

Is the facial bone wall critical to achieving esthetic outcomes in immediate implant placement with immediate restoration? A systematic review

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Abstract

Background. Rehabilitation in the anterior region requires specific conditions for success, such as the presence of papilla, emergence profile, and balance between pink and white esthetic.

Objectives. This systematic review aimed to evaluate the esthetic risk associated with immediate implant placement with immediate restoration in the anterior superior area, where the facial bone plate may be absent or deficient.

Materials and methods. The search was done in PubMed, Embase, Cochrane, Lilacs, Scopus, Scielo, and Google Scholar databases. The investigation involved clinical studies and observational studies published between January 2012 and July 2023. Studies were excluded if there was less than 12-month follow-up, no immediate restoration or facial defect, heavy smokers, or systemic disease. The risk of bias was assessed using the ROBINS-I and Modified-Cochrane RoB tools.

Results. Twelve studies were included in this systematic review. The thinner the facial plate, the higher the alveolus's risk of gingival recession or shrinkage. There was an increased interproximal recession when the thin phenotype was associated with flap surgery. An increase in pink esthetic score (PES) was reached when immediate implant placement (IIP) and immediate restoration were done. Soft tissue augmentation achieved more gingival-level stability. Regardless of the initial phenotype, an esthetic outcome was delivered. The risk of bias was high in 1 study and moderate in 3 studies.

Conclusions. It is possible to conclude that esthetic results and increased final PES or patient satisfaction index in IIP treatments associated with immediate restoration could be obtained even in buccal bone wall defects or gingival recession, regardless of their extension.

Key words: esthetic region, facial bone plate deficiency, immediate implant placement, immediate restoration, peri-implant recession

Background

Several clinical situations can predispose patients to tooth loss,^{1–3} which can cause functional impairment and esthetic challenges for clinicians. Rehabilitation in the anterior zone requires specific conditions for success, such as the presence of papilla, an emergence profile, and a balance between pink and white esthetics.⁴ Previous studies^{5–8} suggest that buccal-plate bone loss results in esthetic sequelae, mainly influenced by the reduction/absence of papillae and the position of the gingival and/or peri-implant mucosa. Currently, several procedures are proposed to increase the predictability of results.^{9–11}

Among the available therapies, implant placement following correct three-dimensional (3D) positioning, filling the socket with a bone substitute, using connective tissue graft, and immediate restoration are procedures that can minimize peri-implant tissue loss over time.^{4,12–15} Otherwise, in light of current knowledge, the clinician's concern in achieving successful rehabilitation is no longer only the success of the osseointegration,^{16–20} but also peri-implant esthetics.^{4,21}

Some factors may interfere with the peri-implant tissue framework in anterior rehabilitation, such as periodontal phenotype, 3D implant position, and prosthetic management with an adequate emergence profile. Then, immediate restoration can be considered an essential variable in the treatment plan,^{4,22–24} especially in areas with a compromised buccal bone plate and high esthetic demand. Therefore, the anterior area of the maxilla present several anatomic and esthetic characteristics that must be considered during dental implant treatment: 1. Thin facial bone that is more prone to resorption due to decreased vascular supply²⁵ after tooth loss^{26,27}; 2. Reduced buccolingual dimensions and facial bone concavity^{28–30}; 3. The type of implant connection used due to the risk of bone loss³¹; 4. Risk of fenestration and exposure of the apical implant's threads^{28,32}; and 5. Peri-implant mucosal recession.^{31,33,34}

Evaluation of the buccal bone plate demonstrated that most cases were <1 mm thick, with 50% presenting <0.5 mm thickness.³⁵ Moreover, <10% of sites showed buccal plate thickness ≥2 mm.³⁶ Another study reported that the mean width of the facial alveolar bone wall in anterior teeth was around 0.9 mm.³⁷ It is clear that thinner buccal bone will probably result in a greater and considerable amount of vertical bone loss.³¹ The literature showed that initial buccal bone thickness and subsequent vertical height bone loss (after implantation) were 1.2 mm with a loss of 0.7 mm,³³ 1.25 mm with a loss of 0.49 mm³⁸ and 0.5 mm with a loss of 1 mm.³⁴ Consequently, the thinner the bone, the greater the vertical loss.

Objectives

Despite the clinical relevance of the topic, well-delimited clinical studies are scarce regarding immediate

implant placement (IIP) in anterior sites with buccal bone defects already present. Also, there is a gap in the literature on whether such a condition incurs esthetic problems after the healing period of the peri-implant tissue. As such, the goal of this systematic review was to evaluate the esthetic risk caused by IIP with immediate restoration in the anterior area, where the facial bone plate may be absent or deficient.

This systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and was registered on the International Prospective Register of Systematic Reviews (PROSPERO) platform (CRD42022341534). The focus question was developed based on the Patient (P), Intervention (I), Comparison (C), and Outcomes (O) (PICOS) strategy, in addition to the design of the studies (S) conducted.³⁹ The focus question was: “For IIP immediately restored, does the absence of a buccal bone plate mean an increased risk for the esthetic and peri-implant mucosa recession?” P. Patients undergoing at least 1 immediate implant in an esthetic region; I. IIP and immediate restoration in sockets with buccal bone defects; C. Buccal bone defects at the IIP with immediate restoration; O. Recession of the peri-implant mucosa and esthetic risk, and if there are procedures in the literature permitting higher predictability in circumventing this bone defect, allowing a better esthetic result; S. Clinical studies and observational studies (cohort studies, case-control studies and cross-sectional studies).

Eligibility criteria

The criteria for inclusion included: 1. Clinical studies and observational studies (cohort studies, case-control studies and cross-sectional studies); 2. Minimum follow-up of 12 months; 3. IIP with immediate restoration in the anterior superior esthetic region; 4. Evaluation of esthetic clinical parameters; 5. Treated sockets (or study group) with buccal wall defects. The exclusion criteria were: 1. Follow-up time of less than 12 months; 2. Without immediate restoration; 3. Diabetic patients; 4. Smokers consuming more than 10 cigarettes per day; 5. Patients systemically compromised.

Information sources and search strategy

Two independent examiners (PHMPT and RGD) performed a broad search for articles in 7 databases: PubMed/Medline, Embase, Cochrane, Lilacs, Scopus, Scielo, and Google Scholar. The investigation included clinical and observational studies (cohort, case-control and cross-sectional studies) published between January 2012 and July 2023 in any language. It used the following descriptors and combination strategies: “peri-implant soft tissue” OR “gingival recession” OR “gingival deficiency” OR “buccal plate deficiency” OR “facial bone defect” OR “facial bone

deficiency” OR “buccal bone defect” AND “immediate implant” OR “single implant” OR “maxillae anterior implant” OR “immediate” OR “immediately” OR “extraction” OR “socket” OR “dental implantation” OR “endosseous implant” OR “dental implants” OR “single tooth” AND “esthetic area” OR “esthetic zone” OR “esthetic region” OR “aesthetic.”

