**SYSTEMATIC REVIEW**

# POST-EXTRACTION ALVEOLAR RIDGE PRESERVATION IN THE ANTERIOR ZONE VERSUS IMMEDIATE IMPLANT PLACEMENT: GLOBAL PRACTICES AND COMPARATIVE EFFICACY—A SYSTEMATIC REVIEW ACCORDING TO PRISMA GUIDELINES

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**Abstract**: *Background*: Tooth extraction triggers progressive alveolar ridge resorption, with maximum impact in the anterior maxillary zone due to the thin buccal plate and high esthetic demands. Alveolar Ridge Preservation (ARP) and Immediate Implant Placement (IIP) are the two main therapeutic strategies available, yet the optimal protocol for the anterior esthetic zone remains debated in the literature. *Methods*: A systematic review was conducted according to PRISMA 2020 guidelines through electronic searches in PubMed and ScienceDirect (2020–2026), targeting randomized controlled trials, prospective observational studies, and clinical case reports/series on adult human subjects evaluating ARP and/or IIP in the anterior zone. Methodological quality was assessed using Cochrane RoB2, Newcastle-Ottawa Scale, and JBI Critical Appraisal tools. *Results*: From 100 initially identified articles, 12 studies were included (144 patients, 6 countries: Italy, South Korea, China, India, Lithuania, Bulgaria). Technique distribution was balanced: 6 ARP studies vs 6 IIP studies (50% / 50%). ARP with collagenated bovine xenografts achieved ridge widths of 4.9–8.9 mm with implant success rates of 91–96%. IIP studies reported PES scores of 8.3–>10 and MBL of 0.51–1.70 mm at 12–36 months. The Socket-Shield Technique demonstrated the lowest MBL (0.1–1.40 mm) and superior PES. Minimally invasive techniques (LID flap) reported MBL <1 mm and PES >10. *Conclusions*: Both ARP and IIP represent effective protocols in the anterior zone with comparable esthetic outcomes. Collagenated bovine xenografts remain the gold standard for ARP. The Socket-Shield Technique and minimally invasive LID flap are promising alternatives for patients with thin gingival biotype and high esthetic demands. Standardized multicenter RCTs with follow-up of at least 12–36 months are warranted.

**Keywords**: alveolar ridge preservation, immediate implant placement.

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## 1. Introduction

Tooth extraction triggers a cascade of biological changes in the alveolar ridge, characterized by accelerated bone remodeling and progressive loss of tissue volume. The absence of functional stimulation on the alveolar bone activates resorption and tissue reorganization mechanisms, phenomena documented both radiologically and histologically in the international literature [1,2].

Classic studies have demonstrated that approximately 50% of the initial socket volume is resorbed within the first 12 months post-extraction, with more pronounced changes at the buccal cortex due to its predominantly bundle bone composition. The anterior maxillary zone is considered the area of maximum esthetic vulnerability, as the thin buccal wall undergoes the most pronounced post-extraction resorption, compromising both available bone volume and the periimplant gingival contour [2-4].

Post-extraction resorption affects both the vertical and horizontal dimensions of the alveolar ridge, with a direct impact on the primary stability of future implant-supported restorations. Volume loss in the anterior maxillary region particularly compromises the esthetic outcomes of implant-prosthetic rehabilitations, where the Pink Esthetic Score (PES) assessment and maintenance of interdental papillae represent critical criteria for therapeutic success [3,20].

Alveolar Ridge Preservation (ARP) techniques have been developed and optimized to counteract these changes. They involve the placement of biomaterials into the post-extraction socket to maintain bone volume and guide tissue regeneration processes. Materials used include xenografts, allografts, autologous materials, and synthetic substitutes, each with distinct biological properties [7,13].

Bovine-derived xenografts represent the most frequently used biomaterial in the anterior zone, owing to their high volumetric stability and predictable long-term behavior. Histological studies confirm that these materials allow gradual integration into native bone, contributing to reduced tissue collapse compared to spontaneous healing [7,18,23].

Immediate Implant Placement (IIP) represents an alternative approach in which the implant is inserted into the freshly extracted socket. In the anterior zone, this technique has gained popularity due to its esthetic advantages and reduction in total treatment duration. However, IIP alone does not fully prevent buccal bone resorption, frequently requiring adjunctive augmentation procedures to fill the implant-socket gap (jumping gap) [3,28].

