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PRACA POGLĄDOWA
REVIEW

Novel approaches for oroantral communication closure: A literature review

Nowoczesne metody zamykania połączeń ustno-zatokowych – przegląd piśmiennictwa

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ABSTRACT

INTRODUCTION: Oroantral communication (OAC) and oroantral fistula (OAF) are common complications of maxillary posterior tooth extraction. Although conventional flap techniques remain effective, they are associated with postoperative morbidity, anatomical alterations, and limitations in patients requiring future implant rehabilitation. Regenerative and biomaterial-based approaches have emerged as potential alternatives. The aim of this study is critically evaluate the clinical effectiveness, safety, and indications of novel regenerative and biomaterial-based techniques for OAC and OAF closure.

METHODS: A systematic search of PubMed/MEDLINE, Scopus, and Embase was conducted for human clinical studies published between 2000 and 2025. Randomized controlled trials, non-randomized clinical studies, cohort studies, and case series (≥5 patients) assessing regenerative or biomaterial-based closure methods were included. Due to heterogeneity, a qualitative synthesis was performed.

RESULTS: Autologous blood-derived products, particularly platelet-rich fibrin and concentrated growth factors, achieved high closure success (90%–100%) in small-to-medium defects (≤5 mm) with reduced postoperative pain and enhanced healing. Heterologous and synthetic biomaterials enabled simultaneous defect closure and bone regeneration, while combined approaches were most suitable for larger defects or planned implant rehabilitation.

CONCLUSIONS: Regenerative and biomaterial-based approaches are effective adjuncts or alternatives to conventional flaps in selected cases. However, evidence quality remains limited, highlighting the need for standardized, controlled clinical trials.

KEYWORDS

oroantral communication, oroantral fistula, platelet-rich fibrin, concentrated growth factors, biomaterials, regenerative dentistry, maxillary sinus, oral surgery

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STRESZCZENIE

WSTĘP: Połączenie ustno-zatokowe (*oroantral communication* – OAC) oraz przetoka ustno-zatokowa (*oroantral fistula* – OAF) to częste powikłania po ekstrakcji zębów bocznych szczęki. Chociaż klasyczne techniki płatowe pozostają skuteczne, wiążą się z licznymi powikłaniami pooperacyjnymi, takimi jak silne dolegliwości bólowe, znaczny obrzęk, zmiany anatomiczne tkanek miękkich, oraz ograniczeniami u pacjentów wymagających przyszłej rehabilitacji implantoprotetycznej. Jako potencjalną alternatywę terapeutyczną wskazuje się nowatorskie metody regeneracyjne oparte na biomateriałach. Celem pracy jest krytyczna ocena skuteczności klinicznej, bezpieczeństwa oraz wskazań do stosowania nowoczesnych technik regeneracyjnych i biomateriałów w zamykaniu OAC i OAF.

METODY: Przeprowadzono systematyczne przeszukiwanie baz PubMed/MEDLINE, Scopus oraz Embase w celu identyfikacji badań klinicznych z udziałem pacjentów, opublikowanych w latach 2000–2025. Do analizy włączono randomizowane badania kontrolowane, nierandomizowane badania kliniczne, badania kohortowe oraz serie przypadków (≥5 pacjentów), oceniające metody zamykania OAC i OAF z wykorzystaniem technik regeneracyjnych lub biomateriałów. Ze względu na heterogeniczność badań zastosowano syntezę jakościową.

WYNIKI: Autologiczne preparaty krwiopochodne, w szczególności fibryna bogatopłytkowa oraz skoncentrowane czynniki wzrostu, wykazywały wysoką skuteczność zamknięcia (90–100%) w przypadku małych i średnich ubytków (≤5 mm), przy jednoczesnym zmniejszeniu bólu pooperacyjnego i poprawie procesu gojenia. Biomateriały heterogenne i syntetyczne umożliwiały jednoczesne zamknięcie ubytku oraz regenerację tkanki kostnej, natomiast techniki łączone były najbardziej odpowiednie w przypadku większych ubytków lub planowanej rehabilitacji implantoprotetycznej.

WNIOSKI: Techniki regeneracyjne i oparte na biomateriałach to skuteczne uzupełnienie lub alternatywa dla klasycznych technik płatowych w wybranych przypadkach klinicznych. Jednak jakość dowodów naukowych pozostaje ograniczona, co podkreśla konieczność prowadzenia standaryzowanych, kontrolowanych badań klinicznych.