Data collection and selection process and data items

A thorough analysis of the data was performed by 2 independent researchers (PHMPT and RGD) for sequential comparison in Microsoft Excel v. 16.50 (Microsoft Corp., Redmond, USA). Information about the authors, year of publication, type of study, follow-up, number of patients, number of implants, eligibility criteria applied, pre-operative patient evaluation, buccal plate defect size, bone graft used, soft tissue graft, number of teeth extracted, extraction technique, implants’ settings, implant position, postoperative care, provisional restoration and definitive prosthesis delivered, implant success/survival rate, esthetic outcome parameters measured in the study, and conclusions were registered when available.

Risk of bias assessment

The risk of bias was assessed using the Risk of Bias In Non-Randomized Studies – of Interventions (ROBINS-I), which is a tool for the prospective and retrospective case-control

papers, and using the Modified Cochrane Risk of Bias tool for the randomized controlled trials (RCTs) included in this research.⁴⁰ When up to 1 “Y” (Yes) or 1 “high risk” were found, the judgment was “low risk of bias”; if 2 “Y” (Yes) or 1 “high risk” and 1 “unclear” were found, the judgment was “moderate risk”; if 3 “yes” or 2 “high risk,” the judgment was “high risk of bias.”

Results

Screening and study selection

An initial search found 32,904 articles, of which, after filtering for the date (last 11 years and 6 months) and study design – randomized clinical trials, 2,485 works were selected ($k = 0.93$). After reading the titles, the reviewers excluded 2,081 studies and another 429 due to duplicity. A total of 186 articles were separated for reading of the abstracts, of which 161 were excluded. Of the 25 remaining articles, 13 did not meet the selection criteria because they did not deal with alveoli with vestibular wall defects (Table 1; $k = 0.98$). Finally, 12 studies were selected for this systematic review (Fig. 1).

Study characteristics

Table 2 describes the types of studies analyzed, the mean follow-up time, and the number of implants and patients evaluated. Among the evaluated studies, there were

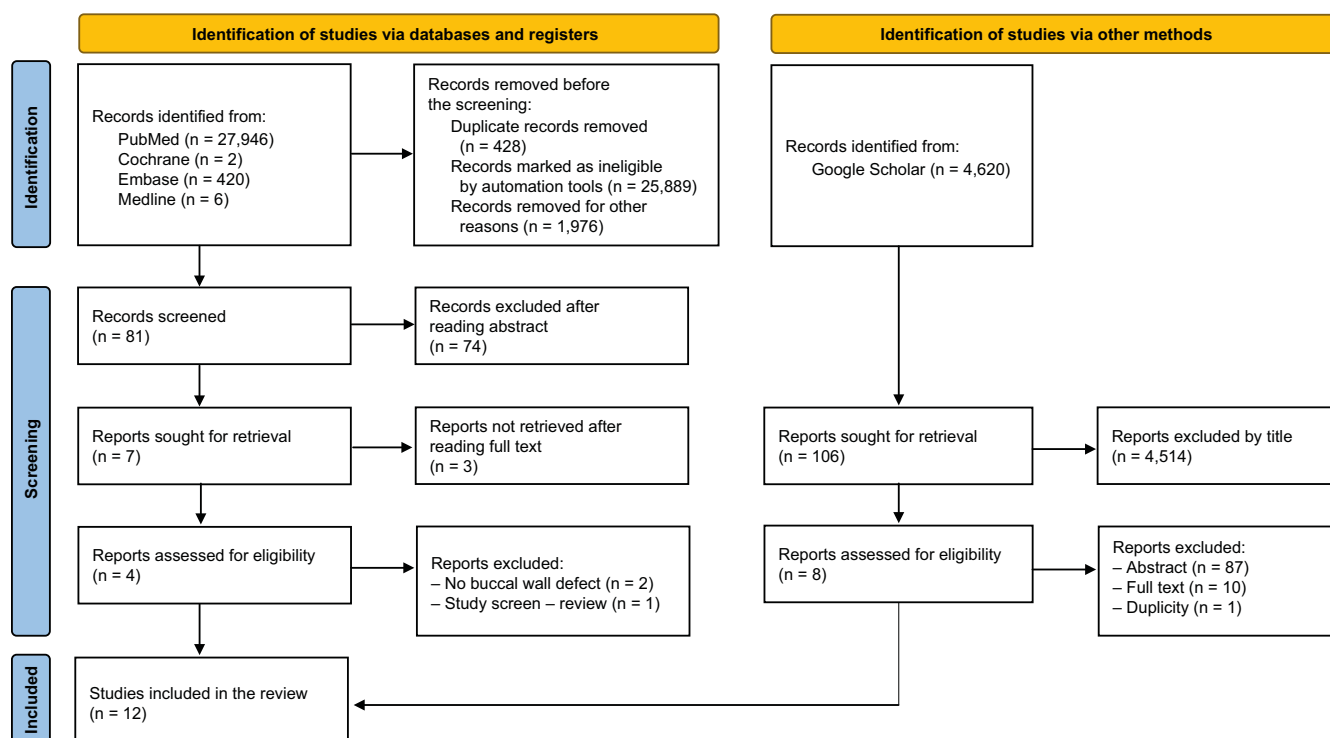


Fig. 1. Research flow and the number of articles included in this systematic review

Table 1. Articles excluded with justification after full-text reading

Author/year	Title	Exclusion criteria
Kirsten et al., 2021	Immediate single-tooth implant placement with simultaneous bone augmentation versus delayed implant placement after alveolar ridge preservation in bony defect sites in the esthetic region: A 5-year randomized controlled trial	There was no immediate provisional.
Happe et al., 2021	Peri-implant soft-tissue esthetic outcome after immediate implant placement in conjunction with xenogeneic acellular dermal matrix or connective tissue graft: A randomized controlled clinical study	intact buccal wall after extraction
Sanz et al., 2016	The effect of placing a bone replacement graft in the gap at immediately placed implants: A randomized clinical trial	intact extraction socket following
Ferrantino et al., 2021	Esthetic outcomes of non-functional immediately restored single post-extraction implants with and without connective tissue graft: A multicenter randomized controlled trial	duplicity
Lemes et al., 2014	Behavior of the buccal crestal bone levels after immediate placement of implants subjected to immediate loading	6-month follow up
Chu et al., 2015	Subclassification and clinical management of extraction sockets with labial dentoalveolar dehiscence defects	case report
Kan et al., 2018	Immediate implant placement and provisionalization of maxillary anterior single implants	guideline
Sun et al., 2019	Comparing conventional flap-less immediate implantation and socket-shield technique for esthetic and clinical outcomes: A randomized clinical study	intact facial alveolar bone wall, without bone or soft-tissue defects.
Rosa et al., 2014	Immediate implant placement, reconstruction of compromised sockets, and repair of gingival recession with a triple graft from the maxillary tuberosity: A variation of the immediate dentoalveolar restoration technique	case report
Arora et al., 2017	Immediate implant placement and restoration in the anterior maxilla: Tissue dimensional changes after 2–5 year follow up	any fenestration or dehiscence in the socket wall of the failing tooth
Arora et al., 2018	Immediate and early implant placement in single-tooth gaps in the anterior maxilla: A prospective study on ridge dimensional, clinical, and esthetic changes	There was a group where provisioning was not performed immediately.
Kuchler et al., 2015	Immediate implant placement with simultaneous guided bone regeneration in the esthetic zone: 10-year clinical and radiographic outcomes	The work did not describe provisioning and did not specify whether the transmucosal was customized.
Ma et al., 2019	Immediately restored single implants in the esthetic zone of the maxilla using a novel design: 5-year results from a prospective single-arm clinical trial	In 2 patients, provisionalization was not immediately performed and the presence of bone defects was not described.

