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The success rate of zygomatic implant in oro-facial reconstructive surgery: A systematic review

Gebretsadik, H. G.

School of Global Health & Bioethics, Euclid University (Pôle Universitaire Euclide)

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Correspondence to:
Dr. Heron Gezahegn Gebretsadik
gezahegn.heron@gmail.com

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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 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 describing the success rate of the zygomatic implant 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 52 prospective and retrospective studies that contained relevant information were selected 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, 2.4% of the implants were reported to have failed. Consequently, the success rate of the zygomatic implant was 97.6%. This review has indicated that the zygomatic implant technique is predictable with a high success rate and satisfactory clinical outcomes. Despite the high success rate indicated in this study, conducting randomized controlled/clinical trials to test the efficacy of this implant in comparison with the other technique to treat similar deficits in the oro-facial region (bone grafting) is crucial. Thus, the findings reported in this review must be interpreted with considerable caution. Moreover, more studies with longer follow-up periods involving an adequate number of zygomatic implants placement are imperative. These will help to procure a better understanding of the success rate of zygomatic implants.

INTRODUCTION

Today 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).

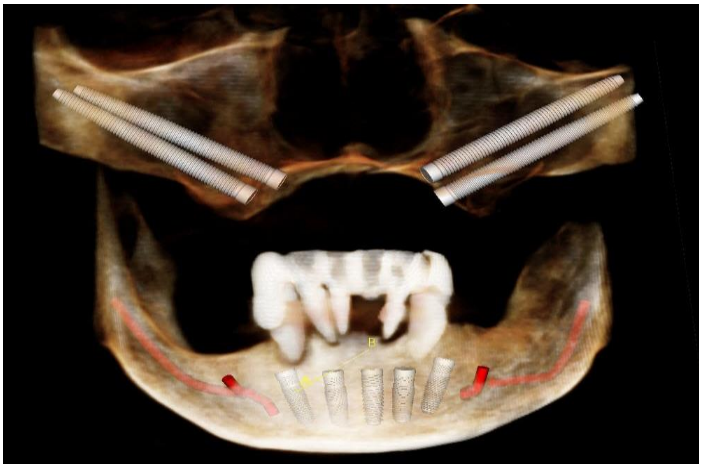
Rehabilitation of oro-facial function with dental implants can be achieved with predictable success in various clinical situations, and acceptable long-term results have been reported in patients with sufficient bone volume. However, the presence of inadequate bone quantity poses a problem for implant 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 **Figure 1 and 2**.

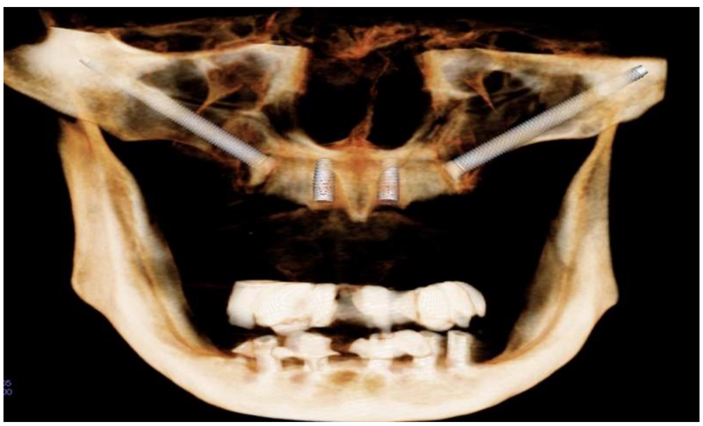
Since the classical description of surgical placement of ZIs in 1998 by Brånemark, some authors have made improvements and modifications to the original technique. The premier aim of this systematic review is to analyze and describe the success rate of zygomatic implants in Oro-facial reconstructive surgery.

Figure 1:
Quad zygomatic implant radiography



(Kuabara et al., 2010)

Figure 2:
Single bilateral maxillary implant radiography



(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 describe the success/survival rate of the zygomatic implant. This review analyses the data extracted from the reviewed literature and depicts the success/survival rate of zygomatic implants, which is what the researcher wanted to ascertain in this study.

