Review Article

HEALING OF POST-EXTRACTION ALVEOLAR DEFECTS BY PRIMARY AND SECONDARY INTENTION: A SYSTEMATIC LITERATURE REVIEW

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ABSTRACT

The alveolar ridge undergoes dimensional changes post-tooth extraction. Studies aim to minimize bone loss and complications by exploring methods to preserve bone height, width, and keratinized tissues. This literature review assesses how primary and secondary intention healing influences alveolar ridge dimensions and bone tissue histomorphometry. Following PRISMA guidelines, a literature search was conducted in PubMed, Cochrane Library, and ScienceDirect databases. This systematic review encompasses randomized controlled trials, as well as observational, retrospective studies, single-blinded, split-mouth randomized studies, and controlled clinical trials. Articles published from March 1, 2013, to March 1, 2023, comparing bone dimensional or histomorphometric changes post-extraction were selected. Studies were evaluated for the risk of bias using the questionnaire known as "The Cochrane Collaboration's risk-of-bias (RoB 2) tool". Five publications were reviewed, involving 92 patients and 128 extracted teethAlveolar height and width resorption were similar between primary and secondary intention groups, with no significant differences reported. Histomorphometric changes did not significantly differ between the two healing methods. The healing method (primary or secondary intention) does not significantly impact dimensional changes or new bone tissue formation in post-extraction defects.

Key words: Primary intention, Secondary intention, Open flap, Closed flap, Socket.

Introduction

The remodeling of the alveolar ridge after tooth extraction is a challenge for specialists in daily clinical practice. The size and shape of the alveolar ridge rely on the tooth structures, as well as the vertical and horizontal alterations that happen to the ridge following tooth loss [1]. Approximately 60% of ridge measurements decrease within the initial 2–3 years post-extraction, with this resorption persisting thereafter at a pace of 0.25–0.5% annually, enduring throughout one's lifetime [2]. It has been observed that most intensive bone loss occurs during the first months after tooth extraction [3]. More bone is lost in the horizontal plane than in the vertical plane [4]. Research suggests that the resorption of the alveolar ridge is more pronounced on the outer (buccal) aspect compared to the inner (lingual) side [5]. The buccal wall of the alveolar process is thinner than the lingual wall. A thin buccal wall makes dehiscence more likely to occur [6]. The likelihood of experiencing a dehiscence is similar to encountering a three-wall bone defect. With fewer bony walls present, there is a decreased opportunity to retain a blood clot within the extraction socket itself [7]. According to studies [8], the extent of bone resorption after tooth extraction depends on many factors: the thickness of the alveolar wall, the position of the tooth and its angle of inclination, surgical trauma, flap rise, and the size of the initial bone defect. Several studies indicate that following tooth extraction, around 30% of the alveolar ridge diminishes due to resorption. Within the initial three months post-extraction, approximately two-thirds of the impacted hard and soft tissues undergo varying degrees of resorption [9]. For the socket to heal after tooth extraction and to lose as little bone as possible, various studies are conducted and the best methods and materials are sought to preserve and/or restore the amount of bone height, width, and keratinized gums.

To preserve the height and width of the socket and to promote the formation of new viable bone tissue, various materials are used: autogenous, allogenic, xenogenic, and alloplastic bone granules. The choice of bone substitute material may depend on the physician's preference, as well as financial considerations or cultural preferences [7]. Different layers offer assistance to keep the bone particles within the attachment. They can be either resorbable, such as collagen films, or non-resorbable, such as PTFE or titanium membranes, the evacuation of which needs an extra surgical intercession. Post-extraction wound closure, as one of the ways to protect the socket from negative external influences, can be performed in several ways: primary intention wound healing, when the wound is hermetically closed using a mucoperiosteal flap, or secondary intention healing, when the mucoperiosteal flap is not completely sutured, leaving space for the wound to drain or not sutured at all [10, 11]. The prevailing opinion in the scientific literature is that to avoid the risk of infection, it is recommended to completely cover most types of membranes with a mobilized mucoperiosteal flap, ensuring primary intention healing. However, it is also possible to leave some d-PTFE or collagen membranes for the secondary intention healing process without suturing [10].