3 RCTs,^{41–43} 7 prospective studies^{44–50} and 2 retrospective studies.^{13,51} The follow-up was from 12 months^{41–45,47,50} to 7 years,⁵¹ and the number of patients included in the studies varied from 100 to 1,245.^{45,50} All studies included patients with at least 1 hopeless tooth in the esthetic maxillary area with an indication of extraction and the possibility of IIP, with the maintenance of the adjacent teeth. The eligibility criteria implemented by the studies are summarized in Supplementary Table 1. The preoperative evaluation, size of the vestibular defect, and the presence of bone graft and/or soft tissue are detailed in Table 3.

The extraction technique and postoperative control are summarized in Table 4. The implants were loaded with immediate restoration, lacking occlusal contacts, and the minimum torque reported ranged from 15 N•cm⁴⁸ to 35 N•cm.^{43,44,49} The presence of an initial esthetic defect had at least 1 mm⁵¹ of gingival recession until the total absence of a facial plate.⁴⁴ Although most of the studies used a minimally invasive technique to remove the target tooth,^{13,42–51} Lee et al.⁴¹ compared 2 groups in which 1 used a flapless procedure and the other used a raised flap.

The conclusion of each article is summarized in Supplementary Table 2.

Patients' assessment

For the initial assessment of the patient, a cone beam computed tomography (CBCT) was used, as well as the clinical parameters including the pink esthetic score (PES).⁵⁰ Photographs, periodontal phenotype, preoperative soft tissue level, and CBCT scans were also used as initial references,^{42,48,49,51} which permitted comparison with the final restoration. Ferrantino et al.⁴³ treated alveoli with up to 1 mm of bony defect, whereas most authors limited the maximal crestal bone defect to 5 mm.^{41,42,45,50} Other studies considered different parameters, including 10 mm of vertical bone defect⁴⁴ and dehiscence of more than 2/3 of the buccal plate.⁵¹ Although most treatments involved reconstruction of the buccal plate with different types of graft, some authors did not reconstruct the wall.^{41,44} Instead, they intended to compare the local bone and soft tissue changes without the interference of socket

Table 2. Types of study, follow-up, and number of patients and implants evaluated in the articles included

Author/year	Title	Type of study	Follow-up	N (patients); n (implants)
Noelken et al., 2018 ¹³	Clinical and esthetic outcome with immediate insertion and provisionalization with or without connective tissue grafting in presence of mucogingival recessions: A retrospective analysis with follow-up between 1 and 8 years.	retrospective study	1–8 years	N = 26; n = 26
Lee et al., 2020 ⁴¹	Predicting bone and soft tissue alterations of immediate implant sites in the esthetic zone using clinical parameters.	randomized controlled trial	12 months	N = 39; n = 39
Zuiderveld et al., 2017 ⁴²	Effect of connective tissue grafting on peri-implant tissue in single immediate implant sites: An RCT.	randomized controlled trial	12 months	N = 60; n = 60
Ferrantino et al., 2021 ⁴³	Esthetic outcomes of non-functional immediately restored single post-extraction implants with and without connective tissue graft: A multicenter randomized controlled trial.	randomized controlled trial	12 months	N = 59; n = 59
Pohl et al., 2020 ⁴⁴	Gingival recession behavior with immediate implant placement in the anterior maxilla with buccal dehiscence without additional augmentation – a pilot study.	prospective case series (observational)	12 months	N = 24; n = 24
Staas et al., 2021 ⁴⁵	Does initial buccal crest thickness affect final buccal crest thickness after flapless immediate implant placement and provisionalization: A prospective cone beam computed tomogram cohort study.	prospective cohort study (observational)	12 months	N = 100; n = 100
Elaskary et al., 2020 ⁴⁶	A novel method for immediate implant placement in defective fresh extraction sites.	prospective case series (observational)	13 months	N = 12; n = 12
Frizzera et al., 2018 ⁴⁷	Impact of soft tissue grafts to reduce peri-implant alterations after immediate implant placement and provisionalization in compromised sockets.	randomized controlled trial	12 months	N = 24; n = 24
Noelken et al., 2013 ⁴⁸	Maintenance of marginal bone support and soft tissue esthetics at immediately provisionalized OsseoSpeed™ implants placed into extraction sites: 2-year results.	prospective case series (observational)	2 years	N = 20; n = 37
Da Rosa et al., 2014 ⁴⁹	Esthetic outcomes and tissue stability of implant placement in compromised sockets following immediate dentoalveolar restoration: Results of a prospective case series at 58 months follow-up.	prospective case series (observational)	58.56 months (mean)	N = 18; n = 18
Groenendijk et al., 2021 ⁵⁰	Does the pre-operative buccal soft tissue level at teeth or gingival phenotype dictate the aesthetic outcome after flapless immediate implant placement and provisionalization? Analysis of a prospective clinical case series.	prospective case series (observational)	12 months	N = 97; n = 97
Sicilia-Felechosa et al., 2019 ⁵¹	Flapless immediate implant placement and provisionalization in periodontal patients: A retrospective consecutive case series study of single-tooth sites with dehiscence-type osseous defects	retrospective consecutive case	1 year min. to 7 years max.	N = 40; n = 40

Table 3. Preoperative analysis, buccal defect size, and bone graft and/or soft tissue presence

Author/year	Patient analysis pre-op	Buccal plate defect size	Bone graft	Soft tissue grafts
Noelken et al., 2018 ¹³	CBCT, position of the lip-line, overall gingival biotype.	Seven (27%) extraction sockets showed a pristine facial bone wall (between 0-mm and 1-mm facial bone loss), 13 (50%) sites had partial bony defects (between 1-mm and 7.5-mm facial bone loss), and 6 (23%) sites presented a total loss of the facial bone wall (between 7.5-mm and 13-mm facial bone loss).	Autogenous bone grafts harvested at the mandibular ramus by a bone block and particulated in a bone mill or by collecting bone chips by a bone scraper.	Autogenous bone graft + connective tissue graft group: subepithelial connective tissue graft was harvested at the palate in the premolar region. Autogenous bone graft group: no soft tissue graft.
Lee et al., 2020 ⁴¹	Measurements of the implant site were performed at the time of the surgery: vertical distance between the buccal gingival margin and the buccal crest; thickness of the mid-buccal gingiva at the level of gingival margin and 3 mm apically from the gingival margin. Phenotype categorized into “thick” gingiva or “thin” gingiva; thickness of the mid-buccal bone crest at the level of crestal margin and 3 mm apically to the crestal margin.	Fenestration with a diameter <5 mm affecting less than half of the socket wall.	no graft	no graft

Table 3. Preoperative analysis, buccal defect size, and bone graft and/or soft tissue presence – cont.

