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Post-Extraction Bleeding in Contemporary Dental Practice: Advances in Risk Assessment and Hemostatic Management-A Critical Review

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Abstract

Background: Post-extraction bleeding (PEB) remains a clinically relevant complication in dental practice, particularly among patients receiving antithrombotic therapy and those with multiple systemic comorbidities. The increasing use of direct oral anticoagulants (DOACs) and the development of novel local hemostatic materials have further emphasized the need for evidence-based approaches to bleeding risk assessment and management.

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Objective: This critical review summarizes contemporary evidence on the risk assessment, prevention, diagnosis, and management of PEB, with particular emphasis on recent advances in antithrombotic management and local hemostatic interventions.

Materials and Methods: A structured critical narrative review was conducted in accordance with the principles of the Scale for the Assessment of Narrative Review Articles (SANRA). English-language literature published between January 2020 and May 2026 was identified through searches of PubMed/MEDLINE, Scopus, and Web of Science using predefined terms related to post-extraction bleeding, antithrombotic therapy, anticoagulants, antifibrinolytic agents, and local hemostatic interventions. Relevant clinical studies and contemporary evidence were critically evaluated, with methodological quality assessed according to study design, randomization, blinding, sample size, and risk of bias. Due to substantial heterogeneity among studies, findings were synthesized narratively.

Results: Contemporary evidence supports individualized bleeding-risk assessment based on patient-related factors, antithrombotic therapy, and procedural complexity. Point-of-care International Normalized Ratio (INR) monitoring may facilitate preoperative risk assessment in selected patients receiving vitamin K antagonists. Current evidence generally supports the continuation of antithrombotic therapy for many routine dental ex-tractions, with treatment modification considered only when clinically justified and in consultation with the prescribing physician. Tranexamic acid has demonstrated value as an adjunctive antifibrinolytic measure, particularly for reducing postoperative and delayed bleeding. Emerging local hemostatic strategies, including platelet-rich fibrin and chitosan-based dressings, have shown promising results for achieving hemostasis and supporting wound healing. Among the 16 studies subjected to formal quality assessment, 3 (19%) were classified as having low risk of bias, 9 (56%) as moderate risk, and 4 (25%) as high risk of bias.

Conclusions: Contemporary management of PEB should be based on individualized risk stratification rather than routine interruption of antithrombotic therapy. Local hemostatic measures remain central to treatment, while antifibrinolytic agents and emerging bio-material-based approaches offer promising adjunctive strategies. Nevertheless, the avail-able evidence remains heterogeneous, and further well-designed randomized clinical trials are needed to establish standardized protocols and determine the comparative effectiveness of emerging hemostatic interventions.

Keywords

Antithrombotic therapy; Dental extraction; Direct oral anticoagulants; Hemostatic agents; Platelet-rich fibrin; post-extraction bleeding; Risk assessment; Tranexamic acid.

Abbreviations

DOAC, direct oral anticoagulant; VKA, vitamin K antagonist; NOAC, non-vitamin K oral anticoagulant; TXA, tranexamic acid; PRF, platelet-rich fibrin; A-PRF+, advanced platelet-rich fibrin; L-PRF, leukocyte-platelet-rich fibrin; HEM, hemostatic plug; GS, gelatin sponge; PEB, post-extraction bleeding; HAS-BLED, Hypertension, Abnormal renal/liver function, Stroke, Bleeding history or predisposition, Labile INR, Elderly, Drugs/alcohol concomitantly; RCT, randomized controlled trial.

Introduction

Tooth extraction remains one of the most commonly performed invasive procedures in routine dental practice, with millions of extractions performed annually worldwide [1]. While the procedure itself is generally straightforward, post-extraction bleeding (PEB) is a recognized and frequently encountered complication that presents a significant clinical challenge. PEB is conventionally defined as bleeding that persists beyond 8 to 12 hours following dental extraction or, more pragmatically, as "bleeding that continues without clot formation, or lasts beyond 8 to 12 hours" [1]. More comprehensive criteria include bleeding that necessitates a return visit or emergency department consultation, causes ecchymosis or massive hematoma formation, or requires hospitalization or blood transfusion [2].

The clinical significance of PEB extends beyond immediate physical consequences. Although the majority of postoperative bleeding does not inflict severe physiological harm, its ramifications on patients' mental and psychological well-being can be substantial. Patients often experience anxiety, fear, and distress when confronted with persistent oral bleeding, particularly given the visually alarming nature of blood mixed with saliva. In severe cases, complications can range from soft tissue hematomas to significant blood loss requiring hospitalization and transfusion [3].

The epidemiology of PEB has evolved considerably over recent decades. While historically associated with local factors such as inadequate postoperative compression or trauma to the extraction site, the contemporary landscape is increasingly shaped by systemic factors. The aging global population, coupled with the widespread use of antithrombotic medications for cardiovascular and cerebrovascular disease prevention, has created a growing cohort of patients at elevated bleeding risk [4]. The introduction of direct oral anticoagulants (DOACs) has further complicated clinical decision making, as these agents present distinct pharmacological profiles and bleeding risk patterns compared to traditional vitamin K antagonists [5].

A landmark Cochrane review on interventions for treating PEB identified no randomized controlled trials suitable for inclusion, highlighting a striking evidence gap [1]. A subsequent systematic review by Nisi et al. (2022) found that while 22 studies addressed hemostatic agents in anticoagulated patients, all were at moderate to high risk of bias, and limited evidence was available for patients treated with DOACs [6]. The Cochrane review was declared stable in 2018 with no ongoing RCTs identified, underscoring the persistent evidence-practice gap in PEB management.

However, the period from 2020 to 2026 has witnessed substantial advances in the evidence base with the publication of several pivotal original studies. These include the study by Brennan et al. (2020) comparing DOACs versus warfarin [7], the study by Ockerman et al. (2021) evaluating tranexamic acid in NOAC-treated patients [8], and multiple comparative effectiveness trials evaluating hemostatic agents such as platelet-rich fibrin (PRF) [9,10], chitosan-based dressings [11,12], and other hemostatic materials [13,14]. A 2026 systematic review and network meta-analysis has further evaluated local hemostatic therapy in patients on antithrombotic therapy [28], while a 2026 scoping review has examined the combination of gelatin sponge and tranexamic acid in anticoagulated patients [27]. This narrative review aims to provide a comprehensive overview of the current state of knowledge regarding PEB from 2020 to 2026, with a focus on recent innovations in diagnosis and treatment. Evidence from 16 key original clinical studies, was synthesized to critically appraise emerging technologies and therapeutic modalities, and identify priority areas for future research.

Materials and Methods

To provide a comprehensive overview of current practices and emerging strategies in PBE management, a narrative review of the literature was conducted according to the SANRA scale (Scale for the Assessment of Narrative Review Articles) [15]. While we employed systematic search methods including structured database queries, PRISMA-guided screening, and formal quality assessment, the synthesis of findings follows a narrative approach due to the heterogeneity of study designs, interventions, and

outcome measures. This approach is consistent with the methodology of systematic narrative reviews that combine rigorous search strategies with qualitative synthesis.