The objective of this study is to assess the impact of both primary and secondary intention in alveolar healing after tooth extraction on dimensional changes in alveolar growth and histomorphometric indicators of bone tissue.

Materials and Methods

When conducting a systematic review of the scientific literature, the PRISMA recommendations for the review planning, objectives, selection of suitable articles, and data analysis were followed [12]. The PICO methodology was applied to raise the problematic question, taking into account the results of the study: P – population, I – intervention, C – control, and O – results [12]. A main question for the study was: Is there a difference in the extent of post-extraction alveolar defects dimensional remodeling between primary and secondary intention healing?

P (population) – Patients undergoing procedures for the augmentation of a removed tooth's socket.

I (intervention) – socket, whose healing occurred through primary intention after tooth extraction.

C (control) – socket, whose healing occurred through secondary intention after tooth extraction.

O (results) – Primary results: dimensional changes in the socket of the extracted tooth during the 3-6 month period after tooth removal. Secondary results: histomorphometric parameters of bone tissue after tooth extraction in healing with primary and secondary intention.

Selection criteria
This systematic review encompasses randomized controlled trials, as well as observational, retrospective studies, single-blinded, split-mouth randomized studies, and controlled clinical trials. The focus lies on comparing the influence of primary and secondary intention healing after tooth extraction on dimensional changes of the alveolar ridge and histomorphometric parameters of bone tissue.

Inclusion criteria
- Scientific articles that are not older than 10 years.
- Studies that are described in full articles in English.
- Human studies evaluating primary and secondary intention healing of augmented alveolar defects after tooth extraction.
- Studies comparing bone dimensional or histomorphometric changes.
- Randomized, retrospective, and prospective studies.

Exclusion criteria
- Studies comparing treatment with primary and secondary intention in terms of complication rates.
- Studies in vitro, and ex vivo.
- Studies that evaluated only one group of sockets with primary intention or secondary intention healing.
- Systematic reviews of scientific literature, meta-analyses, case studies, poster presentations, conference presentations, and theses.
- Studies that observed less than 10 patients.

Search strategy
The search for publications required for the systematic review of scientific literature was conducted by two independent researchers. The search was conducted in three scientific databases: PubMed, Cochrane Library, and ScienceDirect. The selected articles were published from March 1, 2013, to March 1, 2023 (Last search date: March 4, 2023). To ensure uniformity in the combination of keywords across all search databases, 6 Boolean operators 'AND' and 'OR' were used, and the keywords were selected from the MeSH Terms (Medical Subject Headings) thesaurus to include widely used medical terms. The combination was created during the preliminary literature search. The keyword combination used was: (((primary intention) AND (secondary intention)) OR ((open flap) AND (closed flap))) AND ((socket) OR (extraction)) AND (tooth).

The selection of publications was carried out in two stages. In the first stage, duplicate articles in scientific databases were removed, and then, while reading only titles and abstracts, publications not relevant to the topic were also excluded. In the second stage, full-text articles were read, analyzed, and assigned to the literature review or rejected based on the established inclusion and exclusion criteria.

Additionally, the references cited in the selected articles were reviewed for potentially relevant additional publications.

Quality assessment
The assessment of the risk of bias in prospective randomized studies was performed using 'The Cochrane Collaboration's risk-of-bias (RoB 2) tool' questionnaire [13]. The RoB 2 tool consists of 5 standardized criteria, each with algorithms for evaluation. Using these algorithms, each standardized criterion is assigned a risk rating: low (+), medium (-), and high (x).

Results and Discussion

Study selection
During the initial stage of the publication search, 996 publications were found based on the selected keyword combination. Applying additional filters (no older than 10 years, no systematic reviews, no case analysis articles) and removing duplicate publications (n = 153), 350 articles were obtained. In the primary stage, the titles and abstracts of these publications were reviewed. After this stage, the

remaining 29 publications were selected for full-text analysis. During the second stage of the article search, 29 articles that met the selection criteria were read and analyzed. Applying rejection criteria, articles were excluded due to the absence of a control group (n = 11), articles evaluating complications (n = 2), articles not assessing alveolar bone height (BH), alveolar bone width (BW), or bone histomorphometric indicators (n = 8), a duplicate description of a previously selected study (n = 1), an article in Chinese (n = 1), and an article where the socket in the control group were not augmented (n = 1). In total, 24 articles were excluded after full-text analysis. Five publications [14-18] were included in the systematic literature review. The search process diagram is presented in **Figure 1**.