SŁOWA KLUCZOWE

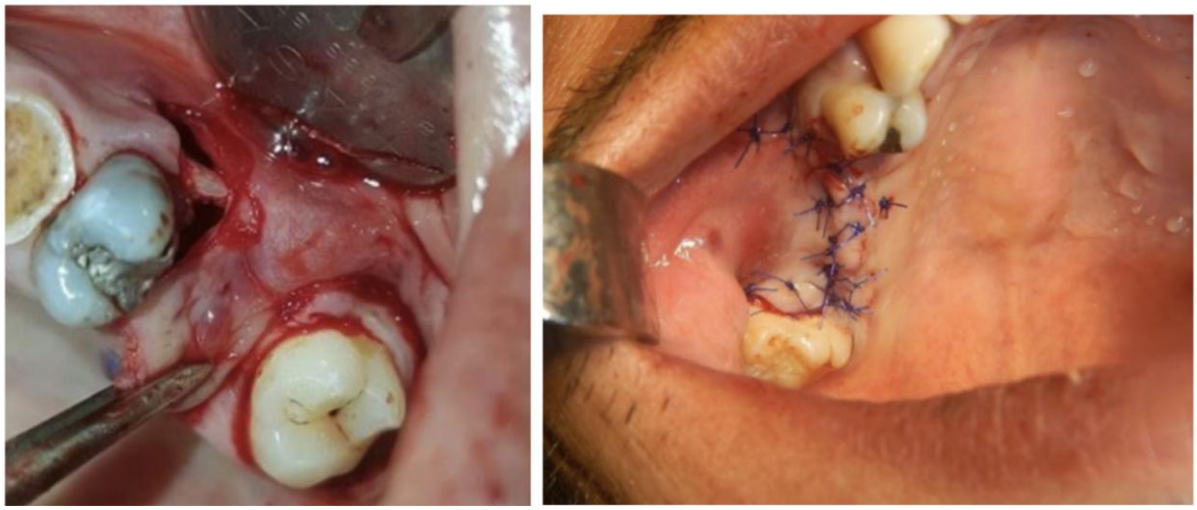
połączenie ustno-zatokowe, przetoka ustno-zatokowa, fibryna bogatopłytkowa, skoncentrowane czynniki wzrostu, biomateriały, stomatologia regeneracyjna, zatoka szczękowa, chirurgia stomatologiczna

INTRODUCTION

Oroantral communication (OAC) is defined as a pathological connection between the oral cavity and the maxillary sinus. It occurs in approximately 4.8% of extractions of maxillary posterior teeth, with the highest incidence reported after removal of the first molar (7.0%) [1,2]. If an OAC remains untreated for 48–72 hours or longer, epithelialization of the tract may occur, leading to the formation of an oroantral fistula (OAF), which necessitates more complex surgical management [3]. Dental extraction represents the predominant etiological factor, particularly when procedures are performed in the presence of periapical pathology [4,5]. Additional predisposing factors include root protrusion into the maxillary sinus, the presence of sinus recesses around the roots, reduced alveolar bone width, and the absence of adjacent teeth [6].

Conventional management of OAC and OAF has traditionally relied on local flap techniques, most notably buccal advancement flaps, palatal rotational flaps, and buccal fat pad mobilization, as shown in Figures 1 and 2 [2,7,8]. Although these methods have reported acceptable success rates, they are associated with several clinically relevant drawbacks. Buccal advancement flaps exhibit increased relapse rates in larger defects measuring 0.6–1.5 cm, with complete failure in large defects reported in some clinical series and frequently result in vestibular shortening that may compromise subsequent prosthetic rehabilitation [7]. Palatal rotational flaps, while effective, require advanced surgical expertise and have been associated with a relatively higher incidence of postoperative complications [2,9]. Management is further complicated by secondary maxillary sinusitis, which is present in up to 48.9% of chronic OAF cases and has historically been regarded as a relative contraindication to primary closure [10,11].

The limitations of traditional surgical techniques, including postoperative morbidity, technical complexity, anatomical alteration, and higher recurrence rates in larger defects, have stimulated interest in alternative regenerative and biomaterial-based strategies. These approaches aim not only to achieve reliable closure of the communication but also to promote tissue regeneration, minimize surgical trauma, reduce postoperative complications, and preserve anatomical conditions favorable for future implant-supported rehabilitation. This trend is particularly relevant in the context of the increasing demand for implant placement in the posterior maxilla following tooth extraction.