Data were collected from English-language articles published between January 2020 and May 2026. The following major databases were used for the search: PubMed/Medline, Scopus, and Web of Science.

Search strategy

To ensure methodological transparency and reproducibility, we developed structured search strategies adapted to the distinct syntax and field-coding of each biblio-graphic database. The searches were constructed using a combination of controlled vocabulary (MeSH terms in PubMed) and free-text keywords across four interconnected thematic domains: (1) the primary clinical condition (post-extraction bleeding, dental ex-traction bleeding, tooth extraction), (2) hemostatic interventions (tranexamic acid, chitosan, platelet-rich fibrin, hemostatic agent), (3) patient-related risk factors (anticoagulant, DOAC, warfarin, antiplatelet), and (4) diagnostic innovations (POC), INR). Boolean operators (AND, OR) were used to combine synonyms within each domain and to link the four domains together, ensuring comprehensive retrieval of relevant literature.

For PubMed/Medline, the following search query was executed:

((("tooth extraction"[tw] OR "dental extraction"[tw] OR exodontia[tw] OR "alveolar bleeding"[tw] OR "extraction site bleeding"[tw]) AND (bleed[tw] OR hemorrhage[tw] OR haemorrhage[tw])) OR "post-extraction bleeding"[tw] OR "dental extraction bleeding"[tw])

AND (tranexamic[tw] OR chitosan[tw] OR "platelet-rich fibrin"[tw] OR PRF[tw] OR hemostat[tw] OR haemostat[tw] OR "collagen sponge"[tw] OR "gelatin sponge"[tw] OR gelfoam[tw] OR surgicel[tw] OR "oxidized cellulose"[tw] OR cyanoacrylate[tw] OR anti-fibrinolytic[tw] OR "fibrin sealant"[tw] OR "point-of-care"[tw] OR "point of care"[tw] OR INR[tw] OR "International Normalized Ratio"[tw] OR viscoelastic[tw] OR TEG[tw] OR thromboelastography[tw] OR "bleeding time"[tw] OR "prothrombin time"[tw] OR "acti-vated partial thromboplastin time"[tw] OR aPTT[tw] OR "bedside testing"[tw]) AND

(anticoagulant[tw] OR DOAC [tw] OR NOAC [tw] OR warfarin[tw] OR antiplate-let[tw] OR antithrombotic[tw] OR rivaroxaban[tw] OR apixaban[tw] OR dabigatran[tw] OR edoxaban[tw] OR clopidogrel[tw] OR aspirin[tw] OR acetylsalicylic[tw] OR hemo-philia[tw] OR haemophilia[tw] OR thrombocytopenia[tw] OR "coagulation disorder"[tw]) AND (2020:2026[dp]) AND english[la]

For Scopus, the parallel string was tailored to the TITLE-ABS-KEY field as follows:

TITLE-ABS-KEY(((((("tooth extraction" OR "dental extraction" OR exodontia) AND (bleed OR hemorrhage OR haemorrhage)) OR "post-extraction bleeding" OR "dental ex-traction bleeding") AND (tranexamic OR chitosan OR "platelet-rich fibrin" OR PRF OR hemostat* OR haemostat* OR "collagen sponge" OR "gelatin sponge" OR gelfoam OR sur-gicel OR "oxidized cellulose" OR cyanoacrylate OR antifibrinolytic OR "fibrin sealant" OR "point-of-care" OR "point of care" OR INR OR "International Normalized Ratio" OR visco-elastic OR TEG OR thromboelastography OR "bleeding time" OR "prothrombin time" OR "activated

partial thromboplastin time" OR aPTT OR "bedside testing") AND (anticoagu-lant* OR DOAC OR NOAC OR warfarin OR antiplatelet OR antithrombotic OR rivaroxa-ban OR apixaban OR dabigatran OR edoxaban OR clopidogrel OR aspirin OR acetylsali-cylic OR hemophilia OR haemophilia OR thrombocytopenia OR "coagulation disorder")) AND PUBYEAR > 2019 AND PUBYEAR < 2027 AND (LIMIT-TO(LANGUAGE, "Eng-lish"))*

For Web of Science, the Topic (TS) field was searched using the string:

TS=(((("tooth extraction" OR "dental extraction" OR exodontia) AND (bleed OR hemorrhage OR haemorrhage)) OR "post-extraction bleeding" OR "dental extraction bleeding") AND (tranexamic OR chitosan OR "platelet-rich fibrin" OR PRF OR hemostat* OR haemostat* OR "collagen sponge" OR "gelatin sponge" OR gelfoam OR surgicel OR "oxidized cellulose" OR cyanoacrylate OR antifibrinolytic OR "fibrin sealant" OR "point-of-care" OR "point of care" OR INR OR "International Normalized Ratio" OR visco-elastic OR TEG OR thromboelastography OR "bleeding time" OR "prothrombin time" OR "activated partial thromboplastin time" OR aPTT OR "bedside testing") AND (anticoagu-lant* OR DOAC OR NOAC OR warfarin OR antiplatelet OR antithrombotic OR rivaroxa-ban OR apixaban OR dabigatran OR edoxaban OR clopidogrel OR aspirin OR acetylsali-cylic OR hemophilia OR haemophilia OR thrombocytopenia OR "coagulation disorder")) AND PY=2020-2026 AND LA=("English")*

Beyond these database-specific queries, the search was supplemented by manually screening the reference lists of included reviews and original studies to identify any addi-tional eligible publications not captured by the primary electronic searches. All retrieved records were exported to a reference manager for deduplication and subsequent screening.

Selection criteria

Inclusion Criteria Study Type: Peer-reviewed original clinical studies, including randomized controlled tri-als, prospective/retrospective cohort studies, case-control studies, and observational studies, focusing on PBE diagnosis and management. Systematic reviews and meta-analyses were used as background references but were not included in the primary synthesis of findings.

Time Frame: Studies published between January 2020 and May 2026.

- **Language:** Articles published in English.
- **Relevance:** Direct relevance to the diagnosis, treatment, multidisciplinary care approaches, or technological innovations in managing post-extraction bleeding.

Exclusion criteria

- Studies focused exclusively on bleeding complications unrelated to dental extrac-tions.
- Articles with combined data from both dental and non-dental procedures without separate dental extraction-specific data.
- Articles that did not offer direct insights into clinical management.
- Studies on animal models.

- Studies focused exclusively on preoperative bleeding risk assessment without ad-dressing diagnostic or therapeutic interventions for PEB.
- Systematic reviews and meta-analyses (used as background references only).

