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Major approaches and clinical optimizations of zygomatic implants through guided surgery: a systematic review

Anna Júlia Martos Kfouri[1*], Ryan Banhato Gonzales Leandro[1], Caio Vinicius Banhato Leandro[1], Andreia Borges Scriboni[1]

[1] UNORTE - University Center of Northern São Paulo, Dentistry Department, São José do Rio Preto, São Paulo, Brazil.

*Corresponding author: Anna Júlia Martos Kfouri.
UNORTE - University Center of Northern São Paulo,
Dentistry department, São José do Rio Preto,
São Paulo, Brazil.
E-mail: annajuliakfouri@hotmail.com
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Abstract

Introduction: In the dental implant scenario, the graft to treat severely reabsorbed jaws is currently the gold standard procedure, but there are flaws in this procedure from 10.0 to 30.0 % are reported in the literature. Zygomatic implants have shown, in many cases, improved clinical outcomes compared to bone graft and represent an essential alternative for compromised maxillary bone. **Objective:** It analyzed the main approaches and clinical optimizations of zygomatic implants through guided surgery. **Methods:** The PRISMA Platform systematic review rules were followed. The search was carried out from November 2024 to January 2025 in the Scopus, PubMed, Science Direct, Scielo, and Google Scholar databases. The quality of the studies was based on the GRADE instrument and the risk of bias was analyzed according to the Cochrane instrument. **Results and Conclusion:** A total of 195 articles were found, and 48 articles were evaluated in full and 36 were included and developed in the present systematic review study. Considering the Cochrane tool for risk of bias, the overall assessment resulted in 22 studies with a high risk of bias and 25 studies that did not meet GRADE and AMSTAR-2. According to the GRADE instrument, most studies presented homogeneity in their results, with X^2=91.7%>50%. It was concluded the zygomatic implant is revolutionizing the procedure of implants in the posterior atrophic maxilla, eliminating the complications of bone augmentation and sinus elevation, with delayed scarring. Zygomatic implants have in many cases shown better clinical results compared to bone grafts and represent a possible gold standard for dental implants. Robotic placement of zygomatic implants has the potential to produce excellent results.

Keywords: Zygomatic Implant. Dental Implant. Reabsorbed jaws. Guided surgery. Robotic placement.

Introduction

In the dental implant scenario, the graft to treat severely reabsorbed jaws is currently the standard gold procedure, but there are flaws in this procedure from 10.0 to 30.0 % are reported in the literature [1]. Zygomatic implants (ZI) have shown, in many cases, improved clinical outcomes compared to bone grafts and represent an essential alternative for compromised maxillary bone [1,2].

In that sense, dental implants are one of the options for dental replacement. The primary predictor of implant success depends on the quality and quantity of bone available [2]. In certain situations where conventional implant placement is not possible without advanced surgical procedures, ZI can be used as a preferable treatment option for wholly and partially edentulous maxillae with insufficient bone volume [2-5].

In this context, the evidence is not entirely accurate in determining the best treatment for prosthetic rehabilitation of implants in partially edentulous patients with bone atrophy. Regarding vertical defects, if small implants can be used, they should be used because the number of complications is reduced compared to longer implants with sinus lift or bone augmentation.

Therefore, no conclusion can be drawn regarding the comparison between different vertical bone augmentation techniques in the posterior atrophic mandible, since quantitative meta-analysis was not performed. Regarding the horizontal defects, the use of a membrane seems to increase the regeneration of the hard tissue, but no differences were detected in prostheses or implant failures or complications [1,2].

Thus, conventional treatment with implants cannot be performed on the edentulous maxilla in some patients due to advanced bone resorption and the presence of extensive maxillary sinuses, leading to inadequate amounts of bone tissue for an implant anchorage [6-9]. For more than three decades, bone grafting before or simultaneously implant placement has become routine in oral rehabilitation [10].

Therefore, the present study analyzed the main approaches and clinical optimizations of zygomatic implants through guided surgery.

Methods

Eligibility and Study Design

This study followed the international systematic review model, following the PRISMA (preferred reporting items for systematic reviews and meta-analysis) rules. Available at: http://www.prisma-statement.org/?AspxAutoDetectCookieSupport=1. Accessed on: 01/19/2025. The AMSTAR 2 (Assessing the methodological quality of systematic reviews) methodological quality standards were also followed. Available at: https://amstar.ca/. Accessed on: 01/19/2025.

Search Strategy and Search Sources

The literature search process was carried out from November 2024 to January 2025 and developed based on Web of Science, Scopus, PubMed, Lilacs, Ebsco, Scielo, and Google Scholar, covering scientific articles from various periods to the present day. The following descriptors (DeCS /MeSH Terms) were used: *Zygomatic Implant. Dental Implant. Reabsorbed jaws. Guided surgery. Robotic placement*, and using the Boolean "and" between MeSH terms and "or" between historical findings.