A B

Fig. 1. Closure of an oroantral communication using a buccal advancement flap technique. (A) Intraoperative view after extraction and identification of the oroantral communication in the posterior maxilla. A trapezoidal mucoperiosteal flap is designed with releasing incisions in the vestibular mucosa. The full thickness flap is elevated to expose the defect and to allow adequate mobilization. Periosteal scoring is performed at the base of the flap to achieve tension free advancement. (B) Postoperative view following coronal advancement of the buccal flap and primary closure of the defect. The flap is sutured with interrupted non resorbable sutures, ensuring complete coverage of the communication and stable wound margins. Tension free adaptation is achieved to promote predictable healing and prevent recurrence.

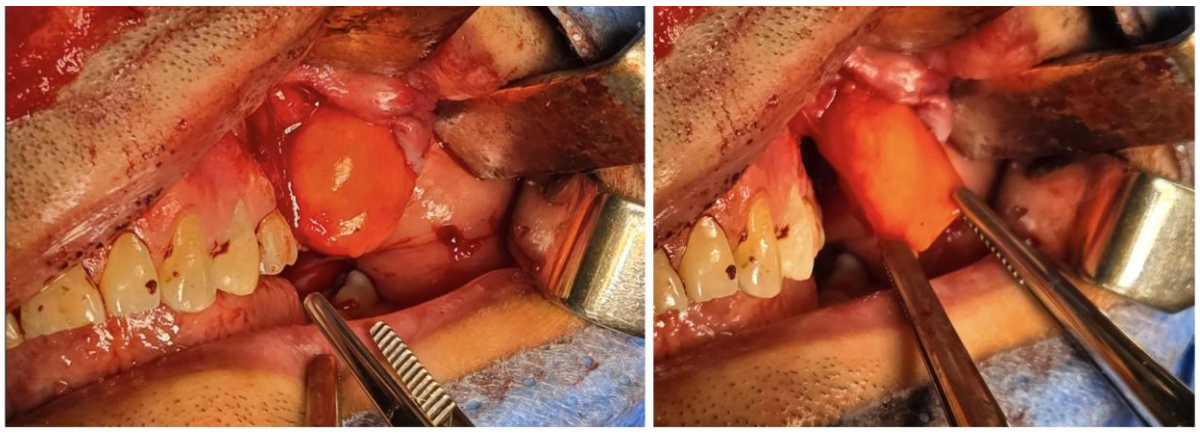


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Fig. 2. Closure of an oroantral communication using the pedicled buccal fat pad, Bichat flap technique. (A) Intraoperative view after identification of the oroantral communication in the posterior maxilla. Following elevation of a mucoperiosteal flap, the buccal fat pad is accessed through a periosteal incision posterior to the zygomatic buttress. The encapsulated adipose tissue is gently mobilized and advanced into the defect while maintaining its vascular pedicle. (B) The buccal fat pad is carefully spread to adequately cover the antral opening without tension. The flap is positioned over the defect to achieve complete closure and is subsequently stabilized with resorbable sutures to the surrounding mucosal margins, providing a well vascularized tissue layer that supports rapid epithelialization and predictable healing.

Recent developments in autologous blood-derived products, particularly platelet-rich fibrin (PRF) and concentrated growth factors (CGF), have shown encouraging clinical outcomes in terms of defect closure and wound healing [5,12,13]. Heterologous biomaterials, including cortico-cancellous bone grafts combined with resorbable collagen membranes and porcine cortical lamina, have been proposed as effective alternatives, that allow simultaneous soft tissue closure and hard tissue regeneration [14,15]. Synthetic biomaterials, such as biodegradable polyurethane (PU) foam and attachable oral wound dressings (OWDs), have been used as minimally invasive treatment options with reduced procedure times [7,16,17]. More advanced technologies, including prefabricated computer-aided design and computer-aided manufacturing (CAD-CAM) allogenic bone scaffolds, represent emerging regenerative approaches, with histological evidence confirming new bone formation sufficient to support subsequent implant placement [18].

This review critically evaluates the available evidence on novel regenerative and biomaterial-based approaches for the closure of OAC and OAF, with particular emphasis on clinical outcomes, indications, limitations,

and comparative effectiveness relative to traditional surgical techniques. By synthesizing data on autologous blood-derived products, heterologous biomaterials, synthetic materials, and combined treatment strategies, this review aims to provide evidence-based guidance for optimal technique selection according to defect characteristics, timing of intervention, sinus pathology, and future restorative requirements.

METHODS

Study design and reporting standard

This study was designed as a systematic review conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines [19]. The review protocol was defined a priori and specified the eligibility criteria, search strategy, study selection process and data extraction. Due to substantial clinical and methodological heterogeneity, quantitative meta-analysis was not performed.

