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# Clinical results of the importance of zygomatic implant by guided surgery in bone elevation loss: a systematic review of safety and efficacy

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## Abstract

**Introduction:** Severe maxillary atrophy represents a burden on aesthetic recovery in patients with trauma and tooth loss. Treatment planning for guided prosthetic rehabilitation of the maxilla with Zygomatic Implant (ZI) can be performed digitally. The surgical and prosthetic plan, position, emergence, implant shape, temporary prosthesis position, interarch relationships, and surgical templates can be designed in a fully virtual environment. **Objective:** The purpose was to present the clinical results of a systematic review demonstrating the importance of zygomatic implants by guided surgery in bone elevation loss. **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:** 111 articles were found, 25 were evaluated in full and 15 were included and developed in the present systematic review study. Considering the Cochrane tool for risk of bias, the overall assessment resulted in 25 studies with a high risk of bias and 31 studies that did not meet GRADE. Most studies did not show homogeneity in their results, with $X^2$=78.5%>50%. It was concluded that the use of virtual tools enables the precision of implant positioning, validating its safety, reliability, and precision of guided surgery for the placement of zygomatic implants. The use of specialized implant planning software is an important tool to achieve predictable results for zygomatic implants and allows a good visualization of the implant-anatomical structures relationship.

**Keywords:** Zygomatic implant. Atrophic maxilla. Guided surgery. Guided prosthetic rehabilitation. Aesthetic rehabilitation.

## Introduction

The rehabilitation of an atrophic maxilla is challenging and, in severe resorption, zygomatic implants (ZI) are indicated and loading of the implants at the end of surgery is desirable. In this context, tooth loss negatively affects quality of life, compromising aesthetic functions, mastication and speech [1-3].

In this context, treatment planning for guided prosthetic rehabilitation of the maxilla with ZI can be performed digitally using a radiographic template for prosthetic treatment planning. The surgical and prosthetic plan, position, emergence, implant shape, temporary prosthesis position, interarch relationships, and surgical templates can be designed in a fully virtual environment on stereolithographic models [4].

Placement of the primary implant at the time of resection surgery is an effective means of accelerating rehabilitation together with early loading protocols. The role of radiotherapy in implant failure has not been fully elucidated, and ZI can be successfully used in the irradiated patient. ZI provides remote anchorage for a variety of oral and facial prostheses that contribute to improving the function and quality of life of patients [2].

Furthermore, quad zygomatic implants have been used as a treatment option for patients with severely resorbed maxilla. However, data on the average prosthetic success rate, ZI survival, and associated complications are scarce. Although data analysis has shown favorable results for the rehabilitation of severely

resorbed maxillas using quad zygomatic implants with high prosthetic success and high implant survival rate, further long-term clinical studies are needed to strengthen the evidence. However, potential implant and prosthetic complications should be considered when planning this treatment approach [3].

Implant contact and bone is referred to as BIC (bone-to-implant contact) and is correlated with implant survival [5-10]. The ZI provides anchorage, as it crosses the maxillary tuberosity, passes through the pyramidal process of the palatine bone and is part of the pterygoid process of the sphenoid bone, making implants successful, and optimized by guided surgery [11-18].

Thus, the present study aimed to present the clinical results of the importance of zygomatic implants by guided surgery in bone elevation loss through a systematic review.

## Methods

### 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. It was accessed on: 12/15/2024. The AMSTAR-2 (Assessing the methodological quality of systematic reviews) methodological quality standards were also followed. Available at: https://amstar.ca/. It was accessed on: 12/15/2024.

### Data sources and research strategy

The literature search process was carried out from November 2024 to January 2025 and developed based on Web of Science, Scopus, Embase, PubMed, Lilacs, Ebsco, Scielo, and Google Scholar, covering scientific articles from various periods to the present day. The descriptors (DeCS / MeSH Terms. Available on: https://decs.bvsalud.org/) were used *Zygomatic implant; Atrophic maxilla; Guided surgery; Guided prosthetic rehabilitation; Aesthetic rehabilitation*, and using the Boolean "and" between MeSH terms and "or" between historical findings.