Study Quality and Risk of Bias

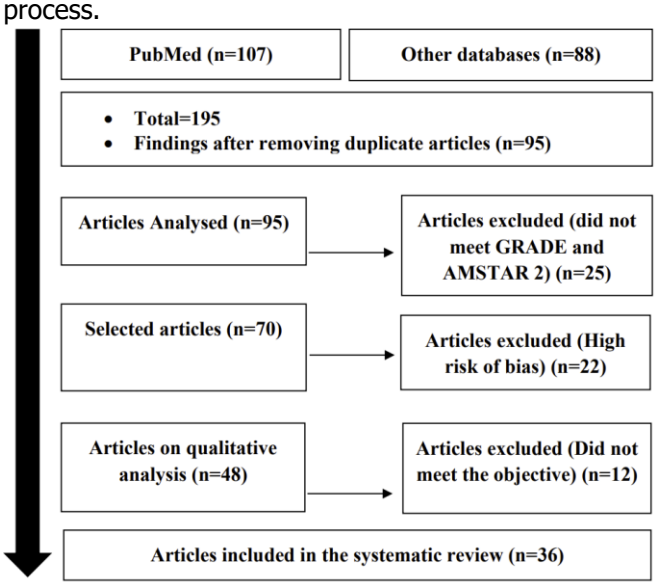
Quality was classified as high, moderate, low, or very low regarding the risk of bias, clarity of comparisons, precision, and consistency of analyses. The most evident emphasis was on systematic review articles or meta-analysis of randomized clinical trials, followed by randomized clinical trials. Low quality of evidence was attributed to case reports, editorials, and brief communications, according to the GRADE instrument. The risk of bias was analyzed according to the Cochrane instrument by analyzing the Funnel Plot graph (Sample size versus Effect size), using Cohen's d test.

Results and Discussion

Summary of Findings

As a corollary of the literature search system, a total of 195 articles were found that were submitted to eligibility analysis, 48 articles were evaluated in full and 36 final studies were selected to compose the results of this systematic review. The studies listed were of medium to high quality (Figure 1), considering the level of scientific evidence of studies such as meta-analysis, consensus, randomized clinical, prospective, and observational studies. Biases did not compromise the scientific basis of the studies. According to the GRADE instrument, most studies presented homogeneity in their results, with X^2=91.7%>50%. Considering the Cochrane tool for risk of bias, the overall assessment resulted in 22 studies with a high risk of bias and 25 studies that did not meet GRADE and AMSTAR-2.

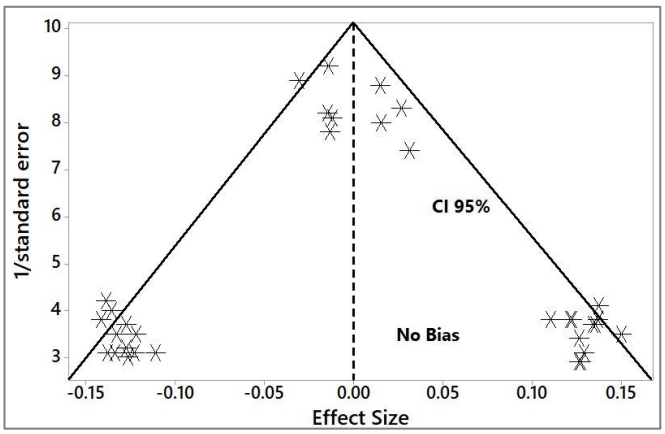
Figure 1. Flowchart showing the article selection process.



Source: Own Authorship.

Figure 2 presents the results of the risk of bias of the studies using the Funnel Plot, showing the calculation of the Effect Size (Magnitude of the difference) using Cohen's Test (d). Precision (sample size) was determined indirectly by the inverse of the standard error (1/Standard Error). This graph had a symmetrical behavior, not suggesting a significant risk of bias, both among studies with small sample sizes (lower precision) that are shown at the base of the graph and in studies with large sample sizes that are shown at the top.

Figure 2. The symmetrical funnel plot does not suggest a risk of bias among the studies with small sample sizes that are shown at the bottom of the graph. Studies with high confidence and high recommendation are shown above the graph (n=36 studies).



Source: Own Authorship.