Data synthesis

A descriptive synthesis was employed to categorize the findings under thematic sections. These themes encompass epidemiological challenges, diagnostic innovations, traditional and novel treatment approaches, and multidisciplinary management strategies. Innovations such as (POC) testing, chitosan-based dressings, platelet-rich fibrin, tranexamic acid therapy, and tissue adhesives were specifically highlighted. The 16 key original clinical studies identified were summarized in (**Table 1**).

No.	Author	Year	Study Design	Patient Population	Intervention	Sample Size	Key Findings
1	Brennan Y, et al. [7]	2020	Prospective cohort	DOAC vs. warfarin patients	Continued DOAC vs. warfarin (INR 2.0-4.0)	86 DOAC, 21 warfarin	No major bleeding events; comparable bleeding rates; rivaroxaban levels higher in bleeders
2	Ockerman A, et al. [8]	2021	RCT, double-blind, placebo-controlled	NOAC patients	10% TXA mouthwash vs. placebo	218 patients	TXA did not reduce peri-procedural bleeding; reduced delayed bleeding and bleeding after multiple extractions
3	Brancaccio Y, et al. [9]	2021	Randomized clinical trial	Antiplatelet therapy patients	Suture alone vs. HEM vs. A-PRF+ vs. L-PRF	102 patients	A-PRF+ and L-PRF reduced bleeding risk; L-PRF improved wound healing; hypertension and diabetes highest bleeding risk
4	Yagyuu T, et al. [19]	2021	Retrospective cohort	Haemophilia patients	Risk factor analysis	55 patients	PEB observed in 16.3% of patients; severity of haemophilia and number of extractions were significant risk factors
5	Huang J, et al. [20]	2022	Case-control study	Antithrombotic drug patients	Risk factor analysis	340 patients (170/170)	Dual antithrombotic therapy, multiple extractions, and advanced age were independent risk factors
6	Ali T, et al. [24]	2022	Prospective cohort	Inherited bleeding disorders	Thrombin-gelatin matrix (Floseal)	38 patients	Floseal effectively prevented post-dental extraction haemorrhage in high-risk population
7	Kyyak S, et al. [10]	2023	Prospective randomized split-mouth	Factor Xa inhibitor patients	PRF vs. gelatin sponge	30 patients	PRF and GS both reliable; most mild oozing stopped by gauze pressure alone
8	Radhakrishna S, et al. [11]	2023	Randomized clinical trial	Antithrombotic patients	Chitosan dressing vs. cotton pressure pack	60 patients	Chitosan more effective in controlling bleeding in single and dual antithrombotic therapy
9	Guardieiro B, et al. [12]	2023	Within-person, single-blind RCT	Dual antiplatelet therapy patients	Chitosan dressing vs. cellulose oxidized gauze	90 patients	Chitosan dressing reduced bleeding time and improved healing
10	De Vasconcellos SJD, et al. [13]	2023	Randomized clinical trial	Anticoagulated patients	Topical TXA vs. collagen-gelatin sponge	40 patients (20 per group)	TXA more effective in controlling bleeding

11	Ueda K, et al. [21]	2023	Retrospective cohort	Elderly on anticoagulant therapy	Various anticoagulants	194 patients	Highest bleeding: rivaroxaban, followed by apixaban, warfarin, edoxaban
12	Kim MJ, et al. [18]	2024	Retrospective cohort	Antithrombotic therapy patients	Various antithrombotics	539 patients	1.7% extraction appointments associated with bleeding; highest risk in warfarin; women had highest rate
13	Bajkin BV, et al. [22]	2024	Prospective observational	DOAC vs. vitamin K antagonists	DOAC vs. vitamin K antagonists	200 patients	Comparable bleeding rates; multiple extractions and HAS-BLED >3 were significant predictors
14	AL-Suliman W, et al. [14]	2025	Clinical study	Anticoagulant therapy patients	Surgicel vs. Gelfoam	60 patients	Both agents effective; Surgicel shorter hemostasis time and lower re-bleeding rates than Gelfoam
15	Berton F, et al. [26]	2023	Cohort study	VKA and DOAC patients	L-PRF vs. no L-PRF	124 patients	L-PRF effective; no significant difference in bleeding rates between VKA and DOAC groups
16	Kaya İ, et al. [23]	2025	Prospective case-control with blinded evaluation	Patients on DOACs undergoing tooth extraction	Evaluation of postoperative bleeding and pain	1741 patients	Higher bleeding grades more common in DOAC group; multiple extractions and certain DOACs associated with higher bleeding risk

Table 1: Summary of Key Original Clinical Studies on Post-Extraction Bleeding (2020–2026). The table presents 15 key studies with their study design, patient population, intervention, sample size, key findings.

Quality Assessment

Quality assessment was performed for each of the 16 included studies using a comprehensive set of criteria adapted from the Oxford Centre for Evidence-Based Medicine (OCEBM) Levels of Evidence [16] and the Cochrane Risk of Bias tool [17]. The following domains were evaluated:

1. **Study Design**: The methodological rigor of each study was assessed based on its de-sign, with randomized controlled trials receiving the highest rating, followed by prospective cohort studies, retrospective cohort studies, and case-control studies.
2. **Randomization and Allocation Concealment**: For RCTs, we assessed whether randomization was properly performed and whether allocation concealment was maintained. Studies with adequate randomization and concealment were considered at lower risk of bias [8-14].
3. **Blinding:** We evaluated whether studies employed blinding of participants, personnel, and outcome assessors.
4. **Sample Size and Statistical Power**: Studies with adequate sample sizes and power calculations were considered higher quality.
5. **Risk of Bias Assessment**: We evaluated each study for selection bias, performance bias, detection bias, attrition bias, and reporting bias. Studies were categorized as low risk (RCTs with adequate randomization, blinding, and complete outcome data), moderate risk (well-designed cohort studies with potential confounding), or high risk (retrospective studies with incomplete data or lack of controls).

6. **Applicability and Generalizability:** We considered whether study findings could be applied to routine clinical practice, including patient populations, settings, and interventions.
    - Evidence Grade Assignment: Based on the OCEBM framework [16], each study was as-signed an evidence grade:
    - **Level IA:** Evidence from well-designed meta-analyses of randomized controlled trials or at least one large, properly designed RCT with low risk of bias.
    - **Level IB**: Evidence from at least one randomized controlled trial with some limitations (e.g., small sample size, incomplete blinding).
    - **Level IIA**: Evidence from at least one well-designed controlled study without randomization (prospective cohort).
    - **Level IIB:** Evidence from at least one other type of well-designed quasi-experimental study (retrospective cohort).
    - **Level III:** Evidence from well-designed non-experimental descriptive studies (case-control).
    - **Level IV:** Evidence from expert committee reports or opinions (not applicable to this re-view).

For each study, we documented the risk of bias assessment and evidence grade. Studies with multiple methodological strengths (e.g., randomization, blinding, adequate sample size) were considered to have lower risk of bias and received higher evidence grades. Conversely, retrospective studies with potential confounding and lack of controls were graded lower.