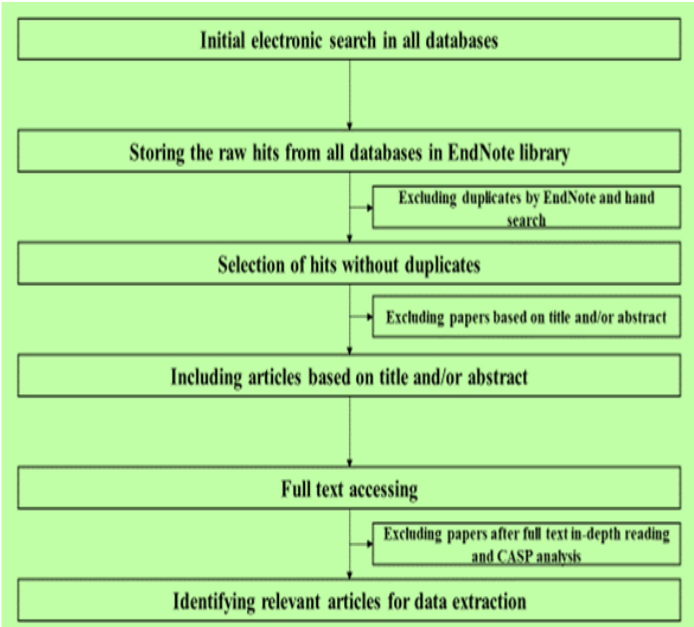
Search Strategy

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, 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 relevant information about the findings and characteristics of the articles finally included in the systematic review were extracted. All the key information retrieved from the papers was recorded in the data extraction template. This relevant information was compiled and later used as an input to the data analysis. The total number of zygomatic implants placed, the total number of failed implants, and the total number of successfully placed implants were critical to calculating the overall success rate.

In general, the data extraction form consisted of the following pertinent information: author 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 the total number of successfully placed implants.

CASP analysis

Evidence-based practice and research are the cornerstones of effective health care and 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 analysis (**Figure 4 [I – iii]**).

Figure 4 [i]:
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 et al.	2008	Prospective	✓	✓	✓	✓	↑
Aparicio et al.	2010	Prospective	✓	✓	✓	✓	↑
Aparicio C. & Aparacio D. C.	2012	Prospective	✓	✓	✓	✓	↑
Aparicio et al.	2014	Prospective	✓	✓	✓	✓	↑
Araujo, R. T. E et al.	2017	Retrospective	✓	✓	✓	✓	IM
Balshi, T. J & G. J. Wolfinger	2002	Prospective	✓	✓	✓	✓	↑
Balshi S F et al.	2009	Prospective	✓	✓	✓	✓	↑
Balshi, T. J., et al.	2012	Prospective	✓	✓	✓	✓	↑
Becktor, 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	✓	✓	✓	✓	↑
Butura C. C. & D. F. Galindo	2014	Prospective	✓	✓	✓	✓	↑
Chow J., et al.	2010	Prospective	✓	✓	✓	✓	↑
D'Agostino A., et al.	2016	Retrospective	✓	✓	✓	✓	IM
Davo R., et al.	2007	Prospective	✓	✓	✓	✓	↑
Davó R., et al.	2008	Retrospective	✓	✓	✓	✓	IM
DavóR.	2009	Prospective	✓	✓	✓	✓	↑
Davo R., et al.	2010	Prospective	✓	✓	✓	✓	↑
Politis C., et al.	2012	Retrospective	✓	✓	✓	✓	IM

Duarte, L. R., et al.	2007	Retrospective	✓	✓	✓	✓	IM
Esposito, M., et al.	2017	Prospective	✓	✓	✓	✓	↑
Fernández, H., et al.	2014	Retrospective	✓	✓	✓	✓	IM
Fortin Y.	2017	Retrospective	✓	✓	✓	✓	IM
Garcia Garcia B., et al.	2016	Prospective	✓	✓	✓	✓	↑
Gasparini G., et al.	2017	Retrospective	✓	✓	✓	✓	IM
González-García R., et al.	2016	Retrospective	✓	✓	✓	✓	IM
Hinze et al.	2011	Retrospective	✓	✓	✓	✓	IM
Kuabara, M. R., et al.	2010	Prospective	✓	✓	✓	✓	IM
Landes C. A., et al	2009	Retrospective	✓	✓	✓	✓	IM
Lombardo, G., et al.	2016	Retrospective	✓	✓	✓	✓	IM
Malevez C., et al.	2004	Retrospective	✓	✓	✓	✓	IM
Maló P., et al.	2014	Retrospective	✓	✓	✓	✓	IM
Maló P., et al.	2015	Retrospective	✓	✓	✓	✓	IM
Migliorança R. M., et al.	2012	Prospective	✓	✓	✓	✓	↑
Mozzati M., et al.	2015	Prospective	✓	✓	✓	✓	↑
Peñarrocha M., et al.	2005	Prospective	✓	✓	✓	✓	IM

