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REVIEW

Alveolar Ridge Preservation in Posterior Extraction Sockets: A Literature Review and Proposal of a Novel Therapeutic Classification

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Background: Alveolar ridge preservation (ARP) is a critical procedure used to maintain post-extraction socket dimensions and the residual bone morphology is a key determinant of surgical outcomes. However, existing classification systems predominantly focus on the timing of implant placement rather than ARP protocols. Limited studies have developed classifications specifically for ARP, and none have addressed the unique anatomical challenges of posterior extraction sockets.

Methods: A comprehensive review of the literature was conducted in PubMed, Web of Science and Scopus from January 2000 to June 2025. Keywords such as "extraction socket", "tooth socket", and "classification" were used to evaluate existing classification systems.

Results: The existing classification systems primarily target timing selection for implant placement in the anterior zone. To date, only three studies have developed classification systems specifically for ARP, all of which fail to differentiate between anterior and posterior sites despite their distinct resorption patterns. Therefore, based on a synthesis of existing literature and clinical rationale, we propose a novel classification system specifically designed for posterior extraction sockets in the context of ARP. Type A sockets are characterized by one compromised wall with a vertical defect of less than 50%, while Type B involves one compromised wall with a vertical defect of no less than 50%. Type C extraction sockets are severely damaged and involve two compromised walls. For each type, specific ARP techniques were recommended, with varying levels of intervention required for optimal ridge preservation.

Conclusion: This study introduces a novel classification system specifically for posterior extraction sockets tailored for ARP procedure. Although the system enhances clinical decision-making, further clinical validation is required to confirm its applicability and effectiveness in practice.

Keywords: alveolar ridge preservation, socket preservation, extraction socket classification, posterior extraction socket

Introduction

Currently, successful osseointegration is no longer the sole objective of implant therapy.[1] An ideal three-dimensional position of the implant, along with long-term aesthetic and functional success, has become a critical element for successful implant treatment.[2,3] Hard tissue, however, is the foundation of obtaining good results aforementioned.[4,5]

As a tooth-dependent structure, the alveolar ridge undergoes significant morphological alterations horizontally and vertically following tooth loss, which occurs rapidly within the first 3–6 months and progresses at a slower rate thereafter. According to a systematic review assessing the magnitude of dimensional changes in the alveolar ridge, 29–63% horizontal bone loss and 11–22% vertical bone loss were observed in the first six months following tooth extraction.[6] Furthermore, facial or buccal bone loss is generally more pronounced than bone loss in other socket walls. This disproportionate resorption shifts the alveolar ridge margin lingually during spontaneous healing, creating an uneven

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ridge contour that may complicate subsequent implant placement.[7] In particular, at sites with severe bone loss due to endodontic or periodontal reasons, tooth extraction may evoke aggravated dimensional changes of the alveolar ridge as well as the overlying soft tissue, thereby increasing the difficulty of implant treatment.[8–10] Posterior sockets, with more complex resorption patterns and proximity to critical structures like the maxillary sinus or inferior alveolar nerve, may complicate implant positioning, making tailored preservation strategies essential. Inadequate assessment of posterior extraction sockets can lead to increased need of secondary augmentations or compromised implant positioning, which ultimately affect functional and aesthetic outcomes.

Prosthetically driven immediate implant placement combined with customized healing abutments may facilitate socket sealing, stabilize peri-implant gaps, and support early soft-tissue conditioning by minimizing flap elevation and guiding tissue maturation.[11,12] Emerging evidence further indicates that, in the maxillary esthetic zone, immediate implant placement supported by appropriate regenerative procedures and prosthetic management can achieve acceptable short-term clinical and radiographic outcomes in extraction sockets with buccal bone defects.[13,14] However, in posterior regions with severe alveolar bone deficiency, immediate implant-based strategies often fail to provide predictable hard-tissue support, and ridge resorption may still occur. Scientific evidence reveals that, compared to natural-healing sockets, alveolar ridge preservation (ARP) treatment may reduce horizontal bone loss by 1.5–2.4 mm, vertical mid-buccal bone loss by 1–2.5 mm, and mid-lingual vertical bone loss by 0.80–1.5 mm.[15] In the molar region, ARP procedure attains better hard tissue preservation and pink esthetic score-a clinical index assessing peri-implant soft-tissue appearance, compared to immediate implant placement.[16] The configuration of socket bone determines the outcome of ridge preservation, so an accurate evaluation of extraction sockets is needed before surgery.[7] To date, most studies have suggested anterior teeth classifications, solely targeting the timing selection for implant placement (immediate, early or delayed implant placement).[17] In contrast, classification systems specifically designed for ARP remain scarce. Existing ARP-oriented classifications mainly emphasize the condition of the buccal bone, while the defects of the palatal/lingual plate are overlooked.[18] Although Kim et al proposed a more comprehensive classification incorporating both hard and soft tissue, its clinical application involves additional soft-tissue augmentation procedures, potentially increasing patient trauma.[19] Moreover, no socket classification has been specifically proposed for ARP in posterior regions. Therefore, the present study aims to propose a new classification for posterior extraction sockets and provide ARP treatment recommendations.