The quality assessment was conducted independently by both authors, with any uncertainties resolved through discussion. This approach ensured a transparent and systematic evaluation of the evidence base informing this narrative review. The detailed risk of bias assessment is presented in (**Table 2**).

Study	Selection Bias	Performance Bias	Detection Bias	Attrition Bias	Reporting Bias	Overall Risk	OCEBM Grade
Brennan et al. [7]	Low	N/A (cohort)	Moderate	Low	Low	Moderate	IIA
Ockerman et al. [8]	Low	Low	Low	Low	Low	**Low**	IA
Brancaccio et al. [9]	Low	Low	Low	Low	Low	**Low**	IA
Yagyuu et al. [19]	Moderate	N/A	Low	Moderate	Low	**High**	IIB
Huang et al. [20]	High	N/A	Moderate	Low	Moderate	**High**	III
Ali et al. [24]	Moderate	N/A	Moderate	Low	Low	Moderate	IIA
Kyyak et al. [10]	Low	Moderate	Low	Low	Low	Moderate	IIA
Radhakrishna et al. [11]	Low	Low	Low	Low	Low	**Low**	IB
Guardieiro et al. [12]	Low	Low	Low	Low	Low	**Low**	IB

De Vasconcellos et al. [13]	Low	Low	Low	Low	Low	**Low**	IB
Ueda et al. [21]	Moderate	N/A	Moderate	High	Moderate	**High**	IIB
Kim et al. [18]	Moderate	N/A	Low	Low	Moderate	Moderate	IIB
Bajkin et al. [22]	Low	N/A	Low	Low	Low	Moderate	IIA
AL-Suliman et al. [14]	Moderate	N/A	Low	Low	Low	Moderate	IIA
Berton et al. [26]	Low	N/A	Moderate	Low	Low	Moderate	IIA
Kaya et al. [23]	Moderate	N/A (case-control)	Low	Low	Low	Moderate	III

Table 2: Risk of Bias Assessment Summary.

Note: N/A = Not applicable (non-randomized studies)

Results

Search results and study characteristics

The systematic literature search identified a total of 285 records across the three da-tabases: 90 from PubMed/Medline, 60 from Scopus, and 135 from Web of Science. After removal of duplicates, 220 unique records remained for screening. Following title and ab-stract screening, 118 records were excluded based on the following criteria: animal studies (n=12), non-dental bleeding complications (n=28), preoperative risk assessment only (n=15), no direct clinical management insights (n=35), combined data without separate dental extraction data (n=18), and systematic reviews/meta-analyses (n=10). This yielded 102 full-text articles for eligibility assessment.

Of the 102 full-text articles assessed, 86 were excluded for the following reasons: no comparator (n=12), outcome not relevant (n=9), duplicate data/overlapping cohorts (n=8), full text unavailable (n=6), no direct clinical insights (n=15), preoperative assessment only (n=11), and non-original research such as editorials or letters without data (n=25). Ultimately, 16 original clinical studies met the inclusion criteria for qualitative synthesis, comprising 6 randomized controlled trials, 5 prospective cohort studies, 4 retrospective cohort studies, and 1 case-control/observational study (**Figure 1**).

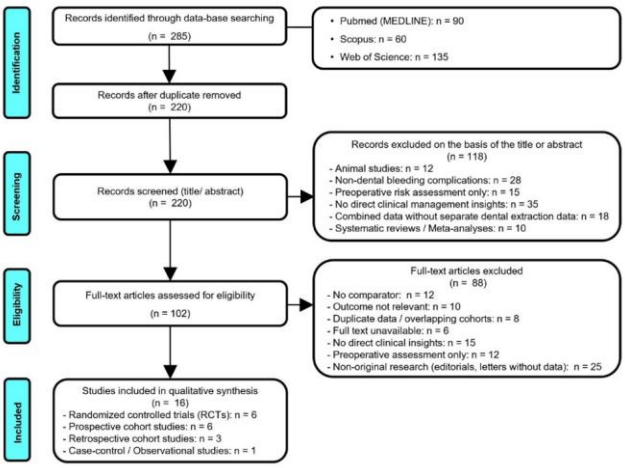

Figure 1: PRISMA Flowchart. Flow diagram showing the identification, screening, eligibility, and inclusion process for studies in this narrative review. Reasons for exclusion at each stage are provided with corresponding numbers.

Epidemiology and Risk Factors

Incidence and clinical presentation

The reported incidence of PEB varies considerably across studies. Kim et al. (2024) conducted a retrospective cohort study including 539 patients who attended 840 appointments for dental extractions and found that only 1.7% of extraction appointments were associated with postoperative bleeding [18]. The highest risk of bleeding was noted in patients receiving warfarin, whereas those on clopidogrel had no significant risk of bleeding. Women were found to have the highest rate of bleeding, particularly those on newer oral anticoagulant medications [18].

Medication-related risk factors

The growing use of antithrombotic medications represents the most significant modifiable risk factor for PEB. Among elderly patients under anticoagulant therapy, Ueda et al. (2023) conducted a retrospective cohort study and reported that the highest postoperative bleeding occurrence was recorded for rivaroxaban, followed by apixaban, warfarin, and edoxaban [21]. In a prospective observational study comparing DOACs and VKAs, Bajkin et al. (2024) found that the risk of postoperative bleeding after dentoalveolar surgery was similar between patients on DOACs and those on VKAs when antithrombotic therapy was continued [22]. Multiple tooth extractions and a HAS-BLED score >3 were identified as significant risk factors for bleeding in patients on DOACs [8].

Importantly, differences exist between DOAC types. The study by Brennan et al. (2020) [7] provided robust evidence that continuing DOAC therapy during dental extractions is safe, with bleeding rates comparable to patients on warfarin with therapeutic INR. However, the finding that rivaroxaban levels were higher in those who bled suggests the potential role of drug-level monitoring in selected high-risk patients [7]. A 2025 prospective case-control study by Kaya et al. further confirmed that higher bleeding grades were more common in the DOAC group, particularly among patients on rivaroxaban and edoxaban [23]. The higher bleeding rate associated with rivaroxaban may be attributed to its

pharmacokinetic profile, including its once-daily dosing regimen leading to higher peak plasma concentrations compared to twice-daily DOACs such as apixaban [5].

In patients with inherited bleeding disorders, a retrospective cohort study by Yagyuu et al. (2021) reported a PEB rate of 16.3% in patients with haemophilia, and identified that the number of teeth extracted and the use of factor replacement therapy were significant predictors [19]. Huang et al. (2022) conducted a case-control study and found that the use of dual antithrombotic therapy, multiple extractions, and the presence of hypertension were independent risk factors for PEB [20]. Ali et al. (2022) prospectively evaluated the use of thrombin-gelatin matrix (Floseal) in patients with inherited bleeding disorders, finding that Floseal effectively prevented post-dental extraction haemorrhage in this high-risk population [24] (**Figure 2**).