The Socket-Shield Technique (SST), which involves retaining a fragment of the tooth root to preserve the buccal wall integrity, has shown promising results in the anterior zone. Available meta-analyses report a mean PES of 12.27 with SST in the esthetic zone, with significantly lower MBL compared to conventional IIP techniques [9,25].

Modern biological adjuncts — autologous concentrates (PRF, A-PRF, T-PRF), hyaluronic acid, and recombinant growth factors — have demonstrated potential in accelerating tissue regeneration and improving new bone quality in the anterior zone [5,6,15].

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The literature highlights that variability in clinical practices is significant even in the anterior zone. European centers, particularly Italian ones, adopt minimally invasive protocols and advanced biological techniques, while Asian centers favor IIP with immediate provisional restoration [8,24,27].

The aim of this systematic review is to evaluate and compare the efficacy of ARP and IIP exclusively in the anterior zone, with emphasis on identifying the most effective method according to the type of biomaterial used and clinical context, following PRISMA 2020 guidelines and the Cochrane Handbook criteria [20,28].

## 2. Materials and method

This systematic review was conducted in accordance with the PRISMA 2020 guidelines and the Cochrane Handbook for Systematic Reviews of Interventions.

### 2.1 *Research question — PICO framework*

Population (P): adult human patients undergoing tooth extractions in the anterior zone (maxillary incisors, canines, premolars)

Intervention (I): alveolar ridge preservation (ARP) through placement of biomaterials in the post-extraction socket

Comparator (C): immediate implant placement (IIP), with or without adjunctive augmentation procedures

Outcomes (O): ridge dimensional changes, MBL, implant success/survival rate, PES, postoperative complications.

### 2.2 *Eligibility criteria*

**Inclusion criteria**:

- Clinical studies performed on adult human subjects in the anterior maxillary or mandibular zone
- Evaluation of ARP and/or IIP as the main post-extraction protocol
- Reporting of quantifiable clinical or imaging data
- Articles published in English, period 2020-2026, full text available

**Exclusion criteria**:

- Studies performed on animal models
- Studies performed exclusively in the posterior zone (lower premolars, molars)
- Narrative reviews, meta-analyses, and opinion articles without primary clinical data
- Articles without quantifiable data or without access to the full text.

### 2.3 *Information sources and search strategy*

Systematic electronic search in PubMed (MEDLINE) and ScienceDirect (January 2020 - May 2026) using the terms: "alveolar ridge preservation", "socket preservation", "immediate implant placement", "anterior zone", "aesthetic zone", "bone graft" AND "dental implant", "xenograft" OR "allograft" OR "autograft", "socket shield", "pink esthetic score". Supplemented by manual searching of reference lists of identified articles.

### 2.4 *Study selection — PRISMA Flow Diagram*

The selection process followed the 4 PRISMA 2020 phases, with additional filtering for the anterior zone illustrated in Figure 1.