Focused research question

The research question was formulated according to the PICO framework:

Population: patients with OAC or OAF

Intervention: regenerative or biomaterial-based closure techniques

Comparison: conventional surgical flap techniques or alternative regenerative approaches

Outcomes: defect closure success, healing parameters, complications, and radiographic bone outcomes

The focused question was: What is the clinical effectiveness and safety of regenerative and biomaterial-based approaches for the closure of oroantral communications and fistulas compared with conventional surgical techniques?

Eligibility criteria

Studies were included if they met all the following criteria:

- human clinical studies involving patients with OAC or OAF
- evaluation of regenerative or biomaterial-based closure techniques
- randomized controlled trials, controlled clinical trials, cohort studies, or case series with at least five patients
- reporting at least one clinically relevant outcome (primary or secondary outcomes defined below)
- published in English between January 2000 and December 2025

Exclusion criteria were:

- animal or in vitro studies
- case reports with fewer than five patients
- studies focused exclusively on sinus augmentation or implant placement without explicit OAC/OAF closure outcomes
- reviews, editorials, and conference abstracts
- insufficient or non-extractable data

When reported, defect size was categorized as small (<5 mm), medium (5–10 mm), and large (>10 mm) to enable structured comparison across studies. When studies used alternative thresholds, data were mapped to the closest category where possible.

For the purposes of this review, OAC was defined as a non-epithelialized communication between the oral cavity and maxillary sinus, whereas OAF was defined as an epithelialized tract persisting beyond 48–72 hours. When studies did not explicitly differentiate OAC and OAF, classification was based on the authors' description and timing of presentation.

Information sources and search strategy

A comprehensive electronic search was conducted in PubMed/MEDLINE, Scopus, and Embase for studies published between January 2000 and December 2025. The search strategy combined controlled vocabulary and free-text terms related to oroantral defects and regenerative interventions.

The core search strategy included combinations of:

("oroantral communication" OR "oroantral fistula") AND ("regenerative" OR "biomaterial" OR "platelet-rich fibrin" OR "platelet-rich plasma" OR "concentrated growth factors" OR "collagen membrane" OR "bone graft" OR "synthetic biomaterial" OR "scaffold").

The reference lists of included studies and relevant reviews were manually screened to identify additional eligible articles.

Study selection

All identified records were imported into reference management software and duplicates were removed. Two independent reviewers screened titles and abstracts for eligibility. Full texts of potentially relevant articles were subsequently assessed against the inclusion criteria. Any disagreements were resolved through discussion and consensus, with a third reviewer consulted when necessary.

Data extraction

Data extraction was performed independently by two reviewers using a standardized data collection form. Extracted variables included study design, sample size, patient characteristics, defect type (OAC/OAF), defect size, intervention details, comparator (if applicable), follow-up duration, and reported outcomes. When required, corresponding authors were contacted for missing or unclear information.

RESULTS

Study selection

The PRISMA flow diagram illustrates the structured study selection process (Figure 3). A total of 1,107

records were identified through database searching, including 312 from PubMed/MEDLINE, 428 from Scopus, and 367 from Embase. After removal of 356 duplicate records, 751 studies remained for title and abstract screening. Of these, 662 were excluded based on predefined eligibility criteria. Eighty-nine reports were sought for full-text retrieval, and all were successfully obtained and assessed for eligibility. Following full-text evaluation, 52 reports were excluded for specific reasons: absence of an OAC/OAF population (n = 18), lack of a regenerative or biomaterial intervention (n = 11), case reports with fewer than five patients (n = 9), insufficient outcome data (n = 8), and review or editorial articles (n = 6). Ultimately, 37 studies met the inclusion criteria and were incorporated into the qualitative synthesis.