Author/year	Patient analysis pre-op	Buccal plate defect size	Bone graft	Soft tissue grafts
Zuiderveld et al., 2017 ⁴²	The height of the bone defect was measured after the failing tooth was extracted, using a periodontal probe at the mid-buccal, mesial and distal aspect of the failing tooth and the adjacent teeth.	less than 5 mm	1/1 autologous harvested from the maxillary tuberosity region/anorganic bovine bone (Bio-Oss®).	Control group: no soft tissue graft; test group: connective tissue graft harvested from the maxillary tuberosity region.
Ferrantino et al., 2021 ⁴³	Clinical examination and CBCT.	less than 1 mm	Bovine bone mineral (DBBM) (Bio-Oss®, Geistlich Biomaterials, Wolhusen, Switzerland).	Test group: patients received a sub-epithelial CTG harvested from palate or tuberosity. Control group: no soft tissue graft.
Pohl et al., 2020 ⁴⁴	Test group: presence of a partial defect of the buccal bony alveolar lamella (at least 25% of the length of the corresponding tooth) up to a completely missing buccal plate. Control group: intact buccal bone wall.	Buccal plate vertical defect – 4.96 mm (min. 2.26 mm; max. 9.68 mm horizontal defect – 4.25 mm (min. 3.2 mm; max. 5.91 mm).	no graft	no graft
Staas et al., 2021 ⁴⁵	CBCT	Bone crest defect ≤5 mm.	Bovine bone (Bio Oss™ S 0.25–1 mm, Geistlich Biomaterials).	no graft
Elaskary et al., 2020 ⁴⁶	A CBCT scan was used for diagnosis and treatment planning. Impressions were also taken and cast in dental stone to fabricate computer-guided surgical templates.	Group 1: no bone defect but thin buccal plate and intact soft tissue; Group 2: deficient buccal bone but intact soft tissue.	Mixture of autogenous bone chips and DBBM in a ratio of approx. 3:1, covered by a slowly resorption xenograft cortical membrane. Autogenous chips harvested from the area of vestibular access with scrapers.	Subepithelial connective tissue graft harvested from the palate.
Frizzera et al., 2018 ⁴⁷	CBCT and clinical evaluation.	Probing depth and clinical attachment level >3 mm.	Xenograft – bovine bone + 10% porcine collagen (Bio-Oss Collagen; Geistlich Biomaterials).	Autogenous – connective tissue; Xenograft-collagen matrix (Mucograft; Geistlich Biomaterials).
Noelken et al., 2013 ⁴⁸	CBCT was performed to evaluate the dimensions of the facial bony lamella prior to surgery. Especially, the thickness of the facial lamella was measured in relation to a defined reference point. The thickness of the facial lamella was measured in distances of 1, 3, and 6 mm apically to this reference level.	Eight extraction sockets showed no recession and a pristine facial bone wall, 11 sites showed a combination of a pristine soft tissue condition and defects of the facial bone walls of various dimension, 18 sites showed a combination of facial recession and bone deficiencies.	Autogenous bone grafts harvested at the mandibular ramus by particulating a bone block in a bone mill or by collecting bone particles by a disposable filter.	Connective tissue graft harvested from the maxillary tuberosity region (test group).
da Rosa et al., 2014 ⁴⁹	CBCT; photograph; gingival biotype	Bony dehiscence in which the defect involves the coronal and medium third of the root without affecting the apical third.	IDR – published by Rosa et al.; autologous removed from tuberosity.	no graft
Groenendijk et al., 2021 ⁵⁰	Light photographs perpendicular to the tooth arch placed into a digital format. Reference lines drawn through gingival margin of the contra-lateral incisor, incisal edge of contra-lateral incisor, and distal from the central and lateral incisors. The gingival margin of the failing tooth at T0 was drawn in blue as a reference at different time points	Crestal bone defect not exceeding 5 mm.	DBBM (Bio-Oss®; Geistlich Biomaterials).	no graft
Sicilia-Felechosa et al., 2019 ⁵¹	Virtual surgery study using a programming software based on the CBCT examination.	Ranging from ≤1/3 or pocket depth 5–6 mm from gingival margin until bone dehiscence ≥2/3 or pocket depth ≥10 mm from gingival margin.	Combination of autogenous bone from drilling and DBBM, or only DBBM (Bio-Oss®; Geistlich Pharma AG).	Autogenous (connective tissue –85%); allogeneic dermis (15%; AlloDerm RTM, BioHorizons).

CBCT – cone beam computed tomography; DBBM – deproteinized bovine bone mineral; IDR – immediate dentoalveolar restoration.

Table 4. Extraction technique, diameter and type of implants used, implant position, postoperative control, and implant survival rate

Author/year	Tooth extraction technique	Implant used	Implant dimensions and platform	Implant position	Post-op control	Implant survival rate
Noelken et al., 2018 ¹³	Atraumatically extraction to maintain alveolar bone and gingival architecture.	Osseo-Speed™ (Astra Tech AB)	Conical connection; diameters: between 3.5 mm and 5.0 mm; length: 15 mm and 17 mm.	Aligned to the oral lamella of the socket. Placement depth determined by the interproximal and facial soft tissue and bone height.	The patients were examined preoperatively, at implant placement, at prosthetic delivery, and at annual follow-up visits up to 9 years following implant insertion.	100%
Lee et al., 2020 ⁴¹	The surgical procedure involved extraction of the tooth with or without elevation of a flap (flapless group, n = 18; flap-involving group, n = 21).	Full OS-SEOTITE Certain Tapered Implant (Biomet 3i, Palm Beach Gardens, USA).	Internal parallel connection. The size of the implant was selected based on the restorative plan and bone dimensions.	The implants were placed at the level of the buccal crest. The horizontal distance between the implant platform and buccal plate should be more than 1 mm.	All patients were seen at 1, 2, 3, 6, and 12 months, and received oral hygiene instructions and a prophylaxis.	One out of 39 implants failed and was removed 4 weeks after its placement. 36 implants had radiographs available and 34 implants had gingival and ridge measurements available for clinical and radiographic analysis.
Zuiderveld et al., 2017 ⁴²	As atraumatically as possible by detaching the periodontal ligament from the failing tooth without raising a flap.	Nobel Active (Nobel Biocare AB, Gothenburg, Sweden).	Conical connection. The implant dimension was not described in the paper.	Palatal side of the alveolus according to the manufacturer's manual by using a template representing the ideal position of the prospective implant crown; 3 mm apically to the most apical prospective clinical crown.	Patients were instructed to follow a soft diet and to avoid exerting force on the provisional restoration.	One implant in each group was lost due to failing osseointegration (96.7% implant survival in both groups).
Ferrantino et al., 2021 ⁴³	Extraction performed as gently and atraumatically as possible, followed by careful cleaning of the socket for any residue of granulation tissue. The status of a chronic infection in the alveolar socket was recorded.	Imax, iRES SAGL	Internal parallel walls; diameters: 3.85 mm or 4.2 mm; lengths: 11.5 mm, 13 mm and 16 mm.	Not detailed in the paper.	<ul style="list-style-type: none"> • Ibuprofen 400 mg twice a day for 2 days. • Chlorhexidine mouthwash 0.2% for 1 min twice a day for 2 weeks. • Amoxicillin 1 g twice a day for 6 days. Patients allergic to penicillin were prescribed clindamycin 300 mg twice a day for 6 days. 	One implant failure was recorded in each group. Test group: 96.8%; control group: 96.4%.
Pohl et al., 2020 ⁴⁴	Cautious and utterly careful tooth extraction, the alveola was carefully excochleated without elevating the flap and under careful preservation of the papilla.	Nobel-Replace Tapered; Nobel® Biocare, Kloten, Switzerland.	Conical connection; diameter: 4.3 mm; length: 13 mm and 16 mm.	The buccal crestal margin of the implant had to be at least 3 mm below the deepest indentation of the gingival margin and 3 mm palatally of the same. The implant had no direct contact with the buccal portions of the facial bone or soft tissue. Thus, the orientation of the implant position was soft-tissue- but not hard-tissue-related.	For assessing the mesial and distal bone level, intraoral radiographs (Sisdex®, Sirona, Bensheim, Germany) were taken on the day of surgery and 4, 6, and 12 months postoperatively.	100%
Staas et al., 2021 ⁴⁵	Atraumatic tooth removal technique.	NobelActive Conical Connection™ (Nobel-Biocare, Washington, DC, USA).	Conical connection; diameter: 3.0 mm (x6), 3.5 mm (x47), 4.3 mm (x45). length: between 11.5 mm and 18 mm.	The seat of the implant was placed 3 mm apically from the buccal gingival margin and at least 2 mm palatal of the buccal bone plate.	Amoxicillin 500 mg x3 day for 5 days (clindamycin 600 mg/x4 day 5 days if allergic to penicillin) and chlorhexidine 0.12% twice a day for 14 days.	100% (2 patients excluded due to trauma and relocation).