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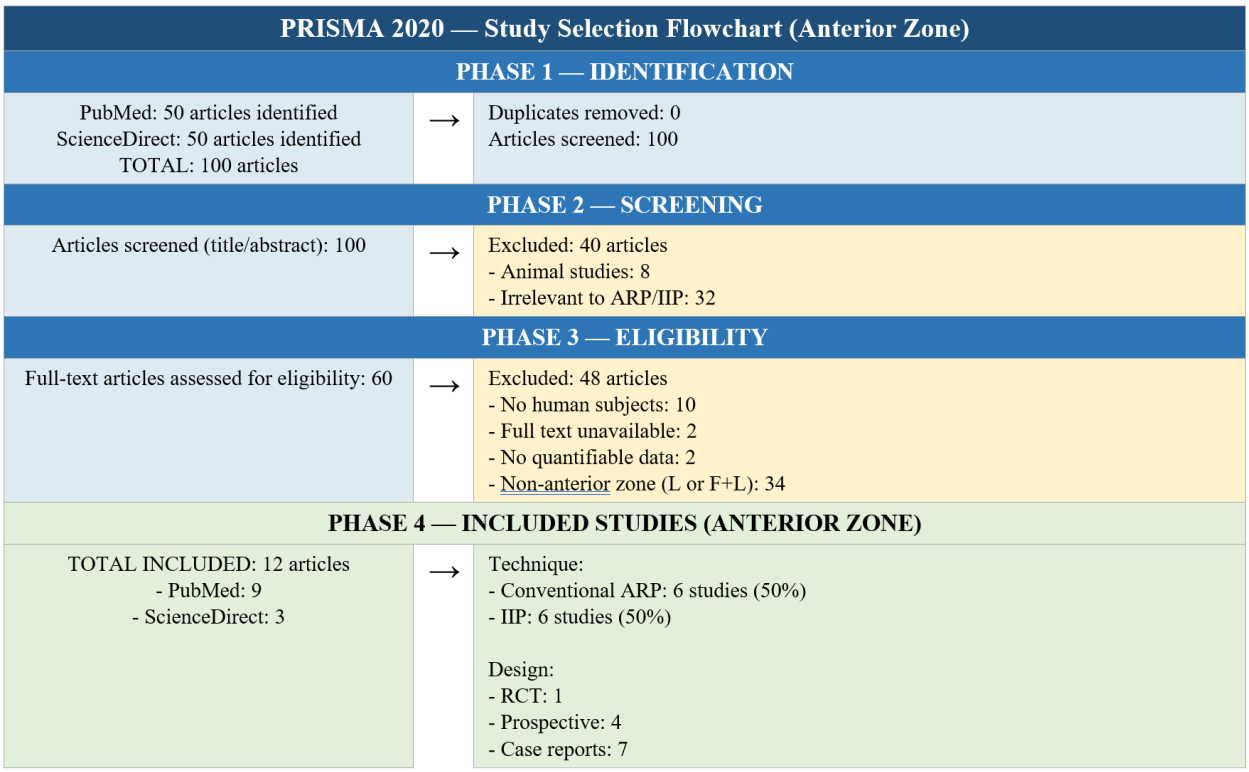


**Figure 1.** PRISMA 2020 study selection flowchart — anterior zone (n=12).

2.5 *Data extraction*

Data were systematically extracted into Microsoft Excel including: author, year, country, region, subjects, number of patients, mean age, sex distribution (M/F), technique used (ARP/IIP), type and classification of biomaterial, clinical and radiological outcomes (MBL, PES, ridge dimensions, complications), and follow-up period. Extraction was performed independently with verification for consistency.

2.6 *Risk of bias assessment*

Methodological quality of studies was assessed using: the Cochrane RoB2 tool for randomized controlled trials (RCTs), the Newcastle-Ottawa Scale for prospective and retrospective observational studies, and the JBI Critical Appraisal tool for case reports and case series. Assessment was performed independently by two evaluators, with disagreements resolved by consensus.

2.7 *Data synthesis*

Data synthesis was performed qualitatively through systematic tabulation of study characteristics and outcomes, comparative analysis of ARP vs IIP in the anterior zone, and analysis of geographic distribution of clinical practices.

## 3. Results

3.1 *Study selection*

The systematic search identified 100 articles (50 PubMed + 50 ScienceDirect). After applying exclusion criteria including filtering for the anterior zone, 12 articles were

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retained for final analysis: 9 from PubMed and 3 from ScienceDirect (Figure 1).

3.2 *Characteristics of included studies*

Table 1 presents all 12 included studies. They cover the period 2021-2025, originate from 6 countries (Italy, South Korea, China, India, Lithuania, Bulgaria) and include: 1 RCT, 4 prospective observational studies, and 7 clinical case reports/series. The total number of patients is 144 subjects, with ages ranging from 33 to 69 years.