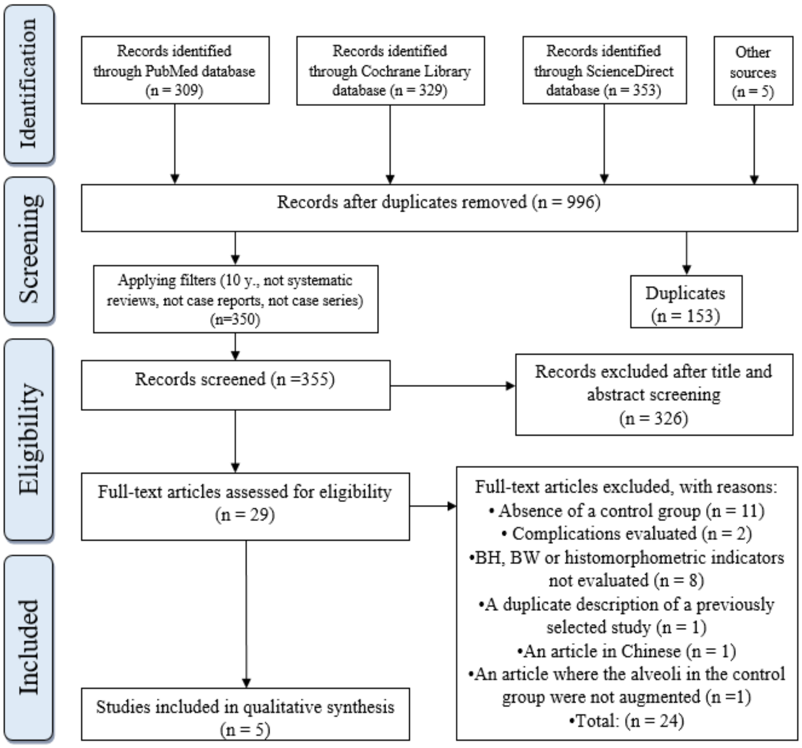

Figure 1. PRISMA flowchart search process diagram.
BH – bone height change, BW – bone width change

Characteristics of included studies

Five studies [14-18] were included in this literature review. All selected studies were prospective randomized controlled trials that had two randomly assigned groups: one control and one experimental.

All studies investigated at least one of the variables matching the selection criteria: bone height change, bone width change, or histological percentage indicators of viable bone. One study examined both bone height changes and histomorphometric indicators [14], three studies examined only the percentage parameters of new bone formation from a histological perspective [15-17], and one study examined bone height, width changes, and histomorphometric indicators of bone tissue [18]. All extracted results are shown in **Table 1**.

Statistical analysis

Firstly, a systematic review and meta-analysis (qualitative and quantitative analysis) were planned. No quantitative analysis (meta-analysis) could be performed due to the high heterogeneity of the data. As a result, the systematic review only conducted a descriptive analysis of the retrieved information, without a quantitative assessment, to identify and analyze relevant data for statistical significance. Statistical data was expressed using the mean and standard deviation (M ± SD).

Risk of bias assessment

'The Cochrane Collaboration's risk-of-bias (RoB 2) tool' was used to assess the systematic risk of bias. A low risk of bias characterized all selected studies. When evaluating randomized controlled trials, three articles [14, 15, 18] had a moderate risk of selective reporting bias. However, this did not diminish the overall assessment of a low risk of bias. Visual assessment of the risk of bias using the 'Robvis' tool [19] is presented in **Figure 2**.