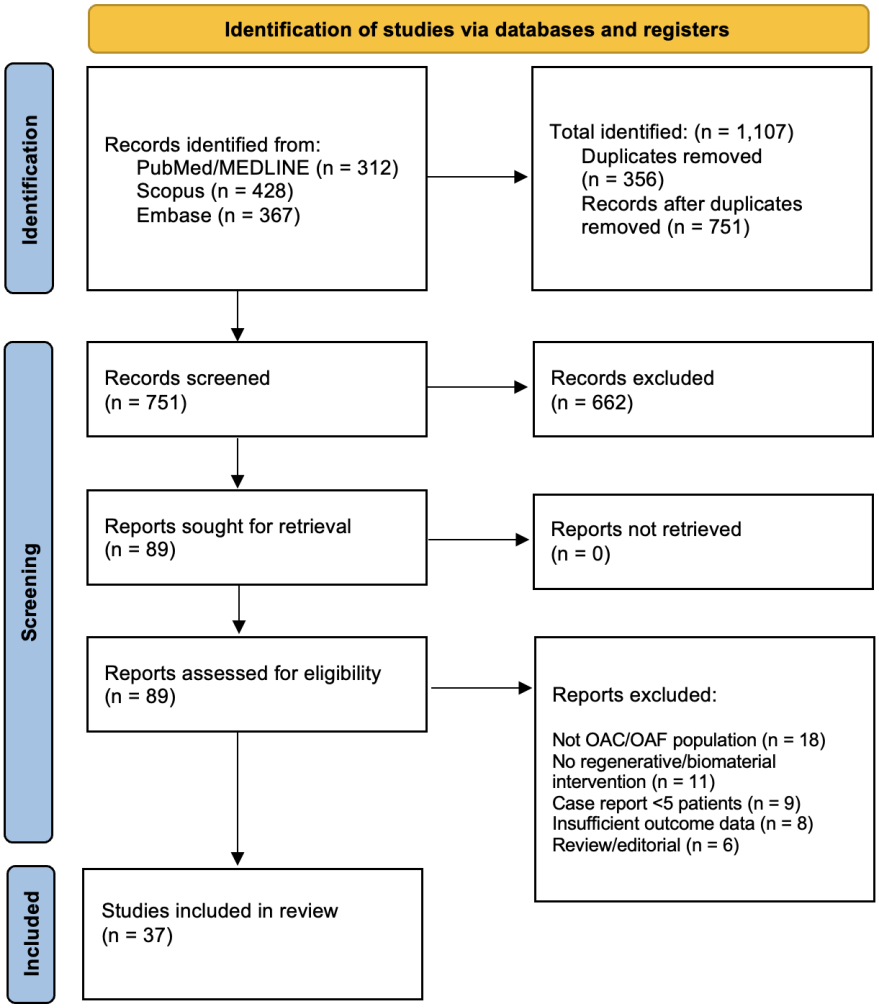

Fig. 3. PRISMA 2020 flowchart

Among regenerative strategies for OAC and OAF closure, PRF and CGF are the most extensively investigated autologous approaches [20,21]. These blood-derived preparations can be used alone or as adjuncts to other techniques.

Autologous blood-derived products

PRF clots can be placed directly into the extraction socket and sutured to surrounding gingiva for stabilization, achieving successful closure in acute OACs larger than 3 mm [22,23]. PRF demonstrates better wound healing scores, less displacement of the mucogingival border, and lower postoperative pain compared to traditional buccal advancement flaps [12,13,14,15,16,17,18,19]. For defects greater than 5 mm, PRF should be considered an adjunct rather than sole treatment [20]. CGFs similarly achieve closure success for 3–5 mm defects while demonstrating better new bone height, volume, and density compared to suture repair alone [13,21,22,23]. CGF provides benefits for both soft and hard tissue healing with reduced postoperative pain. An example of PRF use is shown in Figure 4.

A B C D

Fig. 4. Closure of an oroantral communication using platelet-rich fibrin (PRF). (A) Intraoperative view of the posterior maxilla after extraction with visible oroantral communication and debridement of the socket. The defect margins are refreshed and irrigated to remove granulation tissue and ensure a clean surgical field. (B) Preparation and insertion of autologous PRF into the communication. The PRF membrane is gently adapted to fill and cover the antral opening, providing a biologically active scaffold rich in growth factors. (C) Stabilization of the PRF within the defect and initial adaptation of the surrounding soft tissues. The membrane is positioned to ensure complete coverage of the communication. (D) Final closure with interrupted sutures securing the soft tissues over the PRF clot, achieving primary wound closure and promoting enhanced soft tissue healing through the regenerative potential of the platelet concentrate.

Heterologous biomaterials

Heterologous cortico-cancellous bone grafts covered with resorbable collagen membranes effectively close small OACs (>3 mm) while simultaneously achieving bone regeneration [23]. This approach can be enhanced by stabilization with porcine cortical lamina, which prevents migration of pathological epithelia and increases bone ridge height [24]. Both techniques showed closure success with radiographic evidence of bone regeneration at 6 months.

Prefabricated CAD-CAM allogenic bone scaffolds represent an advanced approach for larger defects with OAC, demonstrating successful closure and bone regeneration sufficient for subsequent implant placement [18,25]. Histological analysis at 5 months showed 32% newly formed bone with 28% volume retention after scaffold biodegradation.