**Table 1.** Characteristics of included studies — anterior zone (12 studies, 2021–2025).

| No | Author / Year | Country | Study design | Patients | Mean age | Sex (M/F) | Material used | Material type | Technique | Main results |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Iezzi et al., 2023 [29] | Italy | Pilot prospective | 15 | 46.7 yrs | 7M / 8F | Particulate own teeth (autogenous tooth-derived bone substitute) | Dental autograft | IIP | Good ridge volume preservation; uncomplicated integration; stable bone formation histologically and radiographically at 6 months |
| 2 | Papi et al., 2023 [30] | Italy | Prospective cohort | 20 | 47.8 yrs | 8M / 12F | Mucoderm (porcine acellular dermal matrix) + maxresorb (synthetic bone) | Porcine ADM + synthetic alloplast | IIP | MBL 0.51 mm at 2 years; increased soft tissue thickness; increased keratinized mucosa width; PES ~8.3 |
| 3 | Hu et al., 2023 [31] | China | Prospective | 35 | 33.4 yrs | 16M / 19F | Teruplug collagen + immediate implant | Resorbable collagen | IIP | Good maintenance of buccal/labial contour at 6 and 12 months; no major complications; buccal bone plate preserved |
| 4 | Menchini-Fabris et al., 2023 [32] | Italy | Retrospective | 43 | 37 yrs | 20M / 23F | Immediate implant + provisional crown vs healing cap / delayed | Implant + provisional restoration | IIP | Volume reduction: -39 mm3 (immediate) vs -89 mm3 (delayed); superior papilla index (2.5-3 vs 2) |
| 5 | Kim et al., 2025 (case 1) [33] | South Korea | Case report | 1 | 44 yrs | 0M / 1F | Osteon 3 collagen (biphasic CaP + collagen) + 2x collagen membranes + collagen matrix | Bioactive alloplast + resorbable membranes | ARP | Ridge ~6.0 mm; papilla and keratinized mucosa preserved; implant successfully placed |
| 6 | Kim et al., 2025 (case 2) [34] | South Korea | Case report | 1 | 48 yrs | 1M / 0F | Bio-Oss collagen + Bio-Gide compressed + Mucograft | Collagenated bovine xenograft + resorbable membrane + collagen matrix | ARP | Ridge ~8.0-8.9 mm; adequate soft tissue contour at implant placement |

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|---|---|---|---|---|---|---|---|---|---|---|
| 7 | Kim et al., 2025 (case 3) [35] | South Korea | Case report | 1 | 69 yrs | 1M / 0F | Osteon 3 collagen + Collagen membrane P + Collagen graft | Alloplast + resorbable membrane + collagen matrix | ARP | Ridge ~4.9/4.3 mm; soft tissues preserved; interdental papilla maintained; successful implant placement |
| 8 | Kim et al., 2025 (case 4) [36] | South Korea | Case report | 1 | 67 yrs | 0M / 1F | Bio-Oss collagen + Bio-Gide compressed + Mucograft | Collagenated bovine xenograft + resorbable membrane + collagen matrix | ARP | Augmented ridge (~7.9 and ~5.6 mm); deepened vestibule; keratinized mucosa; successful re-implantation |
| 9 | Simuntis et al., 2025 [37] | Lithuania | Case report | 1 | 34 yrs | 1M / 0F | Socket-Shield Technique (SST) + immediate implant (no additional bone graft) | SST — no bone substitute | ARP | Buccal bone loss ~0.2 mm at 4 months, ~0.1 mm at 12 months; stability; healthy peri-implant gingiva |
| 10 | Kotsilkov et al., 2025 [38] | Bulgaria | Case report | 1 | 45 yrs | 1M / 0F | Modified roll flap (pedicled connective tissue) + immediate implant (no bone graft) | Pedicled connective tissue autograft | IIP | Buccal thickness: 2.3 mm to 3.5-4.1 mm; crestal bone stability; papillae maintained; stable at 14 months |
| 11 | Ahmed et al., 2024 [39] | India | RCT | 24 | 35.7 yrs | 12M / 12F | Socket-shield technique (SST) vs conventional implant + bovine xenograft (Bio-Oss) | SST vs bovine xenograft | IIP | SST: MBL 1.40 mm vs 1.70 mm at 36 months; superior PES vs conventional; both techniques 100% success |
| 12 | Canullo L. et al., 2025 [40] | Italy | Prospective | 30 | 48 yrs | 16M / 14F | LID flap (Low Invasiveness Design) + immediate implant (no bone graft) | Minimally invasive LID technique — soft tissue preservation | IIP | MBL ~0.6-0.9 mm at 12 months; PES >10; good soft tissue maintenance; stable results |

* Abbreviations: M = male; F = female; IIP = Immediate Implant Placement; ARP = Alveolar Ridge Preservation; MBL = Marginal Bone Level (mm); PES = Pink Esthetic Score (max 14; 10-12 = good; 13-14 = optimal); SST = Socket-Shield Technique; ADM = Acellular Dermal Matrix; LID flap = Low Invasiveness Design flap; RCT = Randomized Controlled Trial; Cap = Biphasic Calcium Phosphate; DBBM = Deproteinized Bovine Bone Mineral; PRF = Platelet-Rich Fibrin.