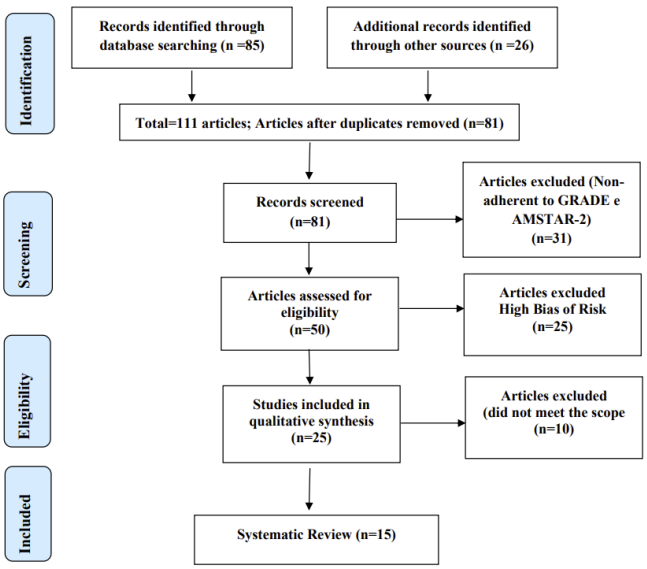
### Study Quality and Bias Risk

The 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

A total of 111 articles were found. Initially, duplicate articles were excluded. After this process, the abstracts were evaluated and a new exclusion was performed, removing the articles that did not include the theme of this article, resulting in 81 articles. A total of 25 articles were evaluated in full and included in this study, and 15 were developed in the systematic review item (Figure 1). Considering the Cochrane tool for risk of bias, the overall evaluation resulted in 25 studies with a high risk of bias and 31 studies that did not meet GRADE and AMSTAR-2. According to the GRADE instrument, the 15 studies that composed the systematic review presented homogeneity in their results, with $X^2$= 78.5% >50%, with p<0.05.

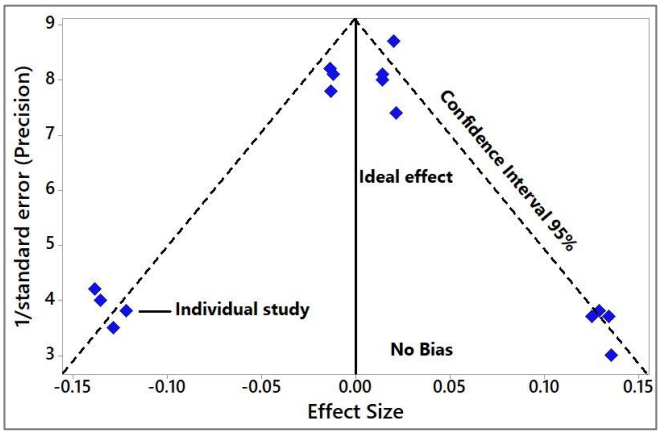
Figure 1. Study Eligibility (Systematic Review).




Source: Own Authorship.

Figure 2 presents the results of the risk of bias in the studies using the Funnel Plot, through the calculation of the Effect Size (Cohen's Test). The sample size was determined indirectly by the inverse of the standard error. The graph showed symmetric behavior, not suggesting a significant risk of bias in studies with small sample sizes, which are shown at the bottom of the graph.

Figure 2. The symmetric funnel plot does not suggest a risk of bias between the small sample size studies that are shown at the bottom of the graph. N=15 studies.




Source: Own Authorship.