Table 4. Extraction technique, diameter and type of implants used, implant position, postoperative control, and implant survival rate – cont.

Author/year	Tooth extraction technique	Implant used	Implant dimensions and platform	Implant position	Post-op control	Implant survival rate
Elaskary et al., 2020 ⁴⁶	Atraumatically using periosteal. Vestibular access horizontal incision made at the socket site 3–4 mm apically to the mucogingival junction and extending 5–10 mm horizontally, submucoperiosteal tunnel created from the facial aspect of the socket orifice until the vestibular access incision.	Megagen implant	Conical connection; diameter and length not described in the text.	Optimum prosthetically guided position with the implant shoulder placed 3–4 mm apically to the labial gingival margin.	Antibiotics (Ciprofloxacin) and non-steroidal anti-inflammatory (Catafast) for 5 days, mouth washing with chlorhexidine 0.12% during 10 days; 6 and 13 months to measure facial bone thickness and height. Pink esthetic score was recorded at 6 and 13 months.	100%
Frizzera et al., 2018 ⁴⁷	Flapless, with a facial pouch creation for the soft tissue augmentations groups.	Flash (Conexão Sistemas de Prótese)	Diameter: 3.5 mm; Length: according to the amount of apical bone; Platform: conical morse-taper.	Implant platform was placed 4 mm below the facial gingival margin (ideal implant position).	Antibiotic (amoxicillin for 7 days) and analgesic for pain relief (paracetamol 750 mg). Clohexidine 0.12% for mouth washing. Measurements of soft tissue at 6 and 12 months after the surgery.	100%
Noelken et al., 2013 ⁴⁸	Atraumatically extracted using the periosteal technique maintaining the alveolar socket walls and gingival architecture. All procedures were performed without raising a flap even when a facial bone defect was observed.	Osseo-Speed™ implants (Astra Tech AB).	Conical connection; Diameters: 3.5–5.0 mm Length: 11–17 mm.	In contact with the oral lamella of the socket. Depth was determined by the interproximal and facial soft tissue and bone height.	Antibiotic prophylaxis (starting the day before surgery until 7 days post-operatively; clindamycin 300 mg 3–4 times/day) and a prescription for post-surgical chlorhexidine rinse 0.2%, for 10 days. After implant placement, the subjects returned for a follow-up visit after 7–10 days for control of the implants, the temporary restoration, and the healing process.	100%
da Rosa et al., 2014 ⁴⁹	As atraumatically as possible using peristomes and mini-livers after minimal incision made around the tooth with microblade. Maintain the integrity of remaining bone wall and papillae.	Nobel replace Tapered TiUnite – (Nobel Biocare).	Conical connection; diameter and length: according to socket dimensions.	Ideal 3D position. Cingulum axis of the alveolus.	500 mg of amoxicillin x3 day (azithromycin 500 mg x2 day if allergic) for 10 days/4mg dexamethasone x2 day for 3 days. Mouth washing with chlorhexidine solution x2 day for 14 days.	100%
Groenendijk et al., 2021 ⁵⁰	After atraumatic extraction, the socket was cleaned extensively using a bone excavator to remove remnants of the periodontal ligament and/or inflammation tissue and to promote bleeding. The keratinized gingiva remained intact as no flaps were raised.	NobelActive Internal implants (Nobel Biocare, Washington DC, USA).	Conical connection. The implant dimension was not described in the paper.	Implant seat positioned 3 mm deeper than the buccal gingival margin.	Amoxicillin every 8 h during 5 days postoperatively and to rinse with 0.12% chlorhexidine solution twice a day during 14 days post-surgery.	100% (3 patients excluded due to trauma, relocation or missing photographs).

Table 4. Extraction technique, diameter and type of implants used, implant position, postoperative control, and implant survival rate – cont.

Author/year	Tooth extraction technique	Implant used	Implant dimensions and platform	Implant position	Post-op control	Implant survival rate
Sicilia-Felechosa et al., 2019 ⁵¹	All surgeries were carried out by an experienced periodontist with the aid of a surgical microscope. Dental extractions were atraumatically performed to the maximum possible extent. Use of sclerotome, forceps and root elevators, avoiding bucco-lingual luxation movements.	Conical: Zimmer Biomet hybrid micro-surface topography (machined surface at the most coronal aspect and dual acid-etched surface on the remainder of the implant body; OSSEOTITE®, Zimmer Biomet). Parallel-walled: Nobel Biocare Speedy®, anodized surface (Ti-Unite®, Nobel Biocare)	Implant length [mm]: 11.5 (n = 1), 13 (n = 13) and 15 (n = 26). Implant diameter [mm]: 3.4 (n = 2), 4.1 (n = 33) and 5.1 (n = 5). External hexagon.	The implants were placed according to the CBCT setting following a computer-oriented surgery procedure with multiple screens.	Not described in the paper.	One implant placed failed at 5.6 years. The remaining implants (39) were monitored, achieving a success percentage of 98.3% (95% CI: 91–99%) in a follow-up period that ranged from 1 to 7 years.