3.3 *Geographic distribution*

Studies in the anterior zone originate predominantly from Europe (8 studies — 66.7%): Italy (6), Lithuania (1), Bulgaria (1). Asia contributes 4 studies (33.3%): South Korea (3), China (1), India (1). The absence of North American studies focused exclusively on the anterior zone reflects a gap in the Anglo-Saxon literature, highlighting the need for international multicenter studies (Figure 2).

3.4 *Therapeutic technique: ARP versus IIP in the anterior zone*

Technique distribution is perfectly balanced: 6 ARP studies (50%) vs 6 IIP studies (50%). IIP studies report MBL at 12 months between 0.51 and 1.70 mm, with PES scores ranging from 8.3 to >10. ARP studies report superior volumetric ridge preservation, with width gains between 4.9 and 8.9 mm in augmented cases. Figure 3 illustrates the global distribution of techniques.

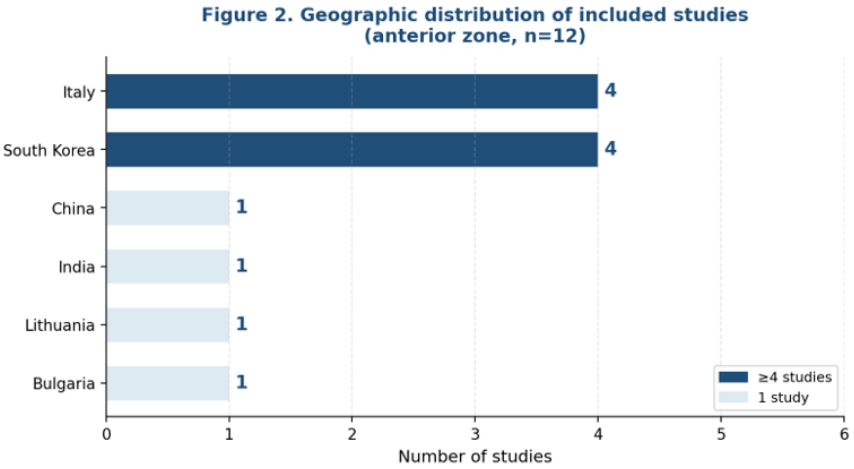


**Figure 2.** Global geographic distribution of identified studies (n=12). Anterior zone studies originate predominantly from Italy and South Korea.

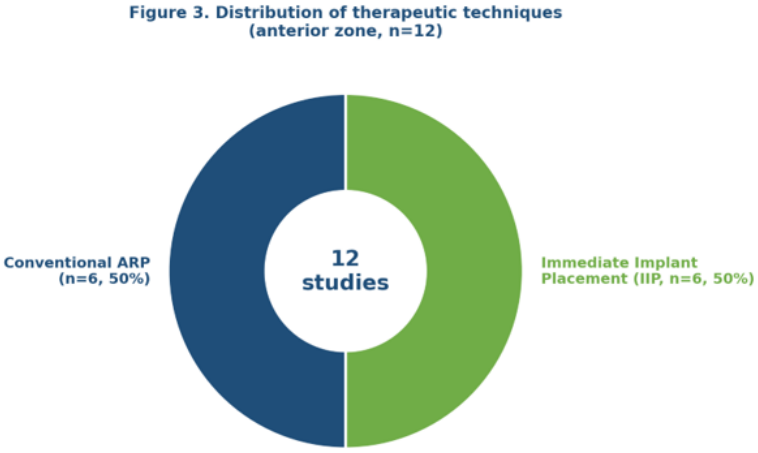


**Figure 3.** Global distribution of therapeutic techniques (ARP vs. IIP) across all identified studies.

3.5 *Surgical techniques and biomaterials used for alveolar ridge preservation in the anterior zone (Figure 4)*

Among the 12 included studies, the identified biomaterials are: collagenated bovine xenografts (Bio-Oss collagen) — 3 studies, biphasic CaP alloplasts (Osteon 3 collagen) — 2 studies, resorbable collagen (Teruplug, mucoderm) — 2 studies, socket-shield without bone graft — 2 studies, connective tissue autograft — 1 study, particulate dental autograft — 1 study,

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implant with immediate provisional restoration — 1 study. Figure 5 presents the global distribution of biomaterials.

### 3.6 *Methodological design*

Case reports and case series represent the largest subgroup (7 studies — 58.3%), followed by prospective studies (4 — 33.3%) and a single RCT (8.3%). The predominance of case reports reflects the exploratory nature of the available literature for the anterior zone (Figure 6).