### Outcomes-Highlights (N=15 studies)

Du et al. (2025) [19] conducted a pilot study that proposed a minimally invasive method of ZI placement that combines static and dynamic computer-guided surgery. The accuracy of implant positioning achieved with this approach validated its safety, reliability, precision, and robustness, reducing the technical sensitivity of ZI placement and facilitating future rehabilitation of severely atrophic maxillae. Furthermore, Rigo et al. (2021) [4] developed a new method using guided surgery for ZI placement, using specially designed metal molds that must be supported by bone. Nineteen of the twenty patients included in the study had successful implants and prostheses at the time of analysis. The present approach met the needs of ZI surgery. According to the clinical results of the last five years, some studies have expanded the clinical understanding based on comparative studies to show the success rate of ZI [20-27]. A study evaluated the anatomical factors influencing the virtual planning of ZI using cone beam computed tomography (CBCT). CBCT scans of 268 edentulous maxillary patients were transferred to specialized implant planning software. The zygomatic bone is a viable site for ZI and the use of specialized implant planning software is an important tool to achieve predictable results for ZI and allows good visualization of the implant-anatomical structures relationship [28].

A retrospective study compared the clinical outcome of immediately loaded ZI-supported maxillary cross-arch prostheses versus conventional implants placed in augmented bone. In total, 71 edentulous patients with severely atrophic maxillae without sufficient bone volume for dental implant placement or when only two implants could be placed in the anterior area (minimum diameter 3.5 mm and length 8 mm) and less than 4 mm in bone height subantrally were randomized according to a parallel-group design to receive ZI (35 patients) to be loaded immediately versus grafted with a xenograft, followed after 6 months of graft consolidation by the placement of six to eight conventional dental implants submerged for 4 months (36 patients). For immediate loading, ZIs had to be inserted with an insertion torque of more than 40 Ncm. Screw-retained metal-reinforced acrylic provisional prostheses were provided to be replaced by definitive Procera Implant Bridge Titanium (Nobel Biocare, Gothenburg, Sweden) prostheses with either ceramic or acrylic veneer 4 months after initial loading. Patients were followed up to 1 year after loading. Therefore, preliminary data from 1 year after loading suggest that immediately loaded ZI were associated with statistically significantly fewer prosthetic failures (one versus six patients), implant failures (two versus eight patients), and time required for functional loading (1.3 days versus 444.3 days) when compared with augmentation procedures and conventionally loaded dental implants. Even though more complications were reported for ZI, it proved to be a better rehabilitation modality for severely atrophic maxillae. Long-term data are necessary to confirm or dispute these preliminary results [29].

A segment of this same study also compared the clinical outcome of immediately loaded ZI-supported maxillary cross-arch prostheses versus conventional implants placed in augmented bone. A total of 71 edentulous patients with severely atrophic maxillae who did not have sufficient bone volume for dental implant placement or who could only place two implants in the frontal area (minimum diameter 3.5 mm and length 8 mm) and less than 4.0 mm of bone height subantrally were randomized according to a parallel-group design. They (35 patients) received zygomatic implants to be immediately loaded versus grafted with a xenograft, followed, after 6 months of graft consolidation, by the placement of six to eight conventional dental implants, submerged for 4 months (36 patients). To be immediately loaded, the zygomatic implants had to be inserted with an insertion torque greater than 40 Ncm. Patients were followed up for up to 4 months after loading. No augmentation procedures failed. Three patients dropped out of the augmentation group. Therefore, preliminary data from four months after loading suggest that zygomatic implants were associated with statistically significantly fewer prostheses (one versus six patients) and implant failures (one patient lost three implants versus 35 implants in eight patients), as well as time required for functional loading (1.3 versus 444.3 days) when compared with augmentation procedures and conventionally loaded dental implants. Even if more complications were reported for ZI, which resolved spontaneously or could be manipulated, ZI proved to be a better rehabilitation modality for severely atrophic maxillae [30].