CBCT – cone beam computed tomography.

grafting after IIP and immediate restoration in the presence of a partial or completely missing buccal bone.

The PES was used to compare initial and final photographs of the patient using the contralateral tooth as a reference.^{13,42,44,46–48,50,51} Some points were evaluated, such as the medial and distal papillae, soft tissue contour, gingival margin level, soft tissue color, and texture. On the other hand, Ferrantino et al.⁴³ applied the Implant Crown Aesthetic Index (ICAI) to clinical digital photographs taken during the follow-up. In contrast, da Rosa et al.⁴⁹ chose the gingiva morphometry method. Staas et al.⁴⁵ and Lee et al.⁴¹ assessed the relationship between the bone margin and thickness as well as the interproximal bone peek to measure the esthetic risk of IIP and immediate restoration and gingival/bone changes during the healing time. Some authors also evaluated patient satisfaction.⁵¹

Bone graft and soft tissue

In paper by Sicilia-Felechosa et al.,⁵⁰ the authors did not describe the bone substitute used, while most of the others chose xenografts.^{43,45,47,51} Two studies had grafted the buccal alveolar space in front of the implant surface with autologous bone chips,^{13,48} while 1 decided to use a specific graft technique using thin lamina of bone from tuberosities.⁴⁹ The association between xenograft and autologous chips was also considered to fill the buccal gap.^{42,46,51}

Regarding soft tissue grafts, there was no preference regarding their use or not. While some authors proceeded with gingival volume augmentation,^{42,43,46–48,51} others did not consider this option.^{13,41,44,45,49,50} Subepithelial connective tissue grafts removed from the palate^{42,46–48} or tuberosity⁴² were used to increase gingival volume. Allogenic dermis (AlloDerm RTM, Biohorizons, Allergan Corp., Dublin, Ireland)⁵¹ and a collagen matrix (Mucograft, Geistlich, Wolhusen, Switzerland)⁴⁷ were also considered.

Implant settings

Tapered implants were used in several studies (Table 4).^{13,41–49,51} Nevertheless, 1 author used a parallel implant,⁵¹ and another did not describe the type of implant used.⁵⁰ The diameter of the implants varied from 3.0 mm⁴⁵ to 5.1 mm,⁵¹ and was chosen based on the socket dimensions. The position of the implant was more palatal, following the best 3D position, creating a gap between the implant surface and the buccal bone wall, which could be filled with graft or not, as described above. This gap ranged from 1 mm⁴¹ to 3 mm long⁴⁴ and was filled as mentioned above. The abutment connection dictates the distance from the perspective of the clinical crown margin to the implant seat. The most commonly described distance was 3–4 mm,^{42,45–47} although implant seats coinciding with the facial bone crest level were found.⁴¹

Implant success/survival rate

The implant success rate (Table 4) was measured based on the absence of pain complaints, discomfort, infection, no implant mobility, and no bone loss (less than 1 mm in the 1st year). A high success rate was found in all of the selected papers. Some authors showed a 100% success rate,^{13,44,46–49} while others described 1 implant loss out of 39%,⁴¹ or 96.80% implant survival.⁴³ Others had a success rate of 98.3%,⁵¹ 96.7%,⁴² while some had a success rate of around 100% after excluding patients who lost the implant due to trauma or did not undergo the follow-up maintenance.^{45,50}

Immediate/provisional restoration

The immediate restoration procedure was mandatory to be included in this review (Table 5). Although different

restorative protocols were found, all authors used temporary restorative crowns during implant healing. Elaskary et al.⁴⁶ chose to maintain the gingival architecture with personalized provisional healing at the gingival margin level instead of installing a complete restorative crown. Some authors^{43,47,49} described a subgingival concave contour of the immediate restoration to maintain the gingival margin position and create space for the soft tissue ingrown. Nevertheless, Groenendijk et al.⁵⁰ differed in 3 clinical situations that could be found during the extraction procedures and 3 restorative approaches: 1. Gingival recession, which should lead to a more concave contour in the subgingival area of the prosthesis, allowing the growth of soft tissue; 2. Gingival margin in the right position, in which the restoration should support the tissue without compression; and 3. When there was a more coronal position of the gingival margin, the restorative crown should compress the soft tissue to promote a controlled recession.

Table 5. Immediate restoration, period for rehabilitation, esthetic outcomes, and measured parameters

Author/year	Provisionalisation	Definitive prosthesis deliver	Esthetics outcomes	Measure parameters
Noelken et al., 2018 ¹³	The temporary restorations were either manufactured from acrylic denture teeth to be cemented on top of titanium abutments using a temporary cement or individual temporary screw-retained restorations fabricated by a laboratory technician using temporary abutments.	Final restoration fabricated after a minimum of 3 months of healing. Zirconia crowns were cemented on top of zirconia abutments.	The primary outcome parameter of this retrospective study was the facial soft tissue level. The secondary outcome parameters were the width of the keratinized mucosa, the interproximal and facial marginal bone levels, the soft tissue esthetics, and overall implant success.	Evaluation of primary and secondary outcome parameter was measured by a periodontal probe with 1 mm calibration. The Pink Esthetic Score (PES) assessed the configuration of the mesial/distal papillae, the vertical level, the contour and symmetry of the soft tissue margin, and the texture and color of the soft tissue on a rating scale (0–2). The status of the interproximal marginal bone level was determined using digital periapical radiographs with paralleling technique.
Lee et al., 2020 ⁴¹	A provisional abutment with a screw-retained custom provisional crown placed immediately. Provisional crowns were free of any occlusal contact. Details about restoration contours not described.	The patients were referred for definitive restorations 6 months after placement. More details are not described in the paper.	Alterations of bone and soft tissue were measured. Linear regression analysis was performed to analyze the association between different clinical parameters and outcomes of interest.	Measurements of tissue alterations obtained at the follow-up visits included: vertical gingival margin (GM) change: mid-buccal gingival level changes calculated through the measurement obtained from the baseline visit compared with the measurement obtained at the 12-month follow-up visit; horizontal buccal ridge dimensional change: longitudinal remodeling of the buccal ridge in the horizontal plane assessed on casts using a stent to measure changes from presurgical baseline to the 12-month cast, with the reference plane of the measurement located 3 mm apically to the preoperative gingival margin; interproximal marginal bone level change: distance between the most coronal bone to implant contact (BI) and the implant platform level (IP) measured both at the mesial and distal sites on digital periapical radiographs

Table 5. Immediate restoration, period for rehabilitation, esthetic outcomes, and measured parameters – cont.