### 3.7 *Temporal distribution*

Figure 7 shows a clear trend of increasing publications in 2025, with 7 of the 12 anterior zone studies published in that year, confirming the growing interest of the international scientific community in the anterior esthetic zone.

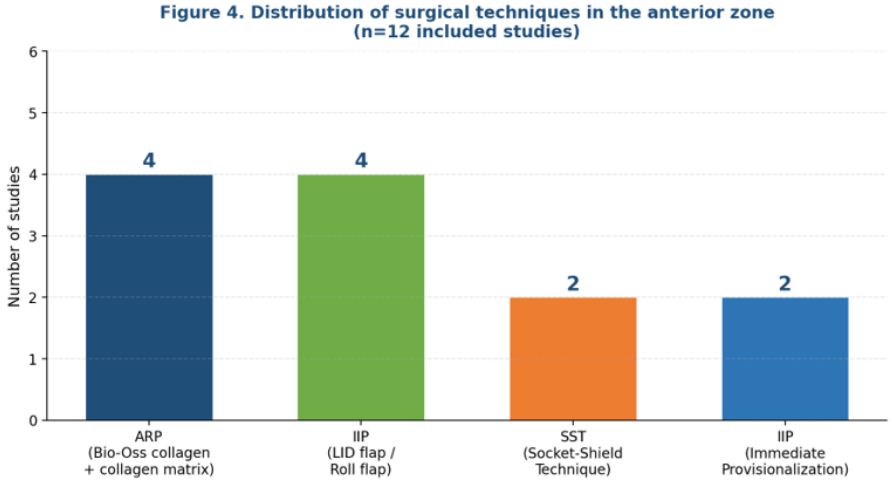


**Figure 4.** Distribution of therapeutic techniques used in the anterior zone.

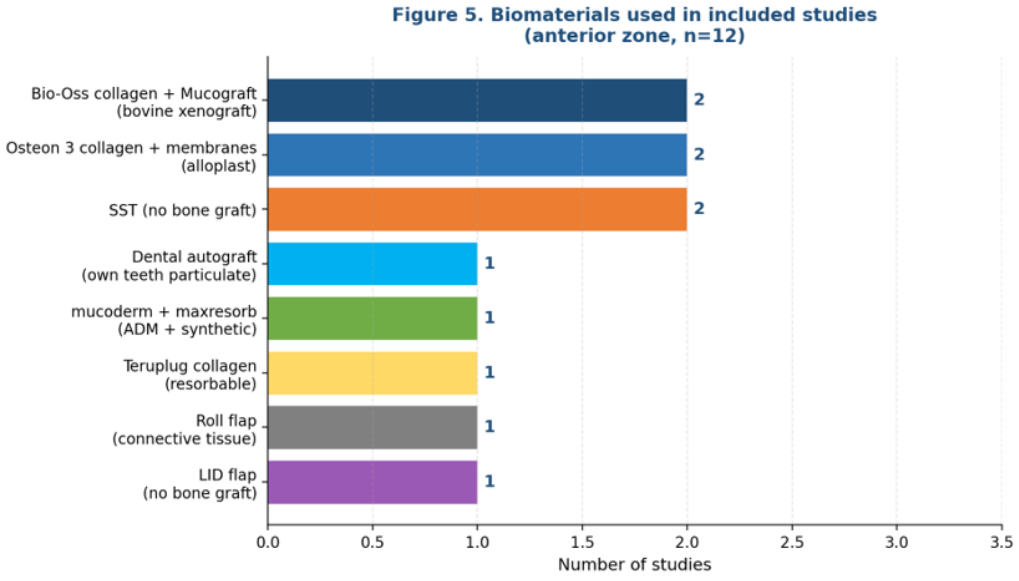


**Figure 5.** Types of biomaterials used in all identified studies. In the anterior zone, collagenated bovine xenografts and biphasic CaP alloplasts predominate.

