based upon CASP analysis criteria. The methodological quality of randomized control trials (RCT) was assessed by using the JADAD scale.

Organization and Screening of The Literature

The bibliographic software EndNote (Thomson Reuters Corp., New York City, NY, United States of America) was used to manage all retrieved references. The organization and screening of the literature began with an initial electronic search from PubMed, ISI Web of Science, Cochrane, and Google Scholar databases to obtain the first raw hits. From the initial raw hits, some literature was excluded as duplicates by Endnote and manual duplicate search strategies. A selection of articles took place based on the title and/or abstract from the hits without duplicates. The identified papers further underwent a full-text review. The full texts were accessed through EndNote full-text search, URL search, google search, and Universities library sources. After in-depth reading of the entire full texts available the relevant articles were distinguished **(Figure 3)**.

Figure 3:
Organization and screening of literature

Extraction of data

The findings and characteristics of the articles that were finally included in the systematic review were extracted and recorded in the data extraction template, compiled, and analyzed. The information garnered included the total number of zygomatic implants placed, the total number of failed implants, and the potential surgical complications. The data extraction form provided for the following pertinent information: author's first name, name of the journal, year of publication, volume/issue/pages, follow up period, sample size, study design, the total number of zygomatic implants placed, the total number of failed implants, and potential surgical complications.

CASP analysis

Evidence-based practice and research are the cornerstones of effective health care and honest scientific pursuits. The ability to critically evaluate and assess the quality of different potentially relevant research articles in a systematic review is crucial. Accordingly, all articles included in this review went through rigorous quality and usefulness assessment.

For the different types of study designs identified in this study, consistent and corresponding CASP (critical appraisal skills program) analysis assessment tools have been implemented. Articles that were adjudged as having passed the appraisal exercise were considered for data extraction and analysis **(Figure 4)**.

Figure 4:
Articles included in the review and CASP analysis

Name of author/s	Year of publication	Type of Study design	Clear aims stated? (Yes or No)	Was the methodology appropriate? (Yes or No)	Were the data collection and analysis appropriate? (Yes or No)	Was the validity rigorous? (Yes or No)	Overall, level of evidences? (High or Low)
Ahlgren F. et al.	2006	Prospective	✓	✓	✓	✓	IM
Aparicio et al.	2006	Prospective	✓	✓	✓	✓	↑
Aparicio C. & Arocio D. C.	2012	Prospective	✓	✓	✓	✓	↑
Araiso R. T. E et al.	2017	Retrospective	✓	✓	✓	✓	IM
Bechtor J. P., et al.	2005	Retrospective	✓	✓	✓	✓	IM
Bedrossian E.	2010	Prospective	✓	✓	✓	✓	↑
Bertolai R., et al.	2015	Prospective	✓	✓	✓	✓	↑
Bothur S., et al.	2015	Prospective	✓	✓	✓	✓	↑
Brånemark, P. I., et al.	2004	Prospective	✓	✓	✓	✓	↑
D'Agostino A., et al.	2016	Retrospective	✓	✓	✓	✓	IM
Davó R., et al.	2008	Retrospective	✓	✓	✓	✓	IM
DavóR.	2009	Prospective	✓	✓	✓	✓	↑
Davo R., et al.	2010	Prospective	✓	✓	✓	✓	↑
Esposito, M., et al.	2017	Prospective	✓	✓	✓	✓	↑
Fernández, H., et al.	2014	Retrospective	✓	✓	✓	✓	IM
Garcia Garcia B., et al.	2016	Prospective	✓	✓	✓	✓	↑
Gasparini G., et al.	2017	Retrospective	✓	✓	✓	✓	IM
Landes C. A., et al	2009	Retrospective	✓	✓	✓	✓	IM
Malo P., et al.	2014	Retrospective	✓	✓	✓	✓	IM
Malo P., et al.	2015	Retrospective	✓	✓	✓	✓	IM
Peñarrocha M., et al.	2005	Prospective	✓	✓	✓	✓	IM
Pi Urgell J., et al	2008	Retrospective	✓	✓	✓	✓	IM
Rojas C., et al	2014	Prospective	✓	✓	✓	✓	↑
Reychler H. & R. Olszewski	2010	Prospective	✓	✓	✓	✓	↑
Rodriguez-Chessa J. G., et al	2014	Retrospective	✓	✓	✓	✓	IM
Sato, F. R. L., et al.	2010	Prospective	✓	✓	✓	✓	↑
Tzenov F., et al.	2016	Prospective	✓	✓	✓	✓	↑
Yates J. M., et al.	2014	Retrospective	✓	✓	✓	✓	IM
Zwahlen R. A., et al.	2006	Prospective	✓	✓	✓	✓	IM