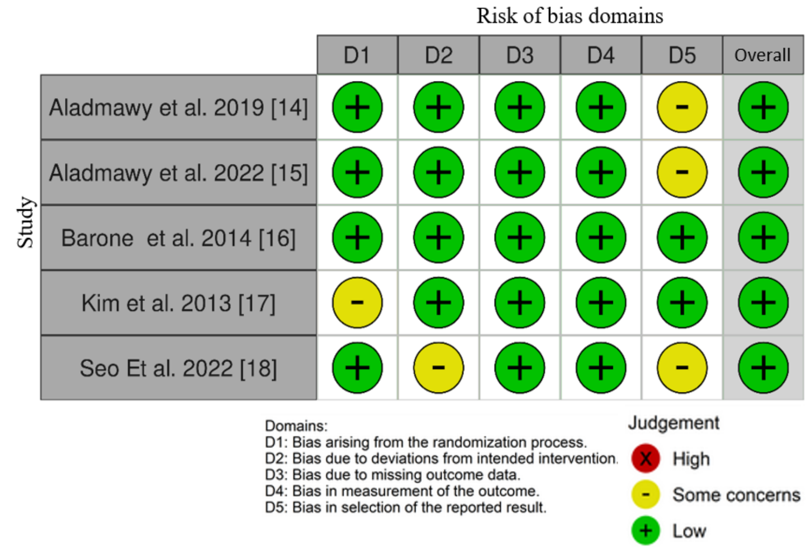

Figure 2. Risk of bias assessment of included studies in the review. A Risk of bias summary; B Risk of bias graph. Symbols. (+): low risk of bias; (?): unclear risk of bias; (-): high risk of bias

Impact of primary and secondary healing intention on alveolar height changes

Changes in alveolar bone height during healing with primary and secondary intention were investigated in two studies [14, 18]. A total of 48 sockets were examined in the studies after tooth extraction. Both studies [14, 18] specified the areas under investigation, including incisors, canines, premolars, and molars.

The studies reported the overall change in alveolar height after tooth extraction [14, 18]. In the study by Aladmawy *et al.* in 2019, during the healing of post-extraction socket with primary intention, a significantly greater decrease in alveolar height was observed, with an average reduction of -8.1 ± 1.9 mm six months after tooth extraction (p = 0.05) [14]. When healing with secondary intention, the decrease in alveolar height varied from -7.5 ± 1.8 mm (p = 0.05) [14] to -0.9 ± 1.5 mm (p < 0.05) [18]. In the study conducted by Seo *et al.* in 2022 [18], the change in alveolar height 4 months after tooth extraction was -1.4 ± 1.2 mm with primary intention healing and -0.9 ± 1.5 mm with secondary intention healing, but the difference between the groups of primary and secondary healing intention was not statistically significant (p = 0.349).

Table 1. Summary of results presented in the studies included in the systematic review.

					Primary Intention Healing			Secondary Intention Healing			
No.	Author / Year	Type of study	Study sample/Number of study areas	Follow up:	BH (mm)	BW (mm)	New Bone %	BH (mm)	BW (mm)	New bone %	Conclusions
1.	Aladmawy *et al.* (2019) [14]	Randomized Prospective Study	10/20	6 months	-7.5±1.8 (p = 0.389)	-0.1±0.3 (p = 0.317)		-8.1 ± 1.9 (p = 0.389)	0.1±0.5 (p = 0.564)		Wound healing with secondary intention did not show statistically significant changes in BH and BW. However, statistically significantly wider keratinized gingival width and lower pain levels were observed in the primary intention healing group compared to the secondary intention healing group.