Another study compared the outcome of oncologic site preparation for ZI using conventional preparation with rotary burs or piezoelectric surgery with dedicated inserts for the placement of two ZI per zygoma. Twenty edentulous patients with severely atrophic maxillae lacking sufficient bone volume for dental implant placement and less than 4 mm of bone height subantrally had their hemimaxillae randomized according to an open-mouth design in implant site preparation with either conventional rotary preparation or piezoelectric surgery. In two patients, drills were also used on the piezoelectric surgery side to allow preparation of the implant sites. One implant for the conventional drill group did not achieve an insertion torque greater than 40 Ncm, as it fractured the zygoma. No patient withdrew and two distal oncological implants failed in the same patient (one per group), who was not prosthetically rehabilitated. Six complications occurred at drilled sites and three at piezoelectric surgery sites (two patients had bilateral complications), the difference is not statistically significant (P (McNemar test) = 0.375; odds ratio = 4.00; 95% CI of odds ratio: 0.45 to 35.79). Implant placement with conventional drills took on average 14.35 ± 1.76 min and with piezoelectric surgery 23.50 ± 2.26 min, with the implant placement time being significantly shorter with conventional drilling (difference = 9.15 ± 1.69 min; 95% CI: 8.36 to 9.94 min; p<0.001). Postoperative hematomas were more frequent at drilled sites (p=0.001), and 16 patients considered both techniques equally acceptable, while four preferred piezoelectric surgery (p=0.125). Both drilling techniques achieved similar clinical results, but conventional drilling required 9 minutes less and could be used in all cases, although it was more aggressive. These results may be system-dependent, therefore, they cannot be generalized to other zygomatic systems with confidence [31].

The management of patients with a severely atrophic or resected maxilla due to ZI can be a surgical challenge. This retrospective cohort study evaluated the percentage of survival of ZI placed over 18 years. In total, 88 ZI were placed in 45 patients aged 42 to 88 years. Of the 88 implants, 54 were immediately loaded. The implant survival rate was 94.32%, with five implants failing during the study period. Failures were not significantly associated with gender, surface finish, implant length, anatomically guided zygomatic approach classification, or implant position (p > 0.05). All failed implants were fitted with fixed prostheses. Failures occurred between 6 months and 15 years after placement. This study of ZI performed in patients with severely atrophic and resected maxilla confirms that this approach is a predictable method for supporting fixed or removable prostheses for up to 18 years, demonstrating high survival rates [32].

Finally, a meta-analysis study included sixty-eight studies, comprising 4556 ZI in 2161 patients with 103 failures [27]. The cumulative survival rate at 12 years was 95.21%. Most failures were detected in the 6-month postoperative period. Studies (n = 26) that evaluated loading exclusively showed a statistically lower ZI failure rate than studies (n = 34) that evaluated loading protocols (p = 0.003). Other studies (n = 5) that evaluated ZI for the rehabilitation of patients after maxillary resections showed lower survival rates. Postoperative complications were as follows: sinusitis, 2.4%; soft tissue infection, 2.0%; paresthesia, 1.0%; and oroantral fistulas, 0.4%. However, these figures may be underestimated, as many studies have not mentioned the prevalence of these complications. Therefore, ZI has a high 12-year cumulative survival rate, with most failures occurring in the early postoperative stages. The main complication observed related to ZI was sinusitis, which can appear several years after implant surgery [33].

## Conclusion

It was concluded that the use of virtual tools enables the precision of implant positioning, validating its safety, reliability and precision of guided surgery for the placement of zygomatic implants. The use of specialized implant planning software is an important tool to achieve predictable results for zygomatic implants and allows a good visualization of the implant-anatomical structures relationship.

## CRediT

Author contributions **Conceptualization**; **Data curation**; **Formal Analysis; Investigation**; **Methodology**; **Project administration**; **Supervision**; **Writing - original draft and Writing-review & editing-** Guilherme Augusto Lima Garcia.

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Not applicable.

## Ethical Approval

Not applicable.

## Informed Consent

It was applicable.

## Funding

Not applicable.

## Data Sharing Statement

No additional data are available.

## Conflict of Interest

The authors declare no conflict of interest.

## Similarity Check

It was applied by Ithenticate®.

## Application of Artificial Intelligence (AI)

Not applicable.

## Peer Review Process

It was performed.

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