Synthetic biomaterials

Biodegradable PU foam in conical shape achieved successful OAC closure in 80% of patients (8/10) for fresh communications present less than 24 hours [16,26]. This represents a straightforward, minimally invasive alternative that may eliminate the need for surgical flap procedures in select cases.

Attachable OWD is a commercially available product that achieved closure success for acute 2–5 mm OACs with significantly shorter procedure duration and lower pain scores compared to both sterile gauze and PRF approaches [7,27]. An example of the use of resorbable membranes is shown in Figures 5 and 6.

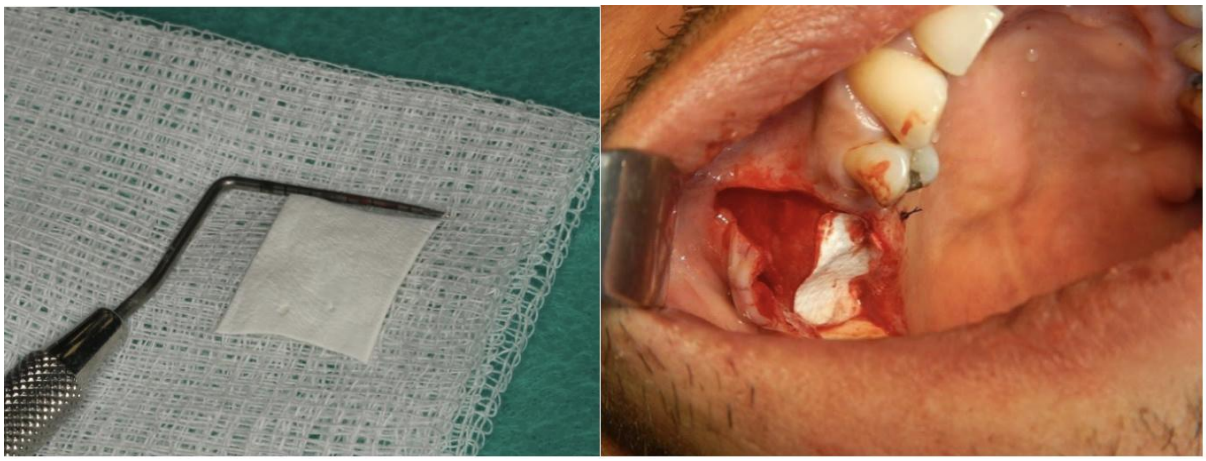

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Fig. 5. Resorbable collagen membrane used for closure of an oroantral communication. (A) Preoperative view of the resorbable collagen membrane trimmed to appropriate dimensions prior to intraoral placement. The material is prepared to match the size of the defect and to allow stable adaptation. (B) Intraoperative view following debridement of the oroantral communication and positioning of the collagen membrane over the antral opening. The membrane is adapted to the defect margins to create a mechanical barrier between the sinus cavity and the oral environment, supporting clot stabilization and guided soft tissue healing.