2.	Aladmawy *et al.* (2022) [15]	Randomized Prospective Study	8/16	6 months			71.1% ± 23.5% (p = 0.066)			50.9 % ± 16.2% (p = 0.066)	The study did not find a statistically significant difference in new bone formation between alveolar healing with primary or secondary intention, considering histomorphometric indicators.
3.	Barone *et al.* (2015) [16]	Randomized Prospective Study	34/34	6 months			22.5% ± 3.9% (p = 0.917)			22.5% ± 4.3% (p = 0.917)	No statistically significant difference in histomorphometric indicators was found when comparing healing with primary and secondary intention.
4.	Kim *et al.* (2013) [17]	Randomized Prospective Study	12/30	6 months			47.3% ± 11.3% (p > 0.05)			40.3% ± 7.8% (p > 0.05)	Alveoli healing with secondary intention exhibited similar clinical, radiological, and histological outcomes as those healing with primary intention.
5.	Seo *et al.* (2022) [18]	Randomized Prospective Study	28/28	6 months	-1.4 ± 1.2 (p = 0.349)	-4.9 ± 3.1 (p = 0.529)	26.2 ± 17.7% (p > 0.05)	-0.9 ± 1.5 (p = 0.349)	-4.2 ± 2.5 (p = 0.529)	24.6 ± 18.4% (p > 0.05)	Both primary and secondary intention healing resulted in a similar formation of new viable bone and radiological changes in alveolar dimensions.

Abbreviations: BH - bone height change, BW - bone width change, B - buccal, L - lingual.

The impact of primary and secondary healing intention on alveolar width changes

Two articles were found that investigate changes in alveolar width after tooth extraction [14, 18]. A total of 48 sockets were examined in these studies. One article mentioned that incisor, canine, and premolar sockets were under observation [18], while the other article stated that the sockets under observation were only from the posterior tooth group, from molars to premolars [14]. In the study conducted by Seo *et al.* in 2022, the change in alveolar width during primary intention healing was -4.9 ± 3.1 mm, and during secondary intention healing, it was -4.2 ± 2.5 mm. These results were evaluated after 4 months of tooth extraction, but they were not statistically significant (p = 0.529) [18]. In the study conducted by Aladmawy *et al.* in 2019, where width was assessed 6 months after tooth extraction, the change in alveolar width during primary intention healing was -0.1 ± 0.3 mm (p = 0.317), and during secondary intention healing, it was 0.1 ± 0.5 mm [14]. The differences in alveolar width between different healing intention groups were not statistically significant (p = 0.564).

The impact of primary and secondary healing intention on bone histomorphometric indicators

In the included systematic review articles, four studies investigated histomorphometric bone indicators 3-6 months after tooth extraction. They assessed the percentage of newly formed viable bone in the socket during primary and secondary healing intentions [15-18].

In the study by Aladmawy *et al.* in 2022, an allogeneic freeze-dried mineralized bone substitute (MinerOss, BioHorizons, Birmingham, Alabama, USA) was used to preserve alveolar dimensional parameters [15]. In the primary healing intention group, allogenic bone granules were covered with a PTFE membrane, and the mucoperiosteal flap was fully sutured. In the secondary healing intention group, bone granules were left to heal without suturing the flap. The results showed that the formation of new bone during primary intention healing 6 months after tooth extraction and alveolar augmentation was 71.1% ± 23.5%, while during secondary intention healing, it was 50.9% ± 16.2% (p = 0.066) [15].

In the study by Barone *et al.* in 2014, xenogeneic bone substitute (MP3, Osteobiol, Coazze, Italy) was used to fill the socket after tooth extraction, and it was covered with a collagen membrane. The results indicated that the percentage of newly formed viable bone in socket healing with primary intention was 22.5% ± 3.9%, and in the secondary intention group, it was 22.5% ± 4.3% at 3 months after tooth extraction (p = 0.917) [16].

Kim *et al.* (2013) study used synthetic bone substitutes (Osteon II, Genoss, Suwon, South Korea) in both primary and secondary intention groups, covered with a collagen membrane. The results showed 47.3% ± 11.3% new bone formation in the primary intention group and 40.3% ± 7.8% in the secondary intention group 6 months after tooth extraction and alveolar filling, with no statistically significant difference between the healing intention groups ($p > 0.05$) [17].

In the study by Seo *et al.* in 2022, xenogenic bone substitutes (InterOss, SigmaGraft, Fullerton, USA) were used, and sockets augmented with xenogenic bone were covered with a collagen membrane. In the primary intention healing group, the collagen membrane was additionally covered with a buccal coronally displaced mucoperiosteal flap. In the secondary intention healing group, the collagen membrane was left exposed for open healing. After 4 months, the percentage of new bone formation in the primary intention group was 26.2 ± 17.7%, and in the secondary intention group, it was 24.6 ± 18.4% ($p > 0.05$) [18].