Data Analysis

The surgical complications reported in both prospective and retrospective studies were extracted and compiled. The retrieved surgical complications data was organized using the kind of oro-facial tissues involved. Each complication reported in the literature was calculated in comparison with other complications identified in the study. The analysis aimed to understand the common kinds of surgical complications related to zygomatic implant placement and thereby priorate the preventive measures.

Ethical Clearance

No ethical clearance was needed for this study.

RESULT

The main objective of this study was to identify possible surgical complications of the zygomatic implant in oro-facial reconstructive surgery. The results have been organized around this objective.

Databases Search Result

The initial search from all the databases yielded a total of 898 studies. A total of 372 papers were found to be duplicated and excluded by EndNote duplicate search (349) and manual duplicate search (23) strategies. The remaining 526 articles underwent selection based on the title and/or abstract. Out of the total, 120 articles were considered potentially relevant based on their title and/or abstract. The full text of all these 120 articles was accessed through a university library portal (57), EndNote (36), and Google (27) search approaches.

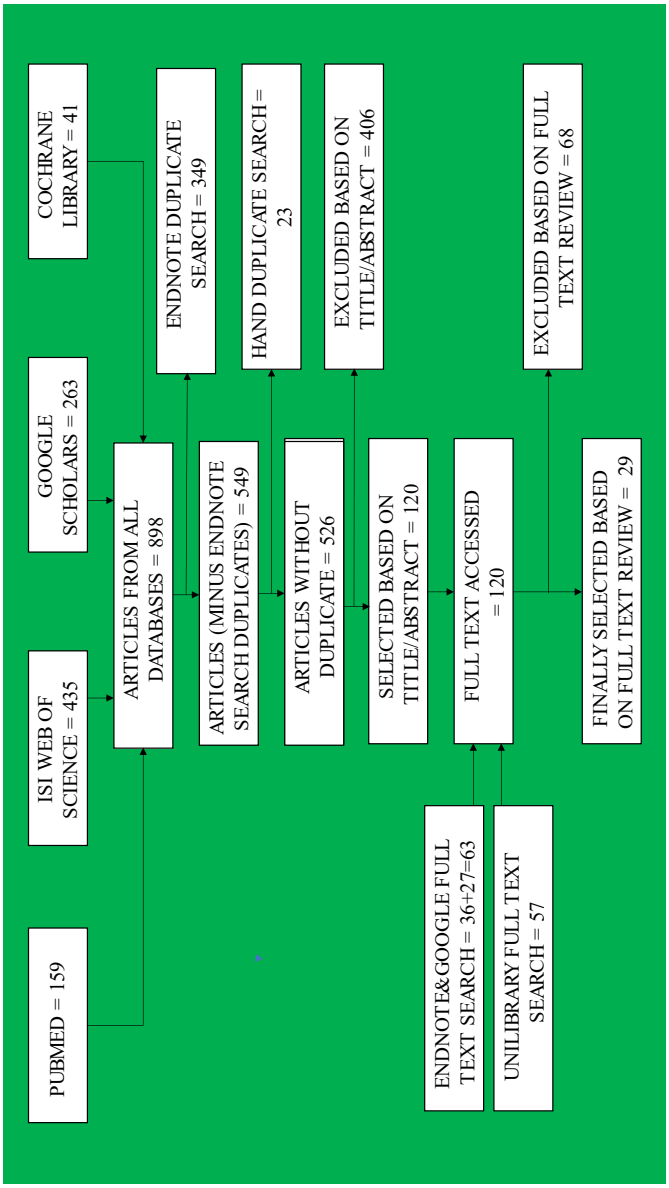
After an in-depth review of the retrieved full texts, 29 pieces of literature fulfilling the inclusion criteria were finally selected for data extraction **(Figure 5)**.

Finding Related to CASP Analysis

A total of 29 articles in this review underwent CASP analysis, which consisted of a series of questions to assess the internal validity, clinical relevance, and external validity of each study identified.