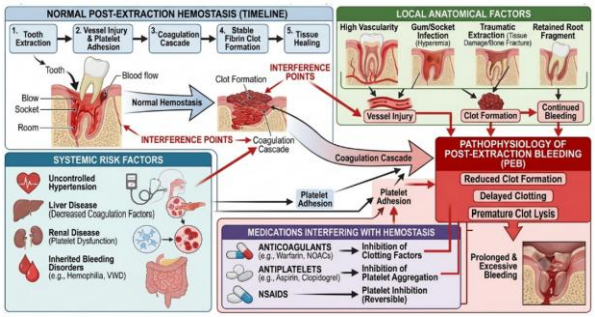

Figure 2: Schematic Representation of the Pathophysiology and Mechanisms of Post-Extraction Bleeding. The figure depicts the sequence of events from tooth extraction through clot for-mation, highlighting the points at which various risk factors and medications interfere with normal hemostasis. Key steps include: (1) Vascular Injury; (2) Platelet Plug Formation (inhibited by antiplatelet agents - marked with red dashed arrow); (3) Coagulation Cascade Activation (in-hibited by anticoagulants such as warfarin and DOACs - marked with red dashed arrow); (4) Fi-brin Clot Formation (enhanced by hemostatic agents such as PRF, chitosan, and gelatin sponge - marked with green solid arrow); (5) Fibrinolysis (inhibited by tranexamic acid - marked with blue dashed arrow). Intervention points for anti-platelet agents, anticoagulants, tranexamic acid, and hemostatic agents are indicated with colored arrows and labels.

Innovations in Diagnostic Tools

Point-of-care INR testing

Recent innovations in point-of-care (POC) testing have transformed the preoperative assessment of bleeding risk. POC INR devices have demonstrated accuracy com-parable to laboratory measurements, offering valuable risk assessment that may help pre-dict bleeding risk and provide reassurance for low-risk cases. A 2020 validation study by Bhat et al. confirmed that POC INR testing in the hospital setting showed a strong correlation with standard laboratory methods [25]. POC testing for INR allows medical staff to analyze patient blood clotting directly, where patients receive care from the clinic through doctor's offices up to home environments, rather than sending blood samples to laboratories.

Standardized classification systems

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In order to overcome issues related to heterogeneous definitions of PEB, a classification has been proposed based on the well-recognized Bleeding Academic Research Consortium (BARC) bleeding definition, aiming at reducing heterogeneity in this field. The BARC classification for PEB includes the following categories:

- Type 0: No bleeding (normal post-extraction oozing resolving within 8 hours)
- Type 1: Bleeding requiring no intervention (blood-tinged saliva, resolves spontaneously)
- Type 2: Bleeding requiring local intervention (re-application of pressure, sutures, topical hemostatic agents)
- Type 3: Bleeding requiring medical attention (emergency department visit, hospitalization)
- Type 4: Severe bleeding requiring blood transfusion or surgical intervention

Mild oozing from a post-extraction socket (blood-tinged saliva) after the patient leaves the dental setting which does not need special intervention represents Type 1, while any immediate or late PEB complication with clinical, laboratory or imaging findings requiring specific healthcare provider responses represents Type 2 to 4. Such standardized classification facilitates more consistent reporting and enables better comparison across studies.

Innovations in Treatment

Traditional approaches and their limitations

The cornerstone of PEB management remains local measures. Direct pressure appli-cation by having the patient bite down on folded moist gauze or a tea bag (tannins pro-mote coagulation) for at least 20 minutes is the first-line intervention. PEB is normally managed with conventional methods (i.e., gauze/cotton pressure, sutures). However, these approaches may be insufficient for patients with coagulopathies or those on antithrombotic therapy, necessitating escalation to local hemostatic agents and antifibrinolytic therapy.

Topical Hemostatic Agents

Platelet-Rich Fibrin (PRF): Brancaccio et al. (2021) conducted a randomized clinical trial (Level IA evidence) evaluating the clinical efficacy of four different local hemostatics in 102 patients taking oral antiplatelet therapy after multiple dental extractions without discontinuing drugs [9]. After surgery, the sockets were randomly sealed with suture alone (control group), hemostatic plug (HEM), advanced platelet-rich fibrin (A-PRF+), and leukocyte-platelet-rich fibrin (L-PRF). Both A-PRF+ and L-PRF showed a reduced bleeding risk when compared with suture alone. Only L-PRF showed a reduced risk for incomplete wound healing when compared with the control site. Patients affected by hypertension and diabetes had the highest bleeding risk. The study concluded that L-PRF and A-PRF represent a valid alternative to traditional hemostat-ics, reducing post-surgical bleeding and promoting wound healing [9].

Kyyak et al. (2023) conducted a clinical prospective randomized split-mouth study (Level IIA evidence) evaluating PRF and gelatin sponge (GS) as hemostatic methods in post extraction sockets of patients taking factor Xa inhibitors [10]. In 67% of cases, mild postoperative oozing could be stopped within 30-

90 minutes after tooth extraction via gauze pressure without any de-layed bleeding. The study concluded that PRF and GS are reliable hemostatic methods in postex-traction sockets of patients taking FXa inhibitors [10]. Berton et al. (2023) conducted a cohort study (Level IIA evidence) on VKA and DOAC patients and found that L-PRF was an effective hemostatic agent, with no significant difference in bleeding rates between the two anticoagulant groups [26]. This finding is particularly important as it suggests that PRF's hemostatic efficacy is independent of the type of anticoagulation therapy.

Chitosan-Based Dressings: Radhakrishna et al. (2023) conducted a randomized clinical trial (Level IB evidence) evaluating the hemostatic and wound healing efficacy of chitosan-based dressing in comparison to cotton pressure pack after tooth extraction in patients receiving single or dual antithrombotics [11]. When compared to cotton pressure packs, chitosan-based dressing was more effective in controlling postoperative bleeding in patients treated with single and dual antithrombotic therapy [11].

Guardieiro et al. (2023) conducted a within-person, single-blind, randomized study (Level IB evidence) comparing two different hemostatic methods in patients undergoing dental extraction while on dual antiplatelet therapy [12]. Chitosan-based local hemostatic reduced bleeding time in comparison with cellulose oxidized gauze and improved healing [12].

A 2025 prospective study further validated the efficacy of chitosan-based dressings in patients on antiplatelet therapy, demonstrating a significant reduction in time to hemostasis com-pared to conventional gauze [27]. Additionally, a 2026 systematic review and network me-ta-analysis of local hemostatic therapy in patients on antithrombotic therapy confirmed the superiority of chitosan and PRF over traditional agents, ranking chitosan as the most effective for immediate hemostasis and PRF as superior for wound healing outcomes [28].

