REVIEW ARTICLE

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Preserving alveolar ridge after tooth extraction to promote tissue aesthetics and dental implants: a systematic review

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Abstract

Introduction: In dental extractions, the preservation of bone and dental sockets should be the preferred option in patient treatment. In this regard, the width and height of the alveolar ridge after extraction can decrease by 3.87 mm and 1.67 mm, respectively, after three months, and by 63% and 22% after six months. Therefore, alveolar ridge preservation procedures have been introduced to prevent alveolar ridge atrophy and preserve sufficient bone dimensions to allow for the placement of implants. **Objective:** The aim was to address the primary clinical considerations for preserving dental sockets after tooth extraction, thereby promoting tissue aesthetics and facilitating the successful placement of dental implants. **Methods:** The PRISMA Platform systematic review rules were followed. The search was carried out from July to August 2025 in the Scopus, Embase, 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 125 articles were found, and 30 articles 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 21 studies with a high risk of bias and 24 studies that did not meet GRADE and AMSTAR-2. According to the GRADE instrument, most studies presented homogeneity in their results, with X^2=87.8%>50%. It was concluded that preserving bone volume after tooth extraction is a challenge in implant rehabilitation, aiming for functional and aesthetic results. An extraction socket filled with xenograft resulted in better preservation of alveolar bone dimensions, less ridge resorption, and provided better healing of both soft and hard tissues, yielding more satisfactory results. Furthermore, the use of photobiomodulation appeared to improve alveolar bone healing after tooth extraction and implant stability in cases of immediate extraction and implantation.

Keywords: Tooth extraction. Bone volume. Dental implants. Alveolar ridge. Aesthetic.

Introduction

In tooth extractions, the preservation of bone and dental sockets should be the preferred option in patient treatment. Tooth loss directly affects the quality of life, hindering communication, chewing, and, in some cases, social interaction. Several clinical studies have contributed to the current understanding of the biology behind the healing of dental sockets after extraction. The healing of the dental socket in humans is characterized by a series of cellular and tissue changes [1,2].

In this sense, the width and height of the alveolar ridge after extraction can decrease by 3.87 mm and 1.67 mm, respectively, after three months and by 63% and 22% after six months. Thus, alveolar ridge preservation procedures have been introduced to prevent alveolar ridge atrophy, preserve sufficient bone dimensions to allow for implant placement, and maintain an acceptable ridge contour in areas of aesthetic interest. It is necessary to understand and

respect the fundamental healing processes and the cellular-molecular interactions involved in the healing of dental sockets [3-5].

Tooth extraction is a traumatic procedure that usually results in damage to the surrounding alveolar bone and soft tissues. Others reported that reabsorption appears to be progressive and irreversible, and have observed that the alveolar ridge will generally decrease in volume and morphologically alter. They believe that this occurs due to the quantitative and qualitative changes that the edentulous areas of the alveolar process will undergo after tooth extraction [6,7].

This bone remodeling can generate damage that affects the installation, aesthetics, survival, and function of the implant in the long term [8-10]. Especially when aesthetic areas are considered, these changes generate obvious consequences for future treatment with implants. Currently, the success of the treatment is not only evaluated by the survival of the implants but also by the aesthetic and functional results. Thus, we should limit the loss of height and width of the alveolar ridge to a minimum, providing a better area for the placement of dental implants [11,12]. The preservation of the alveolar ridge performed immediately after tooth extraction can bring benefits such as reducing operating costs for both the patient and the dentist and the need for future surgical interventions. Preventing bone remodeling resulting in physiological resorption and the need for future interventions is undoubtedly more effective, although there are many techniques for increasing the ridge [7,13].

In attempting to neutralize bone remodeling, several approaches have been suggested, such as the immediate placement of implants, the use of different graft materials associated or not with the use of occlusive membranes, which would prevent the tendency of soft tissues to invaginate into the alveolus, in addition to preventing access [6,7,14]. The maintenance procedures of the post-extraction alveolar ridge contribute to the placement of the implant in a more aesthetically and functionally favorable position because they are predictable procedures that certainly prevent the depression of the collar [15-19]. Today, fresh extraction sockets represent a challenge for the dental surgeon. Much research has been done on the use of synthetic materials to replace, repair, or augment biological tissues. Therefore, a careful evaluation of the risks and benefits of the use of biomaterials should be carried out, with full knowledge by the dental surgeon regarding the characteristics, properties, and concentration of the materials [1,2,20].