All the 29 articles, which were assessed via CASP analysis tools, showed clear aims and objectives. Appropriate research designs and methodologies were chosen. Study participants' selections, data collection instruments, and data analysis methods were also acceptable. The internal and external validities of the articles were found to be satisfactory.

Figure 5:
Flow diagram



Overall Surgical Complications Identified

Among the reported surgical complications, sinus infection constituted the major complication with 65.5% followed by soft tissue trauma, mucositis, hematoma, and paraesthesia (8%, 7%, 5%, and 4% respectively). Non-osteointegration was reported to constitute 3% of all complications reported. Peri-implantitis, oroantral communication, fistula, and sinus membrane perforation comprised of 2%, 1.2%, 1.1%, and 1% reported complications respectively.

Intracerebral penetration, aspergillosis, rhinosinusitis, otitis, orbital cavity penetration, and persistent pain together comprised 2.2% of all the reported zygomatic implant-related surgical complications. However, these reported

post-surgical issues might be underestimated, because many authors might have undermined and failed to mention these complications.

DISCUSSION

Dental implants have shown great success in recent years. However, in certain circumstances, patients can suffer from complications, which usually result from a combination of infection and the host's inflammatory responses or a lack of it. Complications were observed in 65.3% (2360) of the 3613 zygomatic implants reviewed in this study. The main complication of zygomatic implants is reported to be sinusitis in many follow-up studies which may develop even several years after the implant placement. The reported incidence of sinusitis after zygomatic implant placement ranges from 0% to 26.6%. Other complications include oroantral fistula formation, orbital penetration and injury, temporary sensory nerve deficits, and vestibular cortical fenestration. Post-operatively, periorbital and subconjunctival hematoma or edema, subcutaneous malar emphysema, moderate nasal bleeding for 1–3 days, intraoral soft tissue problems (gingival inflammation, wound dehiscence) and implant failure may occur.

In patients with pronounced buccal concavities on the lateral aspect of the maxillary sinus, the use of the original technique with an intra-sinus path results in excessive palatal emergence of the implant head leading to a bulky dental bridge at the palatal aspect, which causes discomfort and problems with oral hygiene and speech (Annibali et al., 2012). The complications reported in this review are presented below:

Sinusitis

The zygomatic implant placement may result in a foreign body reaction, in the form of inflammation of the sinus membrane, may be triggered by a treated implant surface against a finished one, an oroantral communication produced by perforation of the Schneiderian membrane, and a lack of osseointegration of the coronal part of the implant. In the majority of the revised studies, sinusitis is the most frequently observed complication, with an average prevalence of 39 zygomatic implants out of every 100 placed. Other authors also consider this as the most relevant complication, with 19.4% cases (Becktor et al., 2005) and with 5.2% (Chrcanovic et al., 2017). This review has revealed a very high proportion (65.5%) of sinus infections. Great discrepancies in the results obtained by Becktor et al. may be due to, according to the author, difficulty in maintaining optimum hygiene at the posterior palatal emergency; transversal mobility produced by functional forces when there is a lack of osseointegration and bone-implant contact at a marginal level; and the internal design of the implant, which may produce an oroantral communication. However, the extra sinus technique permits a more favorable emergence of the implant and facilitates adequate hygiene maintenance of the area. As for the design of the implant, some authors mention that in later studies, reported rates on this complication are not as high, therefore, more conclusive studies in this area are needed. Another relevant fact that must be considered is the presence of sinusitis before the surgery (Chrcanovic et al., 2017, Becktor et al., 2005).

Mucositis And Peri-Implantitis

Mucositis is directly related to the appearance of sinusitis, favored by the lack of osseointegration, lack of contact between the implant and the bone crest, superficial infection, and lack of cicatrization of the soft tissues. Because peri-implant tissues have a lower capacity to react to the accumulation of oral biofilm compared to periodontal tissues, the peri-implant disease is highly prevalent among implant patients. Peri-implant mucositis is the first stage of peri-implantitis. Unlike the result obtained by Chrcanovic et al. (2017) which revealed a prevalence result of 3.6%, among the reported complications in this study mucositis and peri-implantitis, constituted 9%, and are found to be the second most common kinds of complications (Chrcanovic et al., 2017).