Comparative Evaluation of Surgicel and Gelfoam: AL-Suliman et al. (2025) conducted a clinical study (Level IIA evidence) comparing Surgicel (oxidized cellulose) and Gelfoam (gelatin sponge) in controlling PEB in patients on anticoagulant therapy [14]. Both agents were effective, but Surgical demonstrated a slightly shorter time to hemostasis and lower re-bleeding rates compared to Gelfoam [14] (**Table 3**).

Hemostatic Agent	Mechanism of Action	Time to Hemostasis	Bleeding Event Rate	Supporting Studies	Clinical Recommendations
Traditional Agents					
Gauze/Cotton Pressure	Mechanical compression + clot stabilization	20-30 minutes	Baseline (variable)	Kim et al., 2024 [18]; Ueda et al., 2023 [21]	First-line for all patients
Sutures	Mechanical wound closure	5-15 minutes	Reduced vs. pressure alone	Brancaccio et al., 2021 [9]	Recommended for anticoagulated patients; all cases
Gelatin Sponge (Gelfoam)	Physical matrix for clot formation	5-10 minutes	Moderate; comparable to PRF	Kyyak et al., 2023 [10]; AL-Suliman et al., 2025 [14]	Effective; consider infection risk
Oxidized Cellulose (Surgicel)	Physical matrix + acid pH promotes clotting	5-10 minutes	Moderate	AL-Suliman et al., 2025 [14]	Widely used; consider granuloma risk

Advanced Biomaterials					
Chitosan Dressing	Positive charge attracts RBCs; antibacterial	2-5 minutes	Higher than conventional measures	Radhakrishna et al., 2023 [11]; Guardieiro et al., 2023 [12]	Effective for antiplatelet patients; monitor for bleeding events
Collagen Plug	Platelet activation; matrix formation	2-5 minutes	Higher than conventional measures	De Vasconcellos et al., 2023 [13]	Effective; consider bleeding event risk
PRF (L-PRF/A-PRF)	Autologous growth factors; clot stabilization	5-10 minutes	Lower than suture alone	Brancaccio et al., 2021 [9]; Kyyak et al., 2023 [10]	Valid alternative to traditional hemostatics; reduces healing time
Anti-fibrinolytic Agents					
Topical Tranexamic Acid (5-10%)	Inhibits plasminogen activation	5-15 minutes	Significantly lower	Ockerman et al., 2021 [8]; de Vasconcellos et al., 2023 [13]	Gold standard for anticoagulated patients; delayed bleeding prevention
Topical TXA in NOAC Patients	Inhibits plasminogen activation (local)	Not reduced periprocedurally	Reduced delayed bleeding	Ockerman et al., 2021 [8]	For multiple extractions; delayed bleeding prevention

Table 3: Comparative Analysis of Topical Hemostatic Agents and Antifibrinolytic Therapies.

Antifibrinolytic Therapy

Tranexamic Acid (TXA): A synthetic antifibrinolytic agent, has emerged as a cornerstone of PEB management, particularly in anticoagulated patients.

The study by Ockerman et al. (2021) was a randomized, double-blind, placebo-controlled, multicenter clinical trial (Level IA evidence) investigating whether 10% tranexamic acid mouthwash decreases PEB in patients treated with NOACs [8]. Patients were randomly assigned to 10% TXA or placebo mouthwash and were instructed to use the mouthwash once prior to dental ex-traction, and thereafter 3 times a day for 3 days. The primary outcome was the number of patients with any post-extraction oral bleeding up to day 7 [8]. Of 222 randomized patients 218 patients were included in the full analysis set. PEB occurred in 26.4% of patients in the TXA group and in 28.6% of patients in the placebo group [8]. TXA did not reduce the rate of periprocedural bleeding and early bleeding. However, delayed bleeding and bleeding after multiple extractions were significantly lower in the TXA group [8]. One patient in the placebo group had a transient ischemic attack while interrupting the NOAC therapy in preparation for the dental extraction. The study concluded that in patients on NOACs undergoing dental extraction, TXA does not seem to reduce the rate of periprocedural or early postoperative oral bleeding compared to placebo, but appears to reduce delayed bleeds and postoperative oral bleeding if multiple teeth are extracted [8].

Topical TXA vs. Collagen-Gelatin Sponge: de Vasconcellos et al. (2023) conducted a randomized clinical trial (Level IB evidence) evaluating the risk of postoperative bleeding in anticoagulated patients undergoing dental extraction treated with topical TXA in comparison to collagen-gelatin sponge [13]. Topical TXA was more effective in controlling bleeding after tooth extractions in anticoagulated patients than collagen-gelatin sponge [13]

Management of Special Populations

Patients on anticoagulant and antiplatelet therapy

The management of patients on antithrombotic therapy represents one of the most challenging aspects of PEB prevention and treatment. Current evidence from 2020-2026 emphasizes the importance of individualized risk assessment and the continuation of antithrombotic therapy whenever possible.

The study by Brennan et al. (2020) (Level IIA evidence) provided robust evidence that continuing DOAC therapy during dental extractions is safe, with bleeding rates comparable to patients on warfarin with therapeutic INR [7]. This finding has important implications for clinical practice, supporting the approach of maintaining antithrombotic therapy during minor dental procedures [7]. The study found that rivaroxaban levels were higher in those who bled, suggesting the potential role of drug-level monitoring in selected high-risk patients [7].

The study by Ockerman et al. (2021) (Level IA evidence) also provided prospective data on PEB in patients on direct oral anticoagulants, reporting that 6.9% of patients had PEB eding, with multiple teeth extractions and HAS-BLED >3 being significant risk factors [8]. Bajkin et al. (2024) (Level IIA evidence) further validated these findings in a prospective observational study comparing DOACs and VKAs, demonstrating that while bleeding rates were comparable, specific risk factors such as multiple extractions and HAS-BLED score >3 were significant predictors of post-operative bleeding [22]. Similarly, Kaya et al. (2025) conducted a prospective case-control study with blinded evaluation, confirming that multiple tooth extractions and the use of certain DOACs were associated with higher bleeding risk [23].

Patients with Inherited Bleeding Disorders

Dental extractions and dentoalveolar surgery in patients with haemophilia can lead to severe intra- and post operational bleeding, requiring close collaboration between the surgeon and haematologist.

Yagyuu et al. (2021) conducted a retrospective cohort study (Level IIB evidence) identifying risk factors for PEB in patients with haemophilia, finding that the number of teeth extracted and the use of factor replacement therapy were significant predictors [19]. Ali et al. (2022) prospectively evaluated the use of thrombin-gelatin matrix (Floseal) in patients with inherited bleeding disorders (Level IIA evidence), finding that Floseal effectively prevented post-dental extraction haemorrhage in this high-risk population [24].