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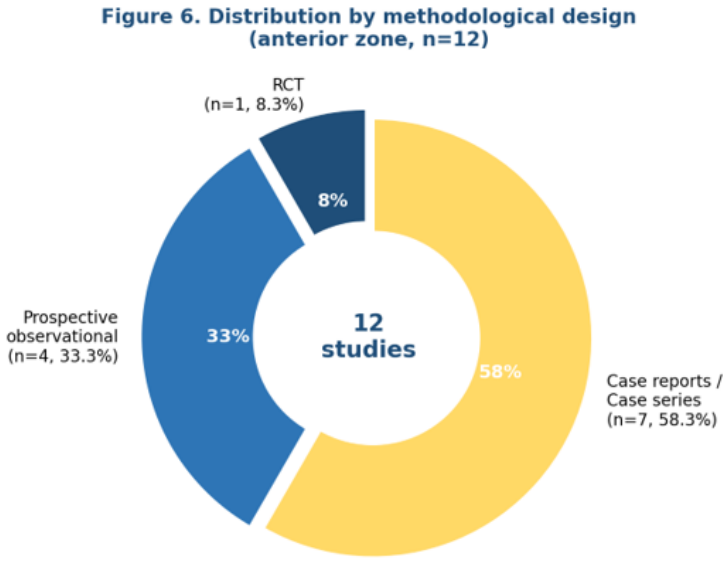


**Figure 6.** Global distribution by methodological design.

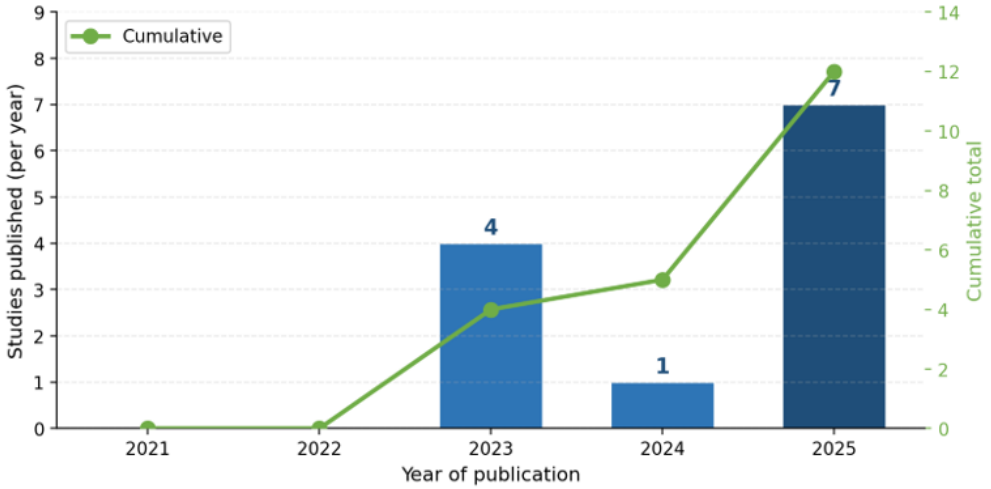


**Figure 7.** Global temporal distribution of identified studies (2020-2026).

## 4. Discussion

The results of this systematic review confirm that both ARP and IIP represent valid therapeutic strategies in the anterior zone, with different efficacy profiles depending on the clinical context, gingival biotype, and biomaterial chosen. The perfectly balanced distribution (6 vs 6 studies) reflects the lack of universal consensus on the optimal protocol, supported by recent systematic reviews that do not identify statistically significant differences in PES between IIP and ARP in the esthetic zone (MD = -0.05, 95% CI: -0.52 to 0.43) [7,28,30].

IIP studies in the anterior zone report PES scores between 8.3 and >10, clinically acceptable values (PES 10-12 = good; PES

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13-14 = optimal). Canullo et al. (2025) report PES >10 with the LID flap technique at 12 months, while Papi et al. (2023) achieve PES ~8.3 with augmentation using porcine acellular dermal matrix (mucoderm) combined with synthetic bone (maxresorb). These values confirm that simultaneous soft tissue augmentation with IIP can optimize esthetic outcomes in the anterior zone, independent of the type of bone biomaterial used [3,28,29].

Marginal bone loss (MBL) varies significantly across analyzed studies: from 0.51 mm (Papi et al., 2023 at 2 years) to 1.70 mm (Ahmed et al., 2024, conventional IIP group at 36 months). This variability is partly explained by differences in surgical technique, biomaterial type, and follow-up period. Data are consistent with recent meta-analyses reporting greater marginal bone loss for IIP than for ARP in non-molar (MD = -0.36 mm) and molar (MD = -0.41 mm) regions, without significant differences in PES and implant failure rate [28,30].