Soft Tissue Trauma

Soft tissue injuries such as bruising and labial laceration are the third most reported complications in this study (8%). The incidence is probably higher, since many authors do not mention this as a complication, possibly due to its less alarming clinical manifestations, being self-limited, and associated with the postoperative period. Lastly, it would not be a complication exclusively linked to rehabilitation with zygomatic implants (Tzerbos et al., 2016).

Hematoma

Though blood effusions infiltrating surface tissues (ecchymoses) and circumscribed blood collections (hematomas) are not common after implant surgery, long and complex procedures, lack of patient compliance with the instructions received for the immediate postoperative

period (application of ice packs, compression, and tamponade, and cold liquid diet), vessel fragility, especially typical in elderly patients, and failure to discontinue antiplatelet therapy before surgery may favor the appearance of ecchymoses and hematomas (Annibali et al., 2012). In this study, 5% of the complications were found to be hematoma and is ranked the fourth more often reported kind of complication.

Paraesthesia

In a systematic review conducted by Chrcanovic et al. (2017), 15 cases of paresthesia from the affection of infraorbital and zygomaticofacial nerves were reported, however, in the majority of reviewed cases, paresthesia remits between 3 and 8 weeks post-intervention. Paresthesia constituted 4% of all the complications reported in this review. For Bedrossian (2010) and Aparicio et al. (2006), paresthesia is considered the most frequent complication, with a prevalence of 5.4% and 4.6%, respectively. The incidence can vary, being a complication closely linked to the surgeon's expertise and the discipline of the surgical team (Bedrossian, 2010; Chrcanovic et al., 2017).

Non-Osseointegration

Lack of osseointegration is diagnosed at phase II surgery or restoration when the implant is loaded (Filho et al., 2016). It is one of the worst complications since it inevitably results in the loss of the implant. The main causes of lack of osseointegration include reduced healing capacity, incorrectly indicated immediate occlusal loading during osseointegration, failure to follow the planned protocol, insufficient bone quantity or quality, lack of primary stability, technical errors during surgery, and especially bone overheating during implant site preparation. Non-osseointegration comprised 3% of all complications reported in this systematic review. Authors such as Becktor et al. (2005) with 9.7% and Chrcanovic et al. (2017) with 4.2% and Migliorança et al. (2012) with 2.5% can be mentioned. Below the aforementioned average, other authors can be noted, such as Duarte et al. (2007) with 2.08%, Aparicio et al. (2006) with 1.5%, and Migliorança et al. with 2.5% (Zwahlen et al., 2006; Miglioranca et al., 2012; Chrcanovic et al., 2017).

Fistula

The frequency of this complication in different pieces of literature varies between 1.5 and 7.5% except in the case of Becktor et al. (2005) who reached 29%. The present study found a frequency of 1.1%, very similar to the one obtained by Davó et al. (2008), who obtained a result of 1% (Davó et al., 2008; Becktor et al., 2005).

Sinus Membrane Perforation and Oroantral Communication

Oroantral communication (OAC) is an abnormal communication between the maxillary sinus and the oral cavity. It may be the result of different pathological processes and trauma. The most common complications of oral surgical procedures that subsequently involve the maxillary sinus perforation include displacement of teeth, roots, dental implants, or instrument fragments into the sinus and unintentional trauma creates communication between the oral cavity and the sinus during surgery of posterior maxilla (Bothur et al., 2015). This review reported 1% Sinus membrane perforation and 1.2% oroantral communication.

Other complications

Several other uncommon surgical complications have been reported (Bothur et al., 2015). Similarly, intracerebral penetration, aspergillosis, rhinosinusitis, otitis, orbital cavity penetration, and persistent pain together comprised 2.2% of all the reported zygomatic implant-related surgical complications in this review.

CONCLUSION

The use of the zygomatic implant in the reconstruction of oro-facial defects has been considered a viable alternative to bone grafting. Rehabilitation using zygomatic implants is a consolidated and predictable therapeutic option. However, the many complications of zygomatic implants, with sinusitis being the most common, should reserve the procedure for clinicians with vast surgical experience and knowledge of the anatomical complexity of the region. Yet, the installation of more studies with longer follow-up periods and larger study participants may be necessary to enhance the scientific evidence of the possible surgical complications of this treatment modality.

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Conflict of Interest: The author declares no conflict of interest.

ORCID iDs: Nil identified

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