Major Approaches and Clinical Results

A clinical study of 20 patients analyzed the variations in the type and frequency of late complications related to new zygomatic implant designs, placed following the Zygoma Anatomy Guided Approach (ZAGA) concept for 3 years. Implants were immediately loaded. Ten patients received two ZI and regular implants; one received three ZI plus regular implants, and nine received four ZI. Fifty-nine ZI were placed: thirty-six (61%) Straumann ZAGA-Flat implants and twenty-three (39%) Straumann ZAGA-Round implants. Four patients (20%) had previous sinus floor discontinuities. Fifteen patients (75%) had previous sinus opacities. Nineteen patients were followed for a period between 38 and 53 months (mean, 46.5 months). One patient withdrew after 20 months. When comparing presurgical CBCT with postsurgical CBCT, 84.7% of sites had identical or decreased sinus opacity; nine sites (15%) had decreased postsurgical sinus opacity, and nine sites had increased sinus opacity (15%). Fifty-three ZIs (89.8%) maintained stable soft tissue. Six ZIs had recessions without signs of infection. The survival rate of ZIs and prostheses was 100%. A 100% survival rate for implants and prostheses was reported during a mean follow-up of 46.5 months [11].

A study evaluated the clinical outcomes of a digitally validated guided technique for ZI placement followed by immediate prosthetic obturation. A total of 12 patients treated for head and neck cancer received a total of 36 ZIs after ablative surgery. The mean duration of ZI follow-up was 30.1 months. The survival rate of ZI placed in non-irradiated patients was 100%, whereas it was 85% in irradiated patients. Patient-reported outcomes were assessed using the Liverpool Oral Rehabilitation Questionnaire (LORQv3) and the University of Washington Quality of Life Questionnaire (UW-QOL v4). Most patients reported satisfactory results in the oral function domain of the LORQv3 (mean score of 17.7 ± 4.5; a possible range of 12–48, with lower scores indicating better results). Regarding the UW-QOL v4, the swallowing and chewing domains had the highest scores (mean of 97.5 ± 8.7 and 95.8 ± 14.4, respectively; maximum possible score of 100) [12].

Also, prosthetic rehabilitation of the atrophic edentulous maxilla is a challenge for which zygomatic implants (ZI) stand out from traditional techniques with reduced treatment duration and immediate loading [1,2]. Some studies showed that implant survival rate was 100.0 % over follow-up periods varying from 5 to 47 months [5-7].

During postoperative follow-up, two patients presented with slight palate inflammation [6]. The results obtained with zygomatic implants are satisfactory in terms of reproducibility and speed of rehabilitation of the maxillary. When the patient wishes a fixed prosthetic rehabilitation, the solution provided by the ZI becomes more common in the daily practice of the clinician [6,7]. General guidelines for zygomatic implants [10] (Table 1).

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

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

Source: Own authorship.

Highlights:

- ✓ In the adequate bone zone 1 and in the absence of bilateral bone in zones 2 and 3, two to four axial implants are indicated. Typically, two to four conventional implants are distributed in the anterior maxilla plus a zygomatic implant on each premolar/molar side [1].
- ✓ In the appropriate bone zone 1 and absence of bone in zones 2 and 3 on only one side. A single zygomatic implant is placed and conventional implants are placed in the anterior maxilla and opposite the zygomatic implant.
- ✓ In the inadequate bone zone 1 and appropriate immaculate bone in zones 2 and 3. An anterior zygomatic implant along with conventional posterior implants may resolve the problem.
- ✓ Lack of bone in the three zones of the maxilla. Four

zygomatic implants can be used for rehabilitation [2].

- ✓ Inadequate bone in zones 1, 2 or 3 in a partially edentulous patient. It is recommended to place three implants to support a partial prosthesis. The use of zygomatic implants in partially edentulous patients requires more clinical validation before widespread use can be advocated.
- ✓ A rescue solution for patients in whom conventional implants and/or maxillary filling procedure failed [1,2].

Thus, as a literature support, a study systematically reviewed and compared the survival rates (SR) of oral rehabilitation performed with two zygomatic implants (ZI) combined with two regular implants (RI) versus 4 ZI. The literature search resulted in a total of 417 studies, of which 6 were included in this study. For the control group (2 ZIs + 2 SR) and the test group (4 ZI), the RS of the implant was 98.6 % and 97.4 %, respectively, with 95,0 % CI. There were no statistically significant differences in terms of SR were obtained between the two groups, with p = 0.286. Therefore, the data analysis showed favorable results for the treatment with 4 ZIs. The results did not show statistical differences in the use of 1 or other treatment, in terms of survival and failure rates. The reduction in treatment time and morbidity related to regenerative approaches may be its main advantage. In conclusion, the zygomatic appears to be the treatment of choice for the rehabilitation of the severely atrophic maxilla [4].

In addition, another study included sixty-eight studies, comprising 4556 zygomatic implants (ZI) in 2161 patients with 103 faults. The accumulated survival rate in 12 years was 95.21%. Most failures were detected within the post-surgical period of 6 months. Studies (n = 26) that exclusively assessed load showed a statistically lower ZI failure rate than studies (n = 34) evaluating loading protocols (p = 0.003). Other studies (n = 5) evaluating ZI for the rehabilitation of patients after maxillary resections presented lower survival rates [5].