In this scientific literature analysis, five scientific publications [14-18] were selected and analyzed. The study aimed to evaluate the impact of primary and secondary intention healing on dimensional changes in the extracted tooth socket and histomorphometric parameters of bone tissue.

During post-extraction wound healing, socket remodeling occurs. Seo *et al.* using cone-beam computed tomography (CBCT), found a smaller vertical bone loss in the socket during secondary healing intention compared to primary healing intention, but this difference was not statistically significant [18]. Despite the different research methodologies, similar results were obtained in the Aladmawy *et al.* (2019) study, where no statistically significant changes in socket height and width were observed between primary and secondary healing intention groups [14].

In the study of horizontal post-extraction alveolar remodeling, Seo *et al.* found similar radiological changes in alveolar dimensions in both primary and secondary intention healing groups, with no statistically significant differences between them [18]. Aladmawy *et al.* also observed horizontal alveolar ridge resorption. The results showed that although the socket healed with primary intention underwent less horizontal resorption than that healed with secondary intention [14], the differences between these groups were not statistically significant. Despite the use of different regenerative materials – xenogenic bone substitute and collagen membrane in the Seo *et al.* study [18], and allogenic bone and non-resorbable d-PTFE membrane in the Aladmawy *et al.* study [14] – the choice of these materials did not affect vertical or horizontal resorption of the alveolar ridge, whether the wound was left open for natural healing or sutured for primary intention healing. Similar results were obtained in the study by Zhao *et al.* [19], where the use of xenogenic bone substitute and collagen membrane showed a tendency for greater horizontal resorption of the alveolar ridge in cases of primary intention healing. Still, the differences between the two healing groups were not statistically significant.

Histomorphometric parameters of bone were described in four articles selected for this systematic review [15-18]. Different materials for socket augmentation were used in these studies: xenogenic or allogenic bone substitutes, and autogenous bone. Various membranes were also used to protect the bone granules. Three studies used non-resorbable collagen membranes [16-18], and one study used a non-resorbable PTFE membrane [15]. In all studies included in this literature review that analyzed histomorphometric bone parameters, a higher percentage of new bone formation was observed in sockets healing with primary intention, but the results did not significantly differ from those in groups with secondary healing intention.

The latest histomorphometric studies suggest that a higher amount of new viable bone tends to form in the socket during primary healing intention, as it provides better protection for the particles of the used bone substitute. In their study, Gabay *et al.* [20] found that after tooth extraction, a higher formation of new viable bone occurs in the socket during primary intention healing compared to secondary intention healing, where more connective tissue is formed than new viable bone. On the other hand, during the analysis of the case series, Ramaglia *et al.* [21] observed that a higher amount of new bone is formed in the socket during secondary intention healing. However, the results of the latter study should be interpreted with caution, as the groups of primary and secondary intention healing were assessed at different time intervals, which could have influenced the obtained results [21].

Dimensional and histomorphometric parameters of socket healing are not the only clinical indicators by which post-extraction wound healing should be evaluated. Patients may experience pain, swelling, and various complications such as dehiscence, alveolitis, infection, or bleeding during socket healing, with both primary and secondary wound healing intention. Jakse *et al.* noted that primary intention healing often provides the patient with a sense of safety and comfort, promoting faster postoperative wound healing and reducing the risk of clot loss in the socket [22]. These findings are supported by Kilinc *et al.* who found that primary intention healing can reduce the risk of alveolitis development [23]. On the other hand, secondary intention healing reduces the trauma of the operation, and the extent of suturing, and allows patients more flexibility in the mucosa [24]. Without the need to mobilize the mucoperiosteal flap, the oral vestibule is not compromised, and a larger amount of keratinized gingiva is preserved [14, 24]. Aggarwal *et al.* study confirmed the lower traumatic nature of the procedure in the secondary intention healing group, as patients in this group felt less pain and experienced less swelling than in the primary intention healing group [25]. Similar results were also reported by Rodrigues *al.*, who found significantly less swelling and pain in the primary healing group compared to the secondary healing group [26].