Author/year	Provisionalisation	Definitive prosthesis deliver	Esthetics outcomes	Measure parameters
Zuiderveld et al., 2017 ⁴²	Immediate implant-level impression taken to fabricate a screw-retained lab-made provisional crown using engaging temporary abutment and composite. Then, a corresponding healing abutment was connected to the implant. The same day as implant placement, the healing abutment was removed and the screw-retained provisional crown was fitted directly onto the implant with 20 N•cm and adjusted to free it from centric contacts with antagonist teeth.	After a 3-month provisional phase, a final open tray impression was taken at implant level using polyether impression material. Next, an individualized zirconia abutment was made. Abutment screws were torqued with 35 N•cm. Depending on the location of the screw access hole, the final crown was screw-retained or cement-retained with glass ionomer cement.	Esthetics of the peri-implant mucosa and implant crown were assessed from photographs taken using the pink esthetic score-white esthetic score (PES/WES).	Change in mid-buccal mucosal level (MBML) compared to the preoperative situation. In addition, gingival biotype, esthetics (using the Pink Esthetic Score – White Esthetic Score), marginal bone level, soft tissue peri-implant parameters and patient satisfaction were assessed.
Ferrantino, et al., 2021 ⁴³	A customized screw-retained resin crown was positioned on an anti-rotational titanium temporary abutment over the implant without any occlusal contact. Special attention was paid to the trans-mucosal shape of the provisional restoration to support the soft-tissue margin of the post-extraction site without any compression and to provide space for a stable blood clot formation.	After 6 months – screw-retained or cemented restoration was fabricated and delivered to the patient after the pick-up impression was treated with a polyether material. For screw-retained restorations, a prefabricated anti-rotational titanium abutment was used, while a customized anti-rotational titanium abutment was manufactured for cemented restorations. Final crowns were either made with monolithic zirconia; porcelain fused to metal or porcelain fused to zirconia.	An esthetic assessment was carried out on digital clinical photos taken during a 1-year follow-up visit on a computer screen by an independent blinded investigator. The pictures of the buccal and occlusal aspects included the 2 adjacent teeth and the contralateral dentition. Further analysis of the primary outcome variable considered the 4 items regarding the esthetic of the mucosa and the 5 items regarding the esthetic appearance of the crown separately.	Implant Crown Aesthetic Index (ICAI) at the 1-year follow-up.
Pohl et al., 2020 ⁴⁴	Provisional rehabilitation in both groups was done using a copy abutment initially in synthetic material exactly imitating the gingival emergence profile of the original tooth. Special care was taken not to give any pressure due to the abutment design to the soft tissues as seen by a change of the color from pink to white as this might influence the soft tissue margin. On the 3 rd to 5 th postoperative day, this abutment was replaced by a copy of zirconium oxide and fixed with a torque of 20 N•cm. Both abutments were provided with the same provisional crown having no interproximal contact with neighboring teeth or eccentric contact with opposing teeth.	After a healing phase of 3–4 months, the abutment screws were fixed using a torque of 25 N•cm, and the provisional crowns were replaced by ceramic crowns by the use of conventional impression technique. In case of a possible visibility of abutment margins due to mucosal retraction, the abutment was ground using diamond drills taking special attention not to touch the soft tissue. The definitive abutments were neither removed at that time nor at any later point of time.	For assessing the buccal soft tissue profile, intra-oral photographs were taken preoperatively and postoperatively after 1 year. The images each comprised the region to be assessed as well as the contralateral tooth. The parameters assessed included: the mesial and distal papilla, the level, contour, color, structure and texture of the soft tissue, and the alveolar ridge of both the test and the control tooth. All measurements of the Pink Esthetic Score (PES) were taken in blinded manner by 2 students in training for dentist, an experienced implantologist and an experienced implant prosthodontist. In addition, a straight line was placed through the most apical point of the gingiva of the neighboring teeth of the implant, and a vertical to this line to the most apical point of the mucosa of the implant crown was determined. Measurements were done in mm based on the actual crown length of one of the neighboring teeth.	The buccal defect was determined with sagittal reconstruction according to the longitudinal axis of the implant in the postoperative cone beam computed tomography (CBCT) scan. The distance between 2 verticals on the implant axis from the most crestal bone margin to the upper implant edge yielded the vertical defect of the buccal lamella. In addition, the maximum size of the defect was evaluated at the transverse section and vertical to the implant axis. For assessing the mesial and distal bone level, intraoral radiographs were taken on the day of surgery and 4, 6, and 12 months postoperatively. The distance between the upper edge of the implant and the first contact of the bone with the implant body was determined both mesially and distally following calibration with the known implant length.

Table 5. Immediate restoration, period for rehabilitation, esthetic outcomes, and measured parameters – cont.

Author/year	Provisionalisation	Definitive prosthesis deliver	Esthetics outcomes	Measure parameters
Staas et al., 2021 ⁴⁵	A titanium temporary customized platform-switch Procera™ abutment was placed allowing fabrication of a composite screw-retained provisional restoration.	After implant placement (3–9 months), the final impression was taken to fabricate either an individualized, screw-retained, zirconium-oxide porcelain veneered crown, or an individualized zirconium-oxide abutment with a resin cemented porcelain.	Correlation between buccal bone thickness and radiographs analyses.	Radiographic procedure measurements. Thickness of the buccal crest was measured at the level of the implant-shoulder, ensuring that thickness of the buccal crest was measured at the same position and angulation at all time points.
Elaskary et al., 2020 ⁴⁶	Customized healing abutment screwed to the implant, adequately finished, and polished to ensure a proper soft tissue emergence profile.	The definitive restoration was delivered 3 months postoperatively.	Two examiners were trained and calibrated to access the esthetic appearance at 6 and 13 months using pink esthetic score (PES). The comparison was made with the contralateral natural tooth. Mesial papilla, distal papilla, soft tissue level, soft tissue contour, deficient alveolar process, soft tissue color, and texture were evaluated.	Cone beam computed tomography (CBCT): superimposing the images at baseline and 6 or 13 months. The facial bone thickness measured on the 6/13 months images from the implant surface to the outer surface of bone at 3 points. Same was done with the contralateral tooth. Facial bone high measured from the facial bone crest and implant platform.
Frizzera et al., 2018 ⁴⁷	20 N•cm screw retained interim restoration or cemented provisional over 20 N•cm torque abutments.	After 6-month final restoration with emergence profile copied from interim restoration. Abutments customized in zirconia and subgingival concave contour to deliver cemented porcelain restoration. Cementation line 0.5 mm bellow gingival margin.	Clinical photographs at baseline and at 6 and 12 months after the surgery, where marginal peri-implant recession (MPR), mesial papilla (MP), and distal papilla (DP) migration were measured based on the adjacent teeth. Pink esthetic score (PES) and modified PES (mPES) were assessed to evaluate soft tissue esthetic outcomes.	Photographic evaluation of peri-implant soft tissue margin and interproximal papillae based on the adjacent teeth. Measurement of the facial bone thickness (FBT) in contact with the implant at different levels, the soft tissue thickness (STT) 2 mm below the gingival margin, and the distance between the implant platform and the 1 st bone-to-implant contact (DIPBIC). Line connecting the mesial and distal bone crest was created and the distance to the palatal bone was recorded to assess the size of the format of the ridge defect (FRD).
Noelken et al., 2013 ⁴⁸	Healing abutments (Healing Abutment Uni 4.5/5.0; Astra Tech AB) were used during the short time of fabrication of the temporary restoration. Manufactured acrylic denture teeth were adjusted to the implant site and cemented on top of titanium abutments (n = 12) using a temporary cement or individual temporary screw-retained restorations fabricated by a laboratory technician using temporary abutments (n = 25). All temporary restorations were inserted at the day of implant placement and adjusted to clear all contacts.	A minimum of 3 months. The final zirconia crowns or bridges were cemented on top of zirconia abutments using a temporary cement or a glass ionomer cement.	–	status of the interproximal marginal bone level was determined using digital periapical radiographs. To ensure reproducibility between the examinations, radiographs were taken with paralleling technique using commercially available film holders. status of the facial bone level was determined with cone beam computed tomography (CBCT) data, specifically by the reconstruction according to the long axis of the teeth/implants at pre-treatment examination, at 1-year and/ or 2-year follow-up. The thickness of the facial bone wall was measured 1, 3, and 6 mm apically to this reference level at the facial aspect of the implant.
da Rosa et al. 2014 ⁴⁹	Provisional crown applied using veneers previously prepared with light curing composite resin. Ideal emergency profile with concave contour allowing free space to accommodate the soft tissue.	After 6 months – cemented metal-ceramic or ceramic zirconia restoration over customized abutment with subgingival contours. Cement line established between 0.5 mm and 1 mm below the gingival margin.	Gingivomorphometry method. Two clinically photographs: 1 week after definitive crown deliver/last follow up visit (1 photograph for rehabilitation planning).	Crown high baseline/follow up; mesial papilla high baseline/follow up; distal papilla high baseline/follow up.