In this context, postoperative complications were as follows: sinusitis, 2.4%; soft tissue infection, 2.0 %; paresthesia, 1.0 %; and oroantral fistulas, 0.4 %. However, these numbers may be underestimated because many studies have not mentioned the prevalence of these complications. Therefore, zygomatic implants have a high survival rate accumulated in 12 years, with most of the failures occurring in the initial stages in the postoperative period. The main complication observed related to zygomatic implants was sinusitis, which may appear several years after implant surgery [1-5].

The presence of increased maxillary sinus pneumatization with advanced posterior alveolus resorption may result in insufficient bone for implant anchorage. Bone augmentation is generally necessary under these conditions to allow for sufficient number and length placement of the implants. Another more serious picture would be the defects of maxillectomy, maxillary sinus aplasia and fissured deformities [1,2].

In this sense, the ZI offers an effective alternative for the treatment of an atrophic maxilla. Survival decreases during the first year after surgery and is more related to local infection than to the number of ZI. In addition, the survival of osseointegrated implants may also be related to the use of appropriate pre-surgical exams and the parameters used during surgical procedures [2].

In this sense, indications for ZI may be for treatment of severely atrophic totally edentulous jaws without using any bone augmentation procedure [13-17]. There may be two different clinical situations involved; treatment of the severely atrophic partially edentulous maxilla, avoiding sinus elevation or other grafting procedures; maxillary reconstruction after partial or total maxillectomy, ZI can be used to fix maxillary obturators as an alternative to non-implanted obturators, local and regional flaps, and free microvascular flaps [18-22].

ZI may provide the only solutions for patients with the severely atrophic posterior maxilla, especially those resulting from surgical removal of tumors, and for patients who do not tolerate conventional removable prostheses [23-26]. These patients can be treated satisfactorily if a comprehensive preoperative evaluation is performed, followed by careful case planning, meticulous surgical technique and appropriate biomaterial selection [27-31].

In cases where a ZI is considered for oral rehabilitation, a computerized surgical stent should be used, a delayed loading protocol should be in place, a rigid connector should be placed between the implant and the prosthesis to better distribute the occlusal loads [32-34], and the implants should be placed in an arc shape to neutralize the flexural forces [35-38].

Added to this, a systematic review study showed the result of immediately loaded zygomatic implants, with an average follow-up of 12 months. The survey provided 236 titles for immediately loaded zygomatic implants and resulted in 106 abstracts for analysis. The full-text analysis was performed in 67 articles, resulting in the inclusion of 38 articles for this systematic review. Therefore, immediate loading of zygomatic implants for severely atrophic maxillary restoration has been shown to present a viable alternative for the treatment of the atrophic maxilla [6].

In relation to the main complications, Molinero et

al. (2018) [7] stated through a review study that the use of zygomatic implants in prosthetic rehabilitation of the patient with severe maxillary bone atrophy is another therapeutic alternative, without complications, selecting studies that included a study period of 6 to 12 months, any type of clinical trial and series that included a follow-up and/or review period. Of 455 studies, 67 were considered potentially relevant to the present study, of which 14 were finally selected. Thus, the main surgical complications are highlighted as sinusitis (3.9 %) and failure in osseointegration (2.44 %).

Another systematic review study showed that the reliability of oral rehabilitation by four zygomatic implants without prior support still needs to be determined. The study evaluated the predictability of this approach in relation to implant survival, technical and biological complications and quality of life. Clinical trials in humans where oral rehabilitation was performed using four zygomatic implants without additional standard implant placement were included. The primary outcome was the survival rate of zygomatic implants. The weighted average survival rate of zygomatic implants was 96.7 %. Only a limited number of surgical complications have been reported, with orbital perforation being the most significant. In addition, patient satisfaction levels were high. Therefore, rehabilitation of the maxilla by four zygomatic implants without anterior support is a reliable approach [16].

Finally, real-time surgical navigation systems (dynamic computer-aided surgery, d-CAIS) and static guided surgery (static computer-aided surgery, s-CAIS) have been shown to increase the accuracy of the ZI placement [39]. The errors of dynamic navigation-guided robotic placement of zygomatic implants were within clinically acceptable limits. Further refinements are needed to facilitate the clinical application of the tested integrated robotic-dynamic navigation system [40].

Conclusion

It was concluded the zygomatic implant is revolutionizing the procedure of implants in the posterior atrophic maxilla, eliminating the complications of bone augmentation and sinus elevation, with delayed scarring. Zygomatic implants have in many cases shown better clinical results compared to bone grafts and represent a possible gold standard for dental implants. Robotic placement of zygomatic implants has the potential to produce excellent results.

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CRediT

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No additional data are available.

Conflict of Interest

The authors declare no conflict of interest.

Similarity Check

It was applied by Ithenticate@.

Peer Review Process

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