Conclusion

1. The healing of post-extraction bone defects with primary or secondary intention does not significantly impact the dimensional changes of the alveolar ridge that occur after tooth extraction.
2. The healing method, whether primary or secondary intention, after tooth extraction does not influence the formation of new viable bone in the post-extraction defect.

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References

1. Kim JH, Wadhwa P, Cai H, Kim DH, Zhao BC, Lim HK, et al. Histomorphometric evaluation of socket preservation using autogenous tooth biomaterial and BM-MSC in dogs. Scanning. 2021;2021(10):6676149. doi:10.1155/2021/6676149
2. Tadic A, Bajkin B, Mijatov I, Mirnic J, Vukoje K, Sokac M, et al. Influence of L-PRF topical application on bone tissue healing after surgical extraction of impacted mandibular third molars: Randomized split-mouth clinical study. Appl Sci. 2023;13(8):4823. doi:10.3390/app130848233
3. Lin HK, Pan YH, Salamanca E, Lin YT, Chang WJ. Prevention of bone resorption by HA/β-TCP + collagen composite after tooth extraction: A case series. Int J Environ Res Public Health. 2019;16(23):4616. doi:10.3390/ijerph16234616
4. Couso-Queiruga E, Stuhr S, Tattan M, Chambrone L, Avila-Ortiz G. Post-extraction dimensional changes: A systematic review and meta-analysis. J Clin Periodontol. 2021;48(1):127-45. doi:10.1111/jcpe.13390
5. El-Sioufi I, Oikonomou I, Koletsi D, Bobetsis YA, Madianos PN, Vassilopoulos S. Clinical evaluation of different alveolar ridge preservation techniques after tooth extraction: A randomized clinical trial. Clin Oral Investig. 2023;27(8):4471-80. doi:10.1007/s00784-023-05068-1
6. Čandrlić M, Tomas M, Matijević M, Kačarević ŽP, Bićanić M, Udiljak Ž, et al. Regeneration of buccal wall defects after tooth extraction with biphasic calcium phosphate in injectable form vs. Bovine xenograft: A randomized controlled clinical trial. Dent J (Basel). 2023;11(9):223. doi:10.3390/dj11090223
7. Aladmawy MA, Natto ZS, Steffensen B, Levi P, Cheung W, Finkelman M, et al. A Comparison between primary and secondary flap coverage in ridge preservation procedures: A pilot randomized controlled clinical trial. Biomed Res Int. 2019;2019:7679319. doi:10.1155/2019/7679319
8. Seyssens L, Eghbali A, Christiaens V, De Bruyckere T, Doornewaard R, Cosyn J. A one-year prospective study on alveolar ridge preservation using collagen-enriched deproteinized bovine bone mineral and saddle connective tissue graft: A cone beam computed tomography analysis. Clin Implant Dent Relat Res. 2019;21(5):853-61. doi:10.1111/cid.12843
9. Kermanshah H, Najafrad E, Valizadeh S. Forced eruption: Alternative treatment approach to restore teeth with subgingival structure. Case Rep Dent. 2022;2022:9521915. doi:10.1155/2022/9521915
10. Pasqualini D, Cocero N, Castella A, Mela L, Bracco P. Primary and secondary closure of the surgical wound after removal of impacted mandibular third molars: A comparative study. Int J Oral Maxillofac Surg. 2005;34(1):52-7. doi:10.1016/j.ijom.2004.01.023
11. Bello SA, Olaitan AA, Ladeinde AL. A randomized comparison of the effect of partial and total wound closure techniques on postoperative morbidity after mandibular third molar surgery. J Oral Maxillofac Surg. 2011;69(6):e24-30. doi:10.1016/j.joms.2011.01.025
12. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. BMJ. 2021;372:n71. doi:10.1136/bmj.n71
13. Flemyng E, Cumpston MS, Arevalo-Rodriguez I, Chandler J, Deeks JJ. Planning a Cochrane review of diagnostic test accuracy. Cochrane Handbook for Systematic Reviews of Diagnostic Test Accuracy. 2023:1-8.
14. Aladmawy MA, Natto ZS, Steffensen B, Levi P, Cheung W, Finkelman M, et al. A comparison between primary and secondary flap coverage in ridge preservation procedures: A pilot randomized controlled clinical trial. Biomed Res Int. 2019;2019(7):1-7. doi:10.1155/2019/7679319
15. Aladmawy MA, Natto ZS, Kreitzer M, Ogata Y, Hur Y. Histological and histomorphometric evaluation of alveolar ridge preservation using an allograft and non-resorbable membrane with and without primary closure: A pilot randomized controlled clinical trial. Medicine (Baltimore) 2022;101(26):e29769. doi:10.1097/MD.0000000000029769
16. Barone A, Borgia V, Covani U, Ricci M, Piattelli A, Iezzi G. Flap versus flapless procedure for ridge preservation in alveolar extraction sockets: A histological evaluation in a randomized clinical trial.