Therefore, this systematic review study addressed the main clinical considerations of preserving dental alveoli after tooth extraction to promote tissue aesthetics, as well as enable the successful placement of dental implants.

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: 08/20/2025. The AMSTAR 2 (Assessing the methodological quality of systematic reviews) methodological quality standards were also followed. Available at: https://amstar.ca/. Accessed on: 08/20/2025.

Search Strategy and Search Sources

The literature search process was carried out from July to August 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: *"Tooth extraction. Bone volume. Dental implants. Alveolar ridge. Aesthetic"*, 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 125 articles were found that were submitted to eligibility analysis, 30 articles were evaluated in full and 15 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=87.8%>50%. Considering the Cochrane tool for risk of bias, the overall assessment resulted in 21 studies with a high risk of bias and 24 studies that did not meet GRADE and AMSTAR-2.

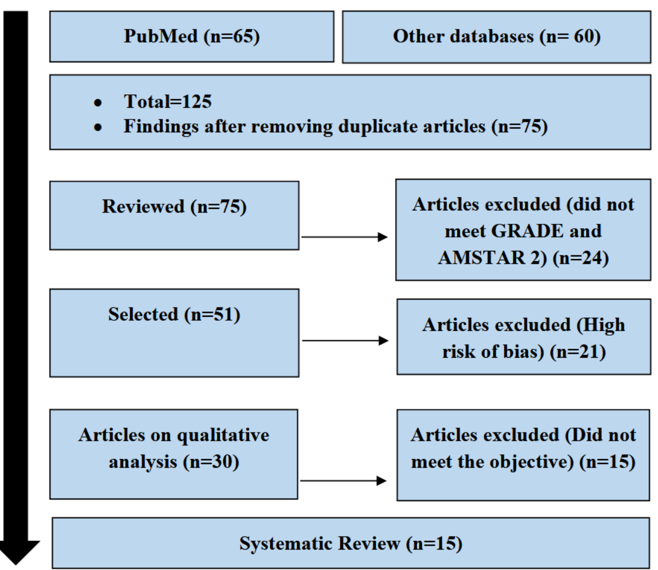

Figure 1. Flowchart showing the article selection process. Source: Own Authorship.

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.

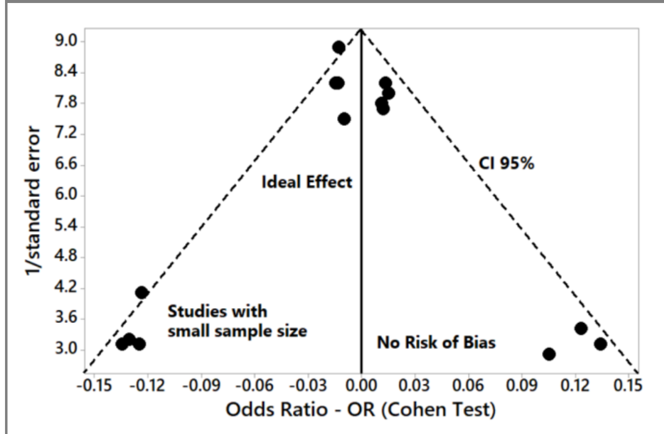

Figure 2. The symmetrical funnel plot does not suggest a risk of bias among the studies with small sample sizes that are shown at the bottom of the graph. Studies with high confidence and high recommendation are shown above the graph (n=15 studies). Source: Own Authorship.

Major Results

The healing of the dental socket after extraction is characterized by a series of cellular and tissue changes; a blood clot quickly forms within the socket, which is then replaced by granulation tissue and, eventually, by osteoid tissue. Alveolar ridge preservation procedures have been introduced to prevent alveolar ridge atrophy, preserve sufficient bone dimensions to allow for implant placement, and maintain aesthetics [1-3].

In this regard, the authors Sah et al. (2025) [1] conducted a systematic review based on clinical studies to evaluate the effectiveness of xenograft as a grafting material for alveolar ridge preservation (ARP) and reported the results through horizontal ridge width, vertical ridge height, periodontal clinical parameters (such as probing pocket depth (PPD), bleeding on probing (BOP), gingival recession, plaque index (PI) and gingival index (GI)), radiological evaluations, and associated complications. The pooled estimate showed that the vertical height of the alveolar ridge (buccal-lingual (DMP = -1.89 (-2.46-1.31), mesial (DMP = -0.18 (-0.65-0.29) and distal (DMP = -0.11 (-0.58-0.36)) decreased more in the extraction-only group, while BOP (DMP = -0.49 (-0.96-0.01)) was more or less similar in both groups. The horizontal width of the ridge (DMP = 1.15 (0.97-2.05)) was better preserved with ARP. The xenograft was clinically and statistically superior ($p < 0.05$).