Figure 4 [iii]:
Articles included for review and CASP analysis

Pi Urgell J., et al	2008	Retrospective	✓	✓	✓	✓	IM
Rajan G., et al	2014	Prospective	✓	✓	✓	✓	↑
Reychler H. & R. Olszewski	2010	Prospective	✓	✓	✓	✓	↑
Rodriguez-Chessa J. G., et al	2014	Retrospective	✓	✓	✓	✓	IM
Ruben M., et al.	2017	Prospective	✓	✓	✓	✓	↑
Salvatori P., et al.	2017	Prospective	✓	✓	✓	✓	↑
Sato, F. R. L., et al.	2010	Prospective	✓	✓	✓	✓	↑
Tzerbos F., et al.	2016	Prospective	✓	✓	✓	✓	↑
Ugurlu F., et al.	2013	Prospective	✓	✓	✓	✓	↑
Wang F., et al.	2017	Retrospective	✓	✓	✓	✓	IM
Yates J. M., et al.	2014	Retrospective	✓	✓	✓	✓	IM
Zwahlen R. A., et al.	2006	Prospective	✓	✓	✓	✓	IM

Data Analysis

The success rate reports in each article included in the data analysis were compiled. The success rate reports were based on clinical and radiographic criteria. The absence of clinically detectable mobility, recurrent per-implant infection, and ongoing radiolucency around the implants after 3, 6, and 12 months of loading were the key criteria to claim success or failure rates. Furthermore, the absence of pain and sensational discomfort were also considered. Accordingly, the success rate of zygomatic implants was calculated using simple algebra as follows:

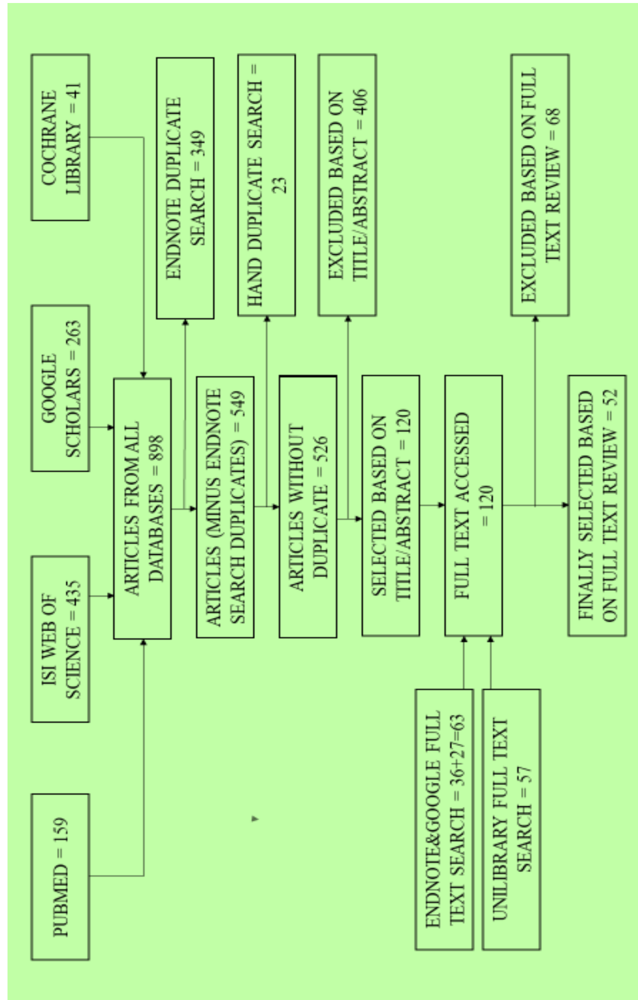
The success rate of zygomatic implant =

$$\frac{\text{Total number of successfully placed zygomatic implants}}{\text{The total number of zygomatic implants placed}} * 100\%$$

Ethical Clearance

No ethical clearance was needed for this study.

Figure 5:
Flow diagram



RESULT

Calculating the success rate of the zygomatic implant in Oro-facial reconstructive surgery was the main objective of this systematic review. Therefore, the findings of the study have been organized around the prime objective of the study.

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, 52 pieces of literature fulfilling the inclusion criteria were finally selected for data extraction.