Materials and Methods

An extensive literature review was conducted on PubMed, Web of Science and Scopus from January 2000 to June 2025 to investigate extraction socket classification. The search was designed to identify studies relevant to extraction sockets and related classification systems. The following keywords were used: "extraction socket", "tooth socket", and "classification". Boolean operators (AND, OR) were used to refine the search. Additionally, a manual search was performed by reviewing the reference lists of relevant articles.

Studies were included in the literature review if they evaluated extraction socket classification systems assessing hard and/or soft tissue parameters, while studies were excluded if they were animal or in-vitro studies or if they focused on multiple sockets.

Two reviewers independently conducted the quality assessment. In cases of disagreement, a third investigator was consulted to finalize the decision, ensuring a robust and unbiased evaluation process.

Results

The included studies investigating extraction socket classification were displayed in Table 1. Extraction socket classifications have evolved to guide implant placement, alveolar ridge preservation (ARP), interdisciplinary communication and bone resorption patterns. Early socket classification systems were primarily developed to facilitate implant placement in the anterior aesthetic zone, incorporating both hard and soft tissue parameters. Hard tissue evaluation typically included assessments of buccal bone height and thickness, the number of compromised socket walls, mesio-distal dimensions, periapical bone topography and interproximal bone level. Soft tissue analysis encompassed periodontal biotype, vertical

Table 1 Summary of Extraction Socket Classification Systems

Year of Publication	Objective	Area	Hard Tissue Parameters	Soft Tissue Parameters
Caplanis, 2005[20]	Classification for implant placement	Anterior sites	Number of affected bone wall, vertical hard tissue loss	Periodontal biotype
Evian, 2011[21]			Integrity of the bone wall	Integrity of the soft tissue
Yafi, 2019[7]			Interproximal bone loss, buccal bone thickness, buccal bone integrity	Gingival phenotype,gingival margin position
Juodzbalys, 2008[22]			Alveolar process height, bone beyond the apex, labial plate vertical position, facial bone thickness, presence of socket bone lesions, intradental bone peak height, mesio-distal distance, need for palatal angulation	Soft tissue contour, soft tissue vertical deficiency, keratinized gingiva width, mesial and distal papillae appearance, gingival tissue biotype
Chaar, 2016[23]		Single-rooted sites	Buccal plate loss, periapical bone topography, interproximal bone level	Soft tissue biotype
Sabri, 2023[24]			Buccal bone thickness and dehiscence, interproximal bone loss, apical lesions, root position	Buccal soft tissue level, the etiology of extraction, soft tissue phenotype
Smith, 2013[25]		Molar sites	Septal bone morphology and the remaining space after immediate implant placement	-
Bleyan, 2021[26]			Interradicular septum width	-
Iyer, 2014[27]	Classification for ARP treatment	-	The number of non-intact alveolar wall, the thickness of surrounding bone wall	-
Kim, 2021[19]		-	The number of residual bone wall, percentage of buccal or palatal/lingual bone loss	The level of buccal or palatal/lingual gingiva
Steigmann, 2022[18]		-	Buccal bone integrity, buccal bone thickness	-
Elian, 2007[28]	Classification for interdisciplinary communication	Anterior sites	Buccal bone	Facial soft tissue
Kan, 2011[29]			Sagittal root position	-
Lin, 2025[30]	Classification for bone resorption patterns	Molar sites	Buccal or lingual/palatal wall loss, difference between buccal and lingual/palatal bone heights	-

soft tissue deficiencies, mesial and distal papillae appearance, gingival margin position and keratinized gingiva width.[7,20–22]

Subsequent classification systems specifically addressed molar immediate implant placement, with a focus on the anatomical characteristics of interradicular septum width, as a key determinant for implant feasibility and stability.[25,26] In contrast to anterior sites, soft tissue was no more a critical factor in molar site.