Clin Oral Implants Res. 2015;26(7):806-13. doi:10.1111/clr.12358
17. Kim DM, De Angelis N, Camelo M, Nevins ML, Schupbach P, Nevins M. Ridge preservation with and without primary wound closure: A case series. Int J Periodontics Restorative Dent. 2013;33(1):71-8. doi:10.11607/prd.1463
18. Seo GJ, Lim HC, Chang DW, Hong JY, Shin SI, Kim G, et al. Primary flap closure in alveolar ridge preservation for periodontally damaged extraction socket: A randomized clinical trial. Clin Implant Dent Relat Res. 2023;25(2):241-51. doi:10.1111/cid.13165
19. Zhao LP, Hu WJ, Xu T, Zhan YL, Wei YP, Zhen M, et al. Two procedures for ridge preservation of molar extraction sites affected by severe bone defect due to advanced periodontitis. Beijing Da Xue Xue Bao. 2019;51(3):579-85. doi:10.19723/j.issn.1671-167X.2019.03.03
20. Gabay E, Katorza A, Zigdon-Giladi H, Horwitz J, Machtei EE. Histological and dimensional changes of the alveolar ridge following tooth extraction when using collagen matrix and collagen-embedded xenogenic bone substitute: A randomized clinical trial. Clin Implant Dent Relat Res. 2022;24(3):382-90. doi:10.1111/cid.13085
21. Ramaglia L, Saviano R, Matarese G, Cassandro F, Williams RC, Isola G. Histologic evaluation of soft and hard tissue healing following alveolar ridge preservation with deproteinized bovine bone mineral covered with xenogenic collagen matrix. Int J Periodontics Restorative Dent. 2018;38(5):737-45. doi:10.11607/prd.3565
22. Jakse N, Bankaoglu V, Wimmer G, Eskici A, Pertl C. Primary wound healing after lower third molar surgery: evaluation of 2 different flap designs. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2002;93(1):7-12. doi:10.1067/moe.2002.119519
23. Kilinc A, Ataol M. How effective is collagen resorbable membrane placement after partially impacted mandibular third molar surgery on postoperative morbidity? A prospective randomized comparative study. BMC Oral Health. 2017;17(1):126. doi:10.1186/s12903-017-0416-z
24. Hong HR, Chen CY, Kim DM, Machtei EE. Ridge preservation procedures revisited: A randomized controlled trial to evaluate dimensional changes with two different surgical protocols. J Periodontol. 2019;90(4):331-8. doi:10.1002/JPER.18-0041
25. Aggarwal V, Umarani M, Baliga SD, Issrani R, Prabhu N. Comparison between primary and secondary method of closing surgical wound after tooth extraction: A split-mouth study. Pesqui Bras Odontopediatria Clin Integr. 2021;21(11):e0227. doi:10.1590/pboci.2021.073
26. Rodrigues ÉDR, Martins-de-Barros AV, Loureiro AMLC, Carvalho M de V, Vasconcelos B. Comparison of two suture techniques on the inflammatory signs after third molars extraction–A randomized clinical trial. PLoS One. 2023;18(6):e0286413. doi:10.1371/journal.pone.0286413