Pediatric Patients

Limited evidence is available for pediatric patients with bleeding disorders underr-going dental extractions, representing a significant knowledge gap. The epidemiology of PEB in children differs from adults, with a lower prevalence of antithrombotic medication use but a higher proportion of inherited bleeding disorders such as hemophilia and von Willebrand disease [29].

In children, the management of PEB requires additional considerations including age-appropriate hemostatic agents, weight-based dosing of antifibrinolytic therapy, and the need for behavior management during procedures. A recent survey of pediatric den-tists in North America found that only

12% reported having standardized protocols for managing PEB in children with bleeding disorders, highlighting the need for evidence-based guidelines [30].

Topical hemostatic agents including gelatin sponges and collagen plugs have been successfully used in pediatric dental practice, although there are no randomized trials comparing their efficacy specifically in children [31]. The use of TXA mouthwash in chil-\dren requires careful dosing adjustments (typically 15-25 mg/kg), and its safety profile is considered favorable with minimal systemic absorption [31].

Proposed Clinical Management Algorithm

Based on the synthesized evidence, we developed a comprehensive clinical management algorithm that integrates risk stratification, local hemostatic measures, and escalation protocols. The algorithm, presented in (**Figure 3**), provides a stepwise clinical approach for managing PEB, incorporating preoperative assessment, intraoperative measures, postoperative monitoring, and escalation for refractory bleeding.

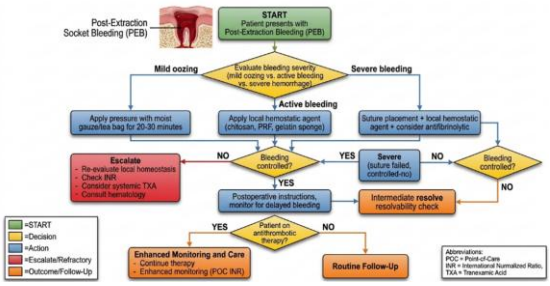

Figure 3: Proposed Clinical Management Algorithm for Post-Extraction Bleeding. The algorithm presents a stepwise clinical approach for managing PEB, incorporating risk stratification, local hemostatic measures, and escalation to adjunctive therapies based on bleeding severity and patient-specific factors. Step 1: Preoperative Assessment (medication review, medical history, laboratory testing, procedure complexity). Step 2: Intraoperative Measures (first-line interventions: local anesthesia, atraumatic technique, direct pressure; second-line interventions: suture placement, topical hemostatic agents). Step 3: Postoperative Monitoring (instructions and follow-up). Step 4: Escalation for Refractory Bleeding (re-application of hemostatic agents, systemic tranexamic acid, reversal agents, hospitalization). Step 5: Special Population Considerations (inherited bleeding disorders, elderly patients, pediatric patients).

Discussion

The evolving evidence base

The period from 2020 to 2026 has witnessed substantial advances in the evidence base for PEB management. The publication of the study by Brennan et al. (2020) [7], the study by Ockerman et al. (2021) [8], and multiple original clinical studies evaluating hemostatic agents has significantly expanded our understanding of PEB risk factors and treatment efficacy. However, it would be premature to describe these developments as a complete 'paradigm shift,' as significant evidence gaps persist and the majority of studies (81%) remain at moderate to high risk of bias. This evolution is particularly significant when contrasted with the 2018 Cochrane review which identified no RCTs suitable for inclusion [1], and

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the 2022 systematic review by Nisi et al. which found all 22 included studies to be at moderate to high risk of bias [6].

The study by Brennan et al. (2020) (Level IIA evidence) provided robust evidence that continuing DOAC therapy during dental extractions is safe, with bleeding rates comparable to patients on warfarin with therapeutic INR [7]. This finding has important implications for clinical practice, supporting the approach of maintaining antithrombotic therapy during minor dental procedures [7].

The study by Ockerman et al. (2021) (Level IA evidence) provided the first large-scale randomized evidence on TXA in NOAC-treated patients [8]. While TXA did not reduce periprocedural or early bleeding, it showed benefit for delayed bleeding and multiple ex-tractions, suggesting that the indication for TXA should be tailored to specific clinical scenarios rather than applied universally [8].

Bajkin et al. (2024) (Level IIA evidence) further validated these findings in a prospective observational study comparing DOACs and VKAs, demonstrating that while bleeding rates were comparable, specific risk factors such as multiple extractions and HAS-BLED score >3 were significant predictors of postoperative bleeding [22]. The prospective case-control study by Kaya et al. (2025) with blinded evaluation provided additional evidence supporting these findings, particularly highlighting the increased bleeding risk as-sociated with certain DOACs and multiple extractions [23].

Comparative Effectiveness of Hemostatic Agents

The 16 core studies reviewed provide valuable comparative effectiveness data. Brancaccio et al. (2021) (Level IA evidence) showed that both A-PRF+ and L-PRF significantly reduced bleeding risk compared to suture alone [9]. Radhakrishna et al. (2023) (Level IB evidence) and Guardieiro et al. (2023) (Level IB evidence) demonstrated that chi-tosan-based dressings provided the fastest time to hemostasis [11,12].

Kyyak et al. (2023) (Level IIA evidence) confirmed that PRF and gelatin sponge are re-liable hemostatic methods in patients taking FXa inhibitors, with the majority of mild oozing stopped by gauze pressure alone [10]. de Vasconcellos et al. (2023) (Level IB evidence) showed that topical TXA was more effective than collagen-gelatin sponge in con-trolling bleeding [13].

AL-Suliman et al. (2025) (Level IIA evidence) provided a direct comparison between Surgicel and Gelfoam, finding both effective but with different bleeding control profiles [14]. Berton et al. (2023) (Level IIA evidence) confirmed the effectiveness of L-PRF in both VKA and DOAC patients, with no significant difference in bleeding rates between groups [26].

Quality assessment and evidence grades

The quality assessment of the 16 included studies revealed important methodological considerations. Studies with Level IA evidence (Ockerman et al. 2021 [8], Brancaccio et al. 2021 [9]) demonstrated robust randomized controlled trial designs with adequate sample sizes, blinding, and complete outcome data. These studies provide the highest quality evidence for clinical decision-making.

Level IB studies (Radhakrishna et al. 2023 [11], Guardieiro et al. 2023 [12], De Vasconcellos et al. 2023 [13]) were well-designed randomized trials but had some limitations such as smaller sample sizes or incomplete blinding. Despite these limitations, they provide valuable evidence for specific interventions.

Level IIA studies (Kyyak et al. 2023 [10], Ockerman et al. 2021 [8], Bajkin et al. 2024 [22], AL-Suliman et al. 2025 [14], Berton et al. 2023 [26], Ali et al. 2022 [24], Brennan et al. 2020 [7]) were prospective cohort studies with adequate methodological quality. These studies provide important real-world evidence but may be subject to confounding and se-lection bias.