More recently, classification systems tailored to ARP have emerged. These systems commonly considered the number of remaining socket walls, the severity of bone loss, and buccal bone thickness.[18,27] Notably, Kim's classification also incorporated the level of the buccal and lingual gingiva as a parameter, reflecting a more comprehensive approach to ARP-related decision-making.[19]

Additionally, Elian[28] and Kan[29] proposed socket classification schemes to enhance interdisciplinary communication and clinical documentation among dental professionals.

Proposal of a New Classification System

The majority of existing studies proposed socket classification systems to guide decision-making for implant placement.[7,21–23,25,31] Only a limited number—specifically three studies—have addressed socket classification in the context of ARP,[18,19] and none of them focused on posterior extraction sites. Thus, the present study focuses on the

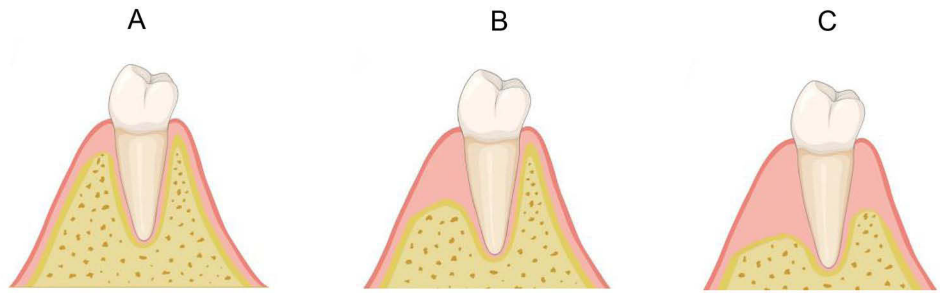

Figure 1 Classification of compromised posterior extraction sockets. (**A**) Type A socket: one compromised wall with a vertical defect of less than 50%; (**B**) Type B socket: one compromised wall with vertical defect of no less than 50%; (**C**) Type C socket: two compromised walls, both on the buccal and lingual/palatal sides.

phenotypic features of the posterior extraction socket for ARP procedure, which primarily relies on these two parameters (Figure 1 and Table 2):

1. Number of compromised socket walls: The morphology of the remaining bone walls should be analyzed via cone-beam computed tomography (CBCT) before tooth extraction.

2. Vertical bone defect: Radiographic measurements were conducted on coronal sections of CBCT images (Figure 2). A horizontal reference line was drawn perpendicular to the long axis of tooth, passing through the root apex (RA). The distance between the RA and 1mm below the cementoenamel junction (CEJ) was defined as RA-CEJ, while the distance from the alveolar crest (AC) to 1mm below the CEJ was defined as AC-CEJ. The vertical bone defect was calculated using the formula: (AC-CEJ)/(RA-CEJ) * 100%.

A Type A extraction socket involves only one compromised wall (either the buccal or palatal/lingual side), with a vertical defect of less than 50%, representing a slightly damaged pattern. A Type B extraction socket also involves one compromised wall, but with vertical defect of no less than 50%. A Type C extraction socket is severely damaged and involves two compromised walls, both the buccal and palatal/lingual sides.

The ARP surgical procedure is proposed on the basis of the extraction socket classification (Figure 3). For Type A sockets, which are defined as slight defects in one wall, DBBM mixed with 10% collagen (DBBM-C) is recommended and collagen sponge is utilized to cover the wound via an open healing technique, followed by cross and interrupted sutures. The graft is used to minimize alveolar resorption, whereas the membrane facilitates bone reconstruction by stabilizing the grafting material and preventing the ingrowth of epithelial and connective tissue.[31,32] A flapless procedure with secondary wound healing is preferred, as primary closure may cause discrepancies at the mucogingival junction and provide no benefit to the augmentation of keratinized tissue.[23] Predictable outcomes can be achieved in Type A sockets.