The authors Mahintach et al. (2024) [21] analyzed whether the use of photobiomodulation (LLLT) impacts implant stability and alveolar bone healing, both in quality and quantity. These authors showed that LLLT demonstrates a positive impact on bone healing and implant stability, as well as alveolar preservation and implant stability.

Amato et al. (2025) [22] investigated and compared, through a retrospective study, the survival rate and success rate of single dental implants placed and restored immediately after extraction in non-infected, acutely infected, and chronically infected sites in the anterior maxilla. Group 1 (Control) non-infected sites (healthy periodontal and endodontic conditions); Group 2 (Test 1) acutely infected sites (presence of abscess and/or periodontal, endodontic, or combined fistula); Group 3 (Test 2) chronically infected sites (presence of periodontal pocket or periapical lesion without signs of acute inflammation). After a mean follow-up of 7 years (range of in a study involving children aged 2 to 12 years, a total of 127 patients were treated, and 143 single dental implants were placed and immediately restored with a fixed provisional prosthesis: 47 implants in Group 1 (control group, non-infected sites), 56 implants in Group 2 (Test 1, acutely

infected sites), and 40 implants in Group 3 (Test 2, chronically infected sites). Survival rates of 97.8% for Group 1, 96.4% for Group 2, and 95% for Group 3 were recorded, with no statistically significant difference between the groups (p = 0.8).

Also, significant three-dimensional bone loss was reported in addition to reducing the quality and quantity of keratinized gingiva in alveoli without adequate treatment, emphasizing the importance of using appropriate materials and demonstrating better results with the use of Bio-Oss® compared to NanoBone. Preservation of the collar using deprotected mineral bovine bone (Bio-Oss®) and nanocrystalline hydroxyapatite (NanoBone), together with a collagen membrane, reduced alveolar ridge changes after tooth extraction and allowed for a more favorable implant positioning. There was no superiority between histological and histomorphometric materials [20-23].

The deproteined bovine bone particles inserted into the bone defects cannot be fully resorbed and remain around the recipient bone as inert foreign bodies. The study also cites other authors, who report osteoclastic activity after months of healing, suggesting that over time these particles will remodel and form new bone. This remodeling would occur only 10% per year [24]. A considerable limitation in horizontal and vertical resorption was observed using the preservation of the alveolus with bovine mineral bone and porcine collagen membrane when compared with spontaneous healing, also histologically observing the formation of new bone with a large mineralized portion due to the xenograft material [25-28].

The alveolus was filled with a matrix composed of mineralized and demineralized allograft together with an absorbable collagen membrane and histologically observed bone formation in three healing periods [29,30]. The authors reported that osseointegration occurred independently of the moment of grafting and that the presence, especially at early times, of intense osteoblastic activities, suggesting a permanently active bone regeneration, may have contributed to implant survival [31,32].

Finally, in immediate implants, defects of about 1.5 mm between bone walls and implants have shown good spontaneous healing, but to avoid loss of vestibular bone volume, these defects should preferably be filled with biomaterial associated with membranes. Although immediate unit implants offer an increased risk of failure, aesthetic results and marginal peri-implant radiographic bone levels are optimized by filling the defect around immediate unit implants using an inorganic bovine bone substitute (Endobone) with resorbable collagen (OsseoGuard) [31,32].

Limitations

Further clinical studies with a larger sample size and longer follow-up period should be conducted to evaluate the secondary outcomes described, in order to obtain higher quality evidence.

Conclusion

It was concluded that preserving bone volume after tooth extraction is a challenge in implant rehabilitation, aiming for functional and aesthetic results. An extraction socket filled with xenograft resulted in better preservation of alveolar bone dimensions, less ridge resorption, and provided better healing of both soft and hard tissues, yielding more satisfactory results. Furthermore, the use of photobiomodulation appeared to improve alveolar bone healing after tooth extraction and implant stability in cases of immediate extraction and implantation.

CRediT

Author contributions: **Conceptualization**; **Formal Analysis**; **Investigation**; **Methodology**; **Project administration**; **Supervision**; **Writing - original draft**; and **Writing-review & editing-** Manuele de Caíres Marcella, André Gabriel Seron Camargo, Guilherme Cesari Santos and Janaina Cardoso Moreira.

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Ethical Approval

Not applicable.

Informed Consent

Not applicable.

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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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