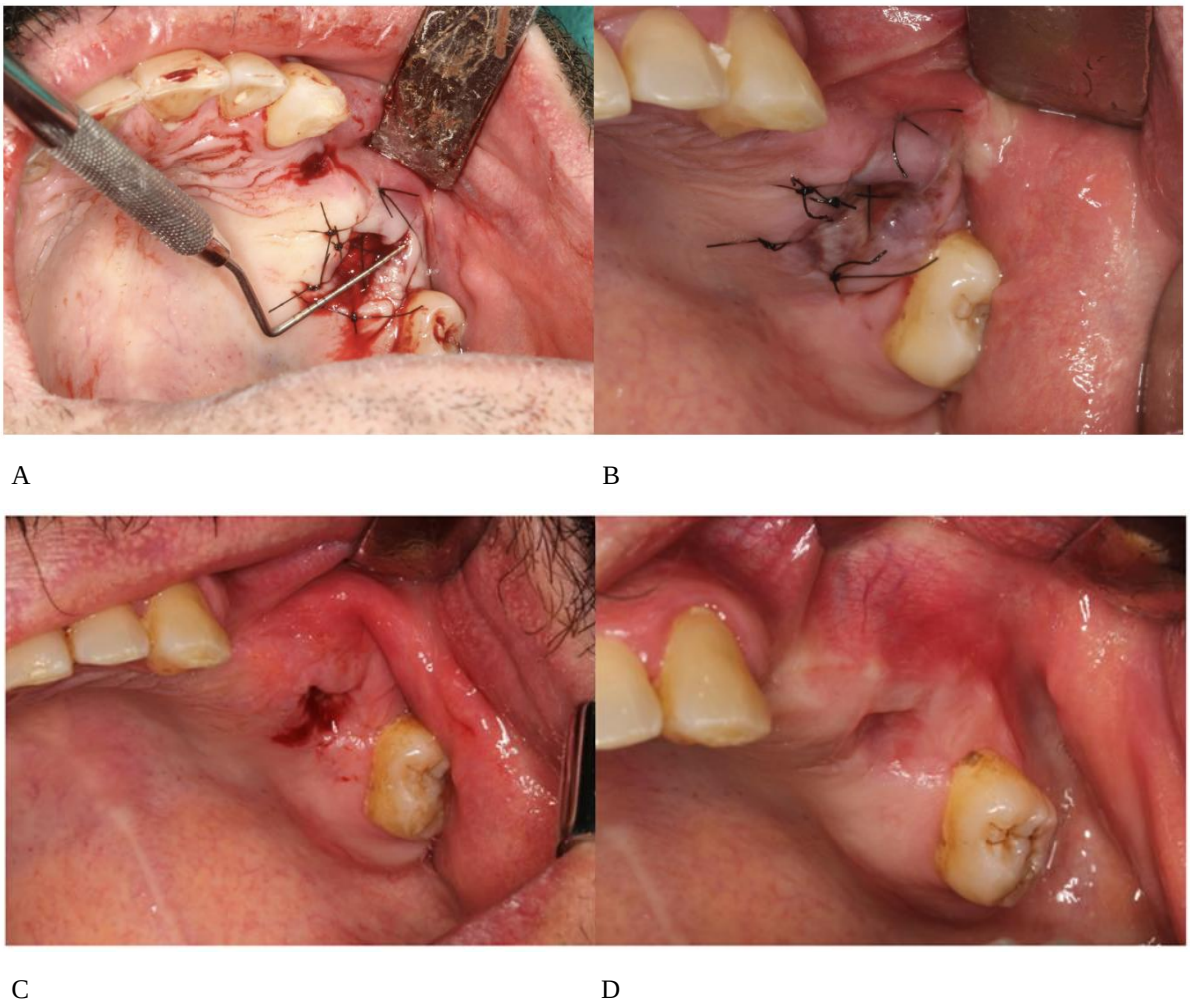

Fig. 6. Closure of an oroantral communication using a resorbable membrane. Clinical follow up. (A) Day 0. Intraoperative view after debridement of the oroantral communication and placement of a resorbable collagen membrane. The membrane is stabilized with interrupted sutures to achieve primary soft tissue adaptation and separation of the sinus cavity from the oral environment. (B) Day 1. Early postoperative appearance showing stable wound margins, initial fibrin coverage, and absence of dehiscence. (C) Day 14. Progressive soft tissue healing with partial epithelialization of the surgical site and reduction of local inflammation. (D) Day 21. Advanced healing with near complete epithelial coverage of the defect and satisfactory soft tissue contour without signs of persistent communication.

Combined approaches

For larger defects or when implant restoration is planned, xenogenic bone grafts combined with buccal fat pad can be utilized through a lateral sinus elevation approach, optimizing conditions for implant placement while preserving vestibular depth [3,28]. This technique provides both functional rehabilitation and anatomic reconstruction.

The selection of regenerative or biomaterial-based methods should consider defect size, timing of intervention (acute versus chronic), presence of sinus pathology, and future restorative needs. Defects smaller than 5 mm can sometimes be managed with blood-derived products, while larger defects typically require combination approaches with biomaterials and/or local flaps [20,29,30].

Across the included studies, defect size consistently emerged as the principal determinant of treatment selection. Blood-derived products such as PRF and CGF demonstrated the most predictable outcomes in acute defects up to approximately 5 mm, whereas larger communications generally required combination approaches incorporating biomaterials and local flaps. These size-dependent trends form the basis for the comparative analysis presented in the discussion [20,21,22,23,24,25,30].

DISCUSSION

Comparative outcomes, indications, and limitations: regenerative/biomaterial vs. traditional flap techniques

Given the heterogeneity of outcome reporting across studies, emphasis in the present review was placed primarily on defect closure success, while secondary outcomes were interpreted descriptively. Comparative analysis indicates that regenerative approaches can achieve high closure rates in carefully selected small-to-medium defects, particularly in acute commu-

nications [16,31,32,33,34,35]. However, outcome variability increases with defect size and chronicity, and direct equivalence with traditional flap techniques cannot be assumed across all clinical scenarios.