Type B sockets are characterized by the presence of one severely compromised wall or two moderately affected walls. In this situation, a tunnel approach is performed around the socket to separate the periosteum from the bone, and bone grafting of DBBM-C is grafted to fill the socket. Considering the large defect in one wall, a resorbable barrier membrane is employed, positioning below the tunneled soft tissue and on top of the bone to cover the graft material. Aside from a cross suture over the orifice, the membrane is fixed to the surrounding soft tissue through interrupted suture. In this category, one bone wall is intact, so predictable outcomes can be anticipated.

Type C sockets are the most challenging extraction sockets with at least one wall defect exceeding 50%. As the residual hard tissue is significantly inadequate, the outcome of the ARP procedure without space maintenance is quite

Table 2 Classification of Compromised Posterior Extraction Sockets

Number of Compromised Socket Walls	Vertical Bone Defect	Classification
1 wall (buccal or lingual/palatal)	< 50%	Type A
	≥ 50%	Type B
2 walls (buccal and lingual/palatal)		Type C

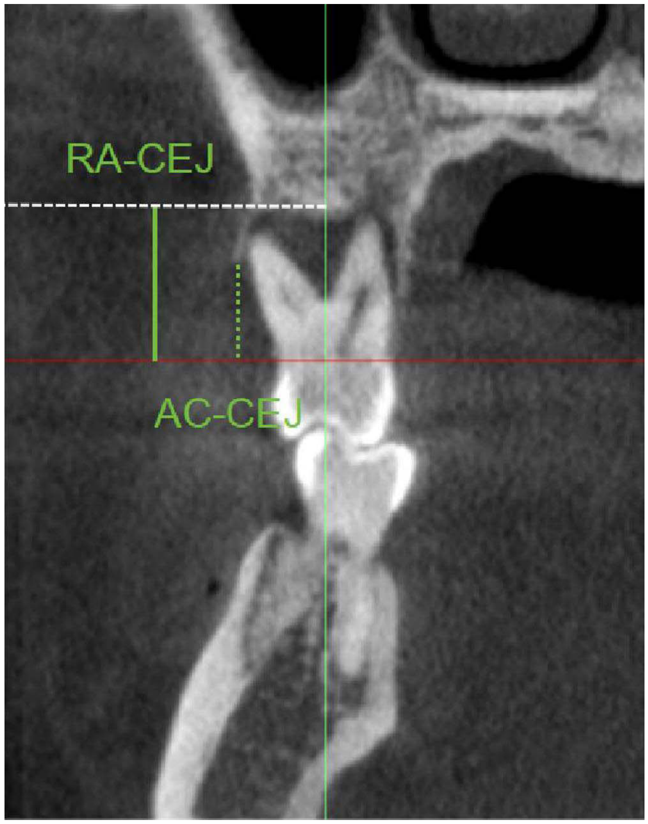

Figure 2 Measurement of vertical bone defect.
Abbreviations: RA, root apex; CEJ, cementoenamel junction; AC, alveolar crest.

poor. Bone screw/ tent screw technique is a good candidate to support the space, combined with the application of DBBM-C, a resorbable membrane or even a biologic agent. In fact, this is the alveolar ridge augmentation (ARA) technique, rather than the ARP procedure. Primary wound healing is necessary when ridge augmentation grafting is performed, to allow successful bone formation.[33] Although ridge augmentation with primary closure immediately after tooth extraction may lead to disharmony in the mucogingival junction, it can be corrected by soft tissue repositioning during implant second-stage implant surgery.

Notably, in patients with a severe soft tissue defect on one side (either the buccal or lingual/palatal side), a delayed ARP protocol is recommended (4–8 weeks post-extracion) rather than immediate surgery (Figure 4).