Finding Related to CASP Analysis

A total of 52 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. Out of the total 52 articles which met the inclusion criteria in this review, 32 articles were prospective studies. The remaining 20 studies were conducted retrospectively.

All the 52 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 commendable.

Success/Survival Rate of Zygomatic Implants

A total of 1539 zygomatic implants were placed in all prospective studies. After an average follow-up period of 4.2 years, 2.5% (39) implants failed. Therefore, the survival rate of the zygomatic implant in the prospective studies was calculated to be 97.5%. On the other hand, 2074 zygomatic implants were placed in all retrospective studies. After an average follow-up period of 4.4 years, 2.3% (47) implants failed. Hence, the survival rate of the zygomatic implant in the retrospective studies was calculated to be 97.7%. Generally, the overall success rate of zygomatic implants was calculated to be 97.6% (3527) in this systematic review.

DISCUSSION

The success rate of zygomatic implants obtained by different authors varied between 82% and 100%. From the systematic review of 25 studies with a mean follow-up of 42.2 months (range 0–144 months) and a total of 1541 zygomatic implants, Goiato et al. (2014) found a survival rate of 97.86% after 36 months. This value remained constant up to the last follow-up period. Chrcanovic et al. (2017) reviewed 42 studies including 1,145 patients and 2402 zygomatic implants. A total of 56 zygomatic implants were reported as failures and the cumulative success rate (CSR) over 12 years was 96.7% (Sharma and Rahul, 2012).

Contemporary literature has revealed that the zygomatic implant technique is predictable with satisfactory clinical outcomes. Compared with major bone grafting, it is still a less invasive technique and can be used in cases where bone grafts cannot be harvested for some reason. Nevertheless, the procedure is associated with serious complications which, although rare, may jeopardize the treatment plan (Tzerbos et al., 2016).

Limited intraoperative visibility, the complexity of anatomical structures, and intricacies of the zygomatic curve made this procedure a clinically demanding task, hence, patients have to be informed of possible complications (Corvello et al., 2011; Vashisht et al., 2014). In this review, the overall success rate of the zygomatic implant was found to be 97.6% in 1679 patients operated to receive an average of 2.2 implants per participant for 4.3 average follow-up years each, which means 86 implants were reported to have failed out of the total 3613 implants placed. The survival rate of zygomatic implants was calculated in two ways based on the types of research designs conducted. The articles which were included in this systematic review were either prospective or retrospective in nature. The survival rate was calculated to be 97.5% in the prospective studies, that is out of 1539 zygomatic implants placed, 1500 implants were found to be successful in an average follow-up period of 4.2 years. Meanwhile, out of the 2074 zygomatic implants placed in the retrospective studies 97.7% (n=2027) implants were successful for an average follow-up period of 4.4 years. Therefore, the success rate of the zygomatic implant in the retrospective studies was found to be comparably more for a longer follow-up time. In general, the overall success rate of zygomatic implants was calculated to be 97.6% (3527) in this systematic review.

A study conducted to assess the long-term use of zygomatic implants has shown a similar survival rate of 97.7% for 10 years of the follow-up period. The researcher has presented the advantage of placing a zygomatic implant over the only treatment option (bone grafting) available before the introduction of zygomatic implants for the rehabilitation of patients with atrophic maxilla. The researcher has suggested that zygomatic implant surgical technique is less invasive and more predictable than bone grafting procedures (Aparicio et al., 2014b). Another study which has been carried out to assess the zygomatic implant survival rate also released a nearly similar figure of 97.4% survival rate of the zygomatic implant after 5 years follow up-period (Davó, 2009a). Consequently, the overall survival rates of zygomatic implants calculated in this review have complemented Aparicio et al.'s and other similar studies as discussed above irrespective of follow-up period variations. Hence, the findings of this review have revealed that zygomatic implant is the best treatment option in the reconstruction of patients with extensive bone resorption in the maxillary region.

CONCLUSION

The use of the zygomatic implant in the reconstruction of oro-facial defects has been considered as a viable alternative to bone grafting. Rehabilitation using zygomatic implants is a consolidated and predictable therapeutic option. The findings of this study have shown that different surgical techniques allow the installation of the zygomatic implant with high predictability, having achieved a high success/survival rate. Yet, the initiation of more studies with longer follow-ups and larger study participants is necessary to enhance the scientific evidence of the success rate of this treatment modality.

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Ethical Approval: No ethical approval was required.

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

ORCID iDs: Nil identified

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