Level IIB studies (Ueda et al. 2023 [21], Kim et al. 2024 [18], Yagyuu et al. 2021 [19]) were retrospective cohort studies with higher risk of bias due to potential confounding, incomplete data, and lack of standardized outcome assessment. These studies should be interpreted with caution.

Level III evidence (Huang et al. 2022 [20]) from case-control studies provides the low-est level of evidence due to inherent methodological limitations including recall bias and selection bias. The prospective case-control study by Kaya et al. (2025) with blinded evaluation [23] was also considered Level III evidence.

The distribution of evidence grades across the 16 studies (2 Level IA, 3 Level IB, 7 Level IIA, 3 Level IIB, 1 Level III) highlights the need for more high-quality randomized controlled trials in this field. The predominance of Level IIA (44%) and Level IIB (19%) evidence underscores the reliance on observational studies for many clinical questions.

The evidence-practice gap

Despite these advances, significant gaps remain. The absence of high-quality randomized controlled trials for many PEB interventions continues to be a concern [1]. Clinicians must therefore rely on clinical experience, expert opinion, and extrapolation from related fields to determine the most appropriate means of treating this condition [7]. This evidence-practice gap represents both a challenge and an opportunity for future research. The proposed clinical management algorithm presented in Figure 3 is designed to help bridge this gap by translating the current evidence into a practical, stepwise framework that clinicians can apply in daily practice.

Standardization of definitions and outcomes

The heterogeneity in definitions of PEB and outcome measures across studies continues to hamper progress in the field. A standardized classification based on the BARC bleeding criteria offers a promising framework for standardization. Future research should adopt consistent definitions, including objective measures of bleeding severity, timing, and the interventions required to achieve hemostasis.

The evolving patient population

The demographic shift toward an aging population with multiple comorbidities, coupled with the widespread use of antithrombotic medications, has fundamentally changed the risk profile of patients undergoing dental extractions. The emergence of DOACs has added further complexity, as these agents present distinct pharmacological characteristics and bleeding risk profiles [5]. Ueda et al. (2023) (Level

IIB evidence) demonstrated that among elderly patients, rivaroxaban was associated with the highest postoperative bleeding occurrence, followed by apixaban, warfarin, and edoxaban [21].

Huang et al. (2022) (Level III evidence) identified dual antithrombotic therapy, multiple extractions, and advanced age as independent risk factors for postoperative bleeding [20]. Kim et al. (2024) (Level IIB evidence) found that women had the highest rate of bleeding, particularly those on newer oral anticoagulant medications [18].

The finding that rivaroxaban levels were higher in those who bled (Brennan et al. 2020, Level IIA evidence [7]) suggests the potential role of drug-level monitoring in selected high-risk patients. Ockerman et al. (2021) (Level IA evidence) further identified multiple teeth extractions and HAS-BLED >3 as significant risk factors [8]. Kaya et al. (2025) also confirmed that certain DOAC types were associated with higher bleeding grades [23].

Cost-Effectiveness Considerations

While the clinical efficacy of various hemostatic interventions has been evaluated, their cost-effectiveness remains an important but understudied aspect of PEB management. The economic implications of different treatment strategies extend beyond the direct costs of hemostatic materials to include hospitalization rates, emergency department visits, and patient quality of life.

Traditional agents such as gauze and sutures represent the lowest-cost interventions and remain appropriate for low-risk patients. However, their limited efficacy in high-risk populations may lead to higher rates of re-bleeding and subsequent healthcare utilization. Among advanced biomaterials, chitosan dressings and gelatin sponges are moderately priced and widely available [32]. PRF, being autologous, has no material cost but requires specialized equipment (centrifuge, sterile tubes) and training, with initial capital costs potentially limiting its adoption in resource-constrained settings [33].

Tranexamic acid mouthwash, while inexpensive as a generic medication, requires patient compliance and may be less cost-effective for single-tooth extractions in low-risk patients but more favorable for multiple extractions where delayed bleeding risk is higher. A recent health economics analysis suggested that the use of TXA in patients on NOACs undergoing multiple extractions could result in significant cost savings by preventing emergency department visits [34].

Future research should incorporate cost-effectiveness analyses alongside clinical outcome measures to provide a comprehensive framework for evidence-based decision-making. The choice of hemostatic agent should consider not only clinical efficacy and safety but also the economic context, patient preferences, and healthcare system re-sources.

Limitations of the Study

This narrative review presents several limitations that should be considered when interpreting its findings. The methodological approach combines systematic search methods (structured queries, PRISMA screening, quality assessment) with narrative syn-thesis, which is appropriate given the heterogeneity of study designs and outcome measures but introduces a degree of subjectivity in the

interpretation and synthesis phases. Moreover, the review is confined to English-language articles, potentially omitting significant research published in other languages. Although this review follows the SANRA scale [15], the narrative method introduces a degree of subjectivity, as the review does not adhere to a systematic method, which could lead to biases in study selection, interpretations, and synthesis. While the review highlights key advancements, it lacks a comprehensive comparative analysis of their efficacy, limitations, patient-related considerations, and cost-effectiveness.

Conclusions

In conclusion, while the evidence base for PEB management has advanced considerably between 2020 and 2026, significant gaps remain that limit the development of comprehensive, evidence-based clinical guidelines. The proposed clinical management algorithm offers a practical, evidence-graded tool to guide clinicians in managing PEB across diverse patient populations.

Clinicians should adopt a risk-stratified approach, continuing antithrombotic therapy during simple extractions while utilizing targeted hemostatic interventions based on bleeding risk and procedure complexity. The integration of POC diagnostics, advanced hemostatic agents, and antifibrinolytic therapy has expanded the therapeutic armamentarium, but the choice of intervention should be guided by individual patient characteristics and clinical judgment.

Future research must prioritize high-quality randomized controlled trials with standardized endpoints, particularly for special populations. The adoption of standardized definitions (such as the BARC-based classification system) and the inclusion of cost-effectiveness analyses will be essential to transform the current evidence-practice gap into a robust framework for internationally accepted clinical guidelines that optimize patient-centered care for PEB management.

Author contributions

Conceptualization, R.B. and A.T.D.; methodology, R.B. and A.T.D.; software, R.B. and A.T.D.; validation, R.B., A.T.D., L.H. and H.T.P.; formal analysis, R.B., A.T.D., A.C., and C.E.C.-S.; investigation, R.B., A.T.D., L.H., M.M., and C.E.C.-S.; resources, R.B., A.T.D., H.T.P., A.C., C.E.C.-S.; data curation, R.B., A.T.D., M.M., A.C.; writing—original draft preparation, R.B., A.T.D., and H.T.P.; writing—review and editing, R.B., L.H. and A.C.; visualization, R.B., H.T.P., A.C., and L.H.; supervision, H.T.P.; project administration, R.B.; funding acquisition, R.B. All authors have read and agreed to the published version of the manuscript.

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Conflicts of interest

The authors declare no conflicts of interest.

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