Discussion

Despite minimally invasive tooth extraction, extraction sockets usually present deficiencies in hard and/or soft tissue aspects due to pathological factors.[15] The ARP procedure demonstrates effectiveness in maintaining severely compromised sockets.[34,35] No difference in implant success after 12 months of functional loading was demonstrated between unassisted sockets and ARP intervention sockets, although less new bone formation was observed at ARP sites.[15,36] A minimum healing time of 3–4 months prior to implant placement is needed, and extended time may be required depending on the phenotype of extraction socket, individual differences and the various ARP techniques utilized.[15]

It was originally believed that primary closure is necessary to protect and stabilize graft materials in ARP treatment.[37,38] Various techniques have been proposed to close the socket orifice, including coronally advanced flaps and soft tissue grafts.[39,40] However, a second surgical site is inevitable with the use of soft tissue grafts and flap elevation may lead to decreased keratinized mucosa width and wound swelling.[17,41] Recently, an open healing technique involving a flapless approach has been applied in ridge preservation, and promising results have been reported regarding ridge dimension maintenance.[42] This technique minimizes surgical trauma and reduces patient discomfort, while also

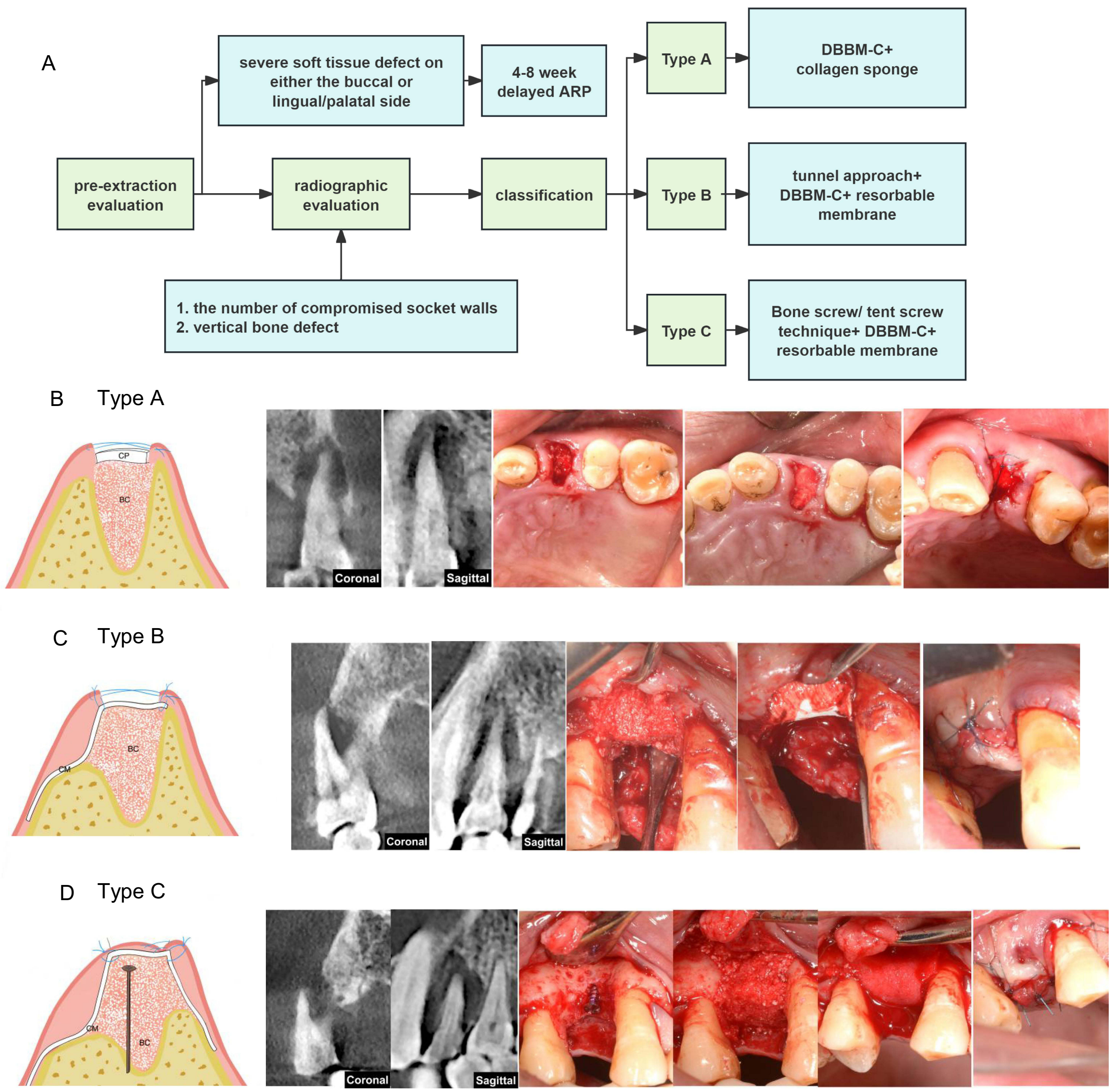

Figure 3 Treatment options and recommendations for the present classification. (**A**) Decision tree of proposed extraction socket classification; (**B**) Type A socket: Particle bone with 10% collagen is recommended to fill the socket; subsequently, a collagen plug is utilized to cover the wound via an open healing technique. The collagen plug is secured by cross and interrupted sutures as illustrated; (**C**) Type B socket: In addition to the particle bone with 10% collagen, an absorbable membrane is employed, positioning below the tunneled soft tissue and on top of the bone to cover the graft material; (**D**) Type C socket: Bone screw/ tent screw technique is used to support the space, combined with the application of DBBM with 10% collagen and a resorbable membrane. The wound is completely sutured to achieve primary wound healing.
Abbreviations: BC, particle bone with 10% collagen; C, collagen plug; CM, collagen membrane.