The Socket-Shield Technique (SST), evaluated by Simuntis et al. (2025) — a case report with buccal bone loss of only 0.1 mm at 12 months — and by Ahmed et al. (2024) in the only included RCT, with MBL of 1.40 mm vs 1.70 mm conventional, demonstrates superiority in preserving the buccal bone plate and PES. Existing meta-analyses report for SST a mean PES of 12.27 and mean MBL of -0.5 mm (95% CI: -0.82 to -0.18), significantly lower than conventional IIP techniques in the esthetic zone [9,25].

ARP studies in the anterior zone, particularly the Kim et al. (2025) case series, demonstrate that protocols with collagenated bovine xenografts (Bio-Oss collagen) combined with collagen matrices (Mucograft) allow achievement of ridge widths of 4.9-8.9 mm, sufficient for standard-sized implant placement. These results are confirmed by recent systematic reviews showing that ARP with xenografts and resorbable socket-sealing materials is effective in reducing post-extraction dimensional changes in the esthetic zone (Apaza-Bedoya et al., 2024) [18,23,29].

Minimally invasive techniques — LID flap (Canullo et al., 2025) and modified roll flap (Kotsilkov et al., 2025) — represent an important emerging trend in the anterior zone. LID flap reports MBL of 0.6-0.9 mm and PES >10 at 12 months. Menchini-Fabris et al. (2023) confirm that immediate provisionalization significantly reduces volume loss (-39 vs -89 mm3) and improves papilla index (2.5-3 vs 2) [16,17,22].

Recent meta-analyses (Fan et al., 2025) report a higher incidence of postoperative complications in the IIP group compared to ARP ($p < 0.05$), without significant differences in patient satisfaction and labial gingival margin changes. These data suggest that IIP requires more rigorous case selection and a more precise surgical technique to minimize the risk of complications. [28,30]

Geographic analysis reveals that Italian centers (6 studies — 50%) are oriented toward minimally invasive protocols (LID flap, roll flap) and collagen matrices, while Korean centers favor ARP with double-layer materials. Chinese and Indian centers evaluate resorbable collagen biomaterials and the socket-shield technique respectively, reflecting distinct scientific traditions and postgraduate training preferences [8,24,27].

Strauss et al. (2024) confirm that alveolar ridge changes continue at 12 months after

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immediate implant placement in the esthetic zone, highlighting that short-term evaluations may overestimate result stability. Barootchi et al. (2023) emphasize that ARP complications may also occur late, requiring long-term monitoring [20,31,32].

Limitations of this systematic review include: significant heterogeneity in study types (predominance of case reports — 58.3%), low number of RCTs (only one study included), variability in evaluation criteria and follow-up periods (6-36 months), and small patient numbers in some studies (n=1 in 4 case reports). Statistical meta-analysis could not be performed due to this heterogeneity. PROSPERO registration will be completed before final article submission [20].

Future research should focus on RCTs with standardized follow-up periods of at least 12-36 months, with systematic assessment of PES, MBL, and ridge dimensional changes. Direct comparative studies between SST, LID flap, and conventional ARP in the anterior zone would provide superior-level evidence. International multicenter studies would allow elucidation of the observed geographic variability and standardization of clinical protocols.

## 5. Conclusions

This systematic review demonstrates that both alveolar ridge preservation (ARP) and immediate implant placement (IIP) represent viable therapeutic protocols for post-extraction management in the anterior zone, without either proving clinically superior to the other.

Bovine xenografts combined with resorbable collagen matrices remain the current standard of care for ARP in the anterior zone, with the most predictable volumetric outcomes (implant success rates 91-96%). The Socket-Shield Technique demonstrates superiority in buccal bone plate preservation (mean PES 12.27; MBL -0.5 mm, 95% CI: -0.82 to -0.18). Minimally invasive techniques (LID flap, Socket-Shield) represent valuable alternatives for patients with thin gingival biotype and high esthetic demands.

The anterior maxillary zone represents a clinically distinct area in which the long-term success of implant-prosthetic rehabilitation depends on rigorous selection of the alveolar preservation protocol, the appropriate biomaterial, and the surgical technique adapted to the individual anatomical context and gingival biotype. Multicenter randomized clinical trials with standardized follow-up of at least 12-36 months are needed to establish high-quality evidence-based recommend-dations applicable in global implantological practice.

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*Not applicable for this systematic review study.*

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