Success rates and outcomes

In one prospective study, PRF achieved a 90% closure rate (18/20), comparable to buccal advancement flap outcomes in similar defect ranges, although age and defect size significantly influenced results [31].
Traditional flaps show variable success depending on defect size and technique. Buccal advancement flaps demonstrate high relapse rates for large defects (0.6––1.5 cm), with all 10 large defects failing in one series [36]. In contrast, buccal fat pad flaps achieved success with zero relapses across all defect sizes, including large communications [36].
Regenerative approaches consistently demonstrate lower pain scores and reduced swelling. PRF showed better wound healing scores, less displacement of the mucogingival border, and lower pain levels compared to buccal advancement flaps [31]. Pain scores on postoperative day 1 were significantly lower for OWD (1.05 ± 1.43) and PRF (2.5 ± 1.82) compared to sterile gauze (4.35 ± 2.85) [7]. CGF patients reported significantly lower pain on days 1 and 3 postoperatively [35].
Traditional flaps, particularly buccal advancement techniques, cause vestibular shortening and mucosal tension that may interfere with prosthetic rehabilitation [37]. The buccal fat pad preserves vestibular depth but requires more extensive surgical expertise [36].

Procedure complexity and duration

Biomaterial-based approaches are generally associated with shorter procedure times and reduced surgical complexity. In particular, the use of OWDs has been reported to significantly decrease operative duration compared with conventional methods [7]. Similarly, PRF and CGF may obviate the need for flap elevation, thereby simplifying the procedure and reducing technical demands [35]. Traditional flaps require greater technical skill, particularly for palatal rotational flaps and buccal fat pad mobilization [2,36,37].

Indications by defect size

Defect size remains the most consistent determinant of technique selection [21,31,35]. Evidence summarized above indicates that blood-derived products are most predictable in small acute communications [21,22,35], whereas larger defects typically require tissue flap procedures, often combined with grafting materials when future implant rehabilitation is planned [3,10,11,28]. Importantly, threshold values reported across studies are not fully standardized [12,24], and clinical decision-making should incorporate defect chronicity, sinus status, and soft tissue availability in addition to linear defect measurements [32,33,34, 35,36].

Bone regeneration capacity

Biomaterial approaches may provide enhanced hard tissue regeneration. CGF demonstrated significantly better new bone height, volume, and density at 90 days [9]. Heterologous cortico-cancellous grafts with resorbable collagen membranes achieved bone regeneration in all cases at 6 months while successfully closing communications [30]. Prefabricated CAD-CAM allogenic scaffolds showed 32% newly formed bone with 28% volume retention at 5 months [25]. Traditional flaps focus primarily on soft tissue closure without addressing bone deficits, though they can be combined with bone grafting materials.
For immunocompromised patients or those receiving radiotherapy, the buccal fat pad demonstrates advantages due to its stem cell capacity and robust vascular supply. Among seven patients who received radiotherapy, four showed relapses with buccal advancement flaps [4]. Buccal fat pad techniques showed no complications even in compromised patients [4]. For acute versus chronic defects, biodegradable PU foam achieved permanent closure [4].

CONCLUSIONS

Regenerative and biomaterial-based approaches have broadened the therapeutic spectrum for the management of OAC and OAF. Autologous blood-derived products, particularly PRF and CGFs, have been associated with favorable closure outcomes in small--to-medium defects, together with reduced postoperative morbidity and improved soft tissue healing. Heterologous and synthetic biomaterials may offer additional benefits by enabling simultaneous defect closure and bone regeneration, which is clinically relevant in patients considered for future implant--supported rehabilitation. When compared with conventional flap techniques, regenerative strategies may achieve comparable closure success in carefully selected cases while preserving vestibular anatomy and potentially reducing patient discomfort. However, defect size, chronicity, sinus status, and soft tissue availability remain critical determinants of treatment selection, and larger communications generally require combined approaches incorporating biomaterials and local flaps. The current evidence base is limited by small sample sizes, heterogeneous study designs, and variable outcome reporting. Therefore, regenerative and biomaterial-based techniques should presently be regarded as complementary rather than definitive replacements for established surgical methods. Future research should prioritize well--designed randomized controlled trials, standardized defect classification, and long-term evaluation of functional and restorative outcomes to support more robust, evidence-based clinical recommendations.

Use of AI tools statement
Grammarly AI was used for language correction.

Authors' contribution
Study design – A. Balicz, J. Fiegler-Rudol
Data collection – A. Balicz, A. Warakomska, P. Mojżesz
Manuscript preparation – A. Balicz, J. Fiegler-Rudol, P. Mojżesz, T. Morawiec
Literature research – A. Balicz, A. Warakomska, P. Mojżesz, T. Morawiec
Final approval of the version to be published – T. Morawiec

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