increasing the keratinized mucosa width and maintaining mucogingival junction line.[43] In particular, studies revealed no difference between primary and secondary healing in terms of vital bone percentage or histological and morphological parameters, although slower wound healing during the first 4 weeks was observed in the secondary healing group.[44,45] The combined use of a barrier membrane and bone grafts revealed better results than the use of bone grafts alone; therefore, resorbable polylactide-polyglycolide sponges, collagen sponges, collagen plugs, collagen matrix seals, and collagen wound dressings were utilized independently as an orifice coverage in ridge preservation.[46–50]

The existing classification systems primarily target timing selection for implant placement in the anterior zone, irrespective of ARP treatment (Table 2). Only three studies have proposed classifications specific to ARP. Steigmann[18] introduced a three-type classification system based on buccal-bone thickness (≥ or <1 mm) and morphology (intact,

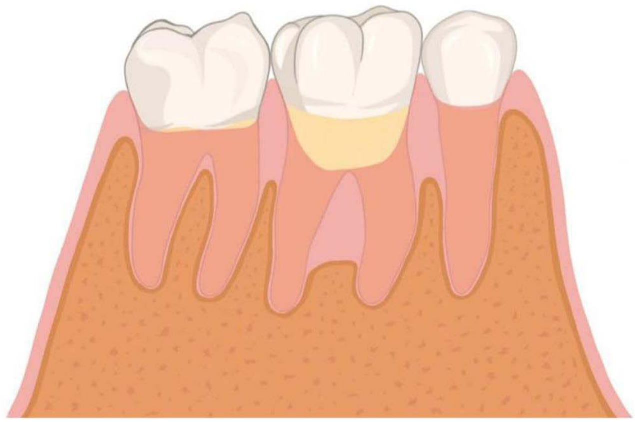

Figure 4 Compromised tooth with severe soft tissue defects on either buccal or lingual/palatal side.

dehiscent, or fenestrated), utilizing a collagen matrix or resorbable/non-resorbable membrane. Nevertheless, limitations could not be overlooked, as this classification exclusively focused on the buccal bone, neglecting defects of the palatal/lingual bone. Kim suggested a more complicated five-type classification considering both the hard and soft tissue; however, connective tissue graft technique was employed to compensate for the soft tissue defects, which could lead to a traumatic results for the patients.[19] On the other hand, posterior extraction sockets experience distinct healing patterns compared to anterior sockets, attributable to three key anatomical differences: (1) larger socket orifice dimensions, (2) the presence of septal and furcation bone in multi-rooted teeth, and (3) significant disparities between buccal and lingual plate dimension in molar region.[51] However, classifications for ARP mentioned above fail to distinguish between anterior and posterior sockets. Although Smith[25] proposed a different classification specifically for the molars, concerning septal bone morphology and the remaining space after implant placement, the main purpose of the study was immediate implant placement, not on the ARP procedure. Compromised molars are frequently associated with severe periodontitis and ARP treatment can reduce the risk of proximity to the mandibular nerve structure and maxillary sinus in subsequent implant surgery.[52] Furthermore, ARP intervention can prevent food impaction by minimizing post-extraction alveolar height discrepancies, particularly at periodontally compromised molar sites where such complications frequently occur.

Hence, a new classification of posterior socket morphology oriented toward the ARP procedure is proposed in the present study, which may improve clinical decision-making and surgical outcomes. The morphology of the buccal and lingual/palatal bone walls directly impacts bone formation patterns;[53] therefore, we propose a simplified extraction socket classification system based solely on the number of affected bone walls and the severity of vertical bone loss. We employed DBBM with 10% collagen as a bone graft to fill the extraction sockets, highlighting the superiority in clinical manageability and mechanical durability compared to DBBM granules. In Type A sockets with slight bone defects, we recommend the use of a sponge to seal the orifice; however, for Type B sockets with severe bone loss, resorbable membrane suturing to the surrounding soft tissue is applied to prevent the ingrowth of epithelial and connective tissue. Both Type A and Type B sockets experience open healing, resulting in the augmentation of keratinized tissue and the maintenance of the mucogingival line consistency. The type C socket is more precisely described as “ridge augmentation” rather than “ridge preservation”, as the objective is to restore the damaged ridge beyond its boundary by using rigid scaffold.[7,54,55] In such sockets, primary wound closure is necessary to ensure undisturbed and uninterrupted wound healing according to the “PASS” principle; therefore, the ARP procedure can be delayed until the socket orifice is fully covered by soft tissue.[33]

Soft tissue contour emerges as a clinically significant prognostic factor for ARP outcomes. Although our proposed classification system is principally designed to assess hard tissue parameters without incorporating soft tissue dimensions, the soft tissue integrity critically influences intervention timing. For soft tissue deficiencies exceeding 50% (buccal or lingual/palatal), we advocate a 4–8 week delay before performing ARP to optimize tissue conditions. This concept is similar to that of early implant, in which no significant bone changes occur within 8 weeks post extraction.[56]

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Various factors may influence the outcome of ridge preservation, such as flap elevation technique or flapless approach, different bone graft materials and barrier membranes, but none of these factors can completely prevent alveolar bone loss following tooth extraction.[57–59] In addition to xenogeneic bone substitutes, allogeneic graft materials with enhanced osteogenic potential have demonstrated favorable outcomes in ridge preservation, while their clinical use is limited by restricted donor availability and higher costs.[60] Autologous grafts, including particulate autologous bone and autologous dentin, have been reported to reduce dimensional ridge changes and support new bone formation in extraction sockets, though their application may be limited by donor-site morbidity and additional surgical time.[57,61,62] Likewise, both resorbable and non-resorbable membranes have proven effective in ridge preservation, with material selection primarily influenced by defect morphology, soft-tissue conditions, and the need for space maintenance.[63,64] Despite the presence of various ARP approaches, no definitive conclusion has been reached on the best ARP procedure.[15] Also, reduced vertical and horizontal dimensional changes in the alveolar ridge are still observed after ARP intervention, indicating that ARP adoption cannot fully compensate for bone resorption after tooth extraction.[65] Nevertheless, a randomized controlled trial focusing on molar extraction sites demonstrated that ridge preservation significantly reduced horizontal bone loss compared with unassisted healing.[42] Therefore, the present study proposes a simplified classification of posterior extraction sockets and the relevant surgical protocol from the perspective of minimally invasive surgery, minimal patient complaints and reduced surgical time. Further randomized controlled trials are needed to validate the superiority of this classification.

Conclusion

This study introduces a streamlined classification system for posterior extraction sockets in alveolar ridge preservation, categorizing sockets into three types based on the number of compromised walls and the extent of vertical bone loss. Type A sockets are characterized by one compromised wall with a vertical defect of less than 50%, while Type B involves one compromised wall with a vertical defect of no less than 50%. Type C extraction sockets are severely damaged and involves two compromised walls. Although the system offers a structured approach for decision-making, its validity must be confirmed through prospective clinical trials and inter-examiner reliability studies. Future research should focus on evaluating long-term functional and aesthetic outcomes to establish its clinical relevance.

Disclosure

Li-li Zhou and Wenlin Yuan are co-first authors for this study. The authors report no conflicts of interest in this work.

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