Table 5. Immediate restoration, period for rehabilitation, esthetic outcomes, and measured parameters – cont.

Author/year	Provisionalisation	Definitive prosthesis deliver	Esthetics outcomes	Measure parameters
Groenendijk et al., 2021 ⁵⁰	Titanium temporary abutment positioned onto the implant that allowed the fabrication of a screw-retained temporary crown.	Six months later, either an individualized, screw-retained, zirconium-porcelain crown, or an individualized zirconium abutment with a cemented porcelain facing.	Pink esthetic outcome.	Both the implant and contralateral site were photographed in a standardized way at different timepoints; preoperatively, 7–14 days postoperatively, direct after placement of the permanent crown, and 1 year post-operation. On each time point, 2 light photographs were taken: 1 perpendicular to the mid-buccal of the tooth arch, and 1 perpendicular to the implant site. Before examination, the light photographs were placed in a digital format. Evaluation of the pink esthetic outcome was executed by 2 blinded examiners, who were not involved in the patient treatments.
Sicilia-Felechosa et al., 2019 ⁵¹	Immediately produced in the laboratory a direct-to-implant screw-retained resin provisional prosthesis which completely sealed the gingival alveolus and offered support for soft tissues, without creating additional pressure on the tissues at the critical and subcritical contour levels. The restorations were designed in such a way that no direct occlusal contact was allowed during the 1 st 3 months.	Not described in the paper.	Soft-tissue esthetics were achieved analyzing the intraoral pictures taken in the last follow-up visit according to the Pink Esthetic Score and using the contralateral tooth as a reference. At last, patient subjective satisfaction was secondarily assessed through a clinical questionnaire consisting of 6 questions with 4 options (bad, average, good and excellent) to analyze esthetics, comfort, chewing function, and global evaluation.	The stability of interproximal bone levels was achieved assessing the distance from the implant's platform to the 1 st implant/bone contact point by means of calibrated digital periapical X-rays and using a dedicated software.

One point of convergence between all authors was the necessity of leaving the immediate restoration with a lack of occlusal contacts. Meanwhile, a healing time of 3^{13,42,44–46,48} or 6 months^{41,43,47,49} was allowed before delivering the final restoration (Table 5). Various materials were used for the final crown and the cemented or screw-retained prosthesis. The definitive restorative crowns were made from multiple materials, including metal-ceramic,^{43,49} monolithic zirconia, zirconium oxide^{45,48} or ceramic.⁴⁴ Those prosthetic crowns could be 1 piece screwed to the implant^{43,45} or 2 pieces using a zirconia abutment to receive the cemented crown.^{13,45,48}

Phenotypes and esthetics

Regardless of the importance of the initial phenotype, the thinner the buccal plate thickness, the higher the risk of gingival recession or shrinkage of the alveoli. The final result showed (in most cases across all studies) that the esthetic result can be delivered. The thin phenotype could promote great changes in the mid-buccal gingival margin and the mid-buccal ridge dimension. Also, when combined with flap release, there was an increase in the interproximal gingival recession⁴¹ (Table 6).

Even when IIP and immediate restoration involved compromised sockets presenting with buccal bone deficiency or gingival recession, an increase in the PES could be achieved.⁵⁰ Many different approaches could overcome bone deficiency, as shown by da Rosa et al.,⁴⁹ and achieved stable peri-implant soft tissue levels after 58 months, even in compromised fresh sockets. Another study²⁴ did not proceed with any kind of buccal plate reconstruction or soft tissue augmentation, and, at the end of the follow-up, still demonstrated an increase in PES for patients treated with IIP and immediate restoration in the presence of bone deficiency, even though minimal adjustment of the restoration had to be performed in every patient due to slight alterations of the gingival margin.

Although the association between buccal gap filling and soft tissue augmentation is not mandatory for satisfactory esthetic results,⁴³ its application adjunctive to immediate restoration in IIP seemed to deliver the most predictable treatment, guaranteeing marginal gingival level stability.^{42,46,47} In addition, using subepithelial connective tissue grafts improved the results compared to other soft tissue substitutes.⁴⁷ Even though an expected increase in PES was noticed, reaching the maximal score in 73–89% of cases, there was still a risk of a gingival recession of 1–2 mm in around 20% of the treatments.⁵¹

Table 6. Average bone loss found in the studies included

Authors/year	Average bone loss
Noelken et al., 2018 ¹³	0.1 ±0.5 (range: 1.4–1.1 mm) in the ABG group and 0.0 ±0.5 (range: –1.0–0.9 mm) in the ABG/CTG.
Lee et al., 2020 ⁴¹	The mean buccal ridge dimensional reduction at 12 months was 1.01 ±0.87 mm. The mean interproximal crestal bone loss was 0.81 ±0.90 mm. Mean interproximal marginal bone gain was 1.28 ±2.22 mm.
Zuiderveld et al., 2017 ⁴²	The average loss of marginal bone was 0.06 ±0.42 mm and 0.04 ±0.46 mm on the mesial side in the control and test group, respectively. Distal sides of the control and test groups gained, on average, 0.03 ±0.38 mm and 0.02 ±0.37 mm, respectively. The intergroup results were comparable.
Ferrantino et al., 2021 ⁴³	Not evaluated in the paper.
Pohl et al., 2020 ⁴⁴	The average postoperative bone level for the TG was 2.60 ±2.67 mm (mesial, 2.46 ±3.45 mm; distal 2.97 ±2.40 mm) and for the CG was 1.72 ±1.09 mm (mesial 1.55 ±1.43 mm; distal 1.88 ±0.96 mm), and the bone level at 12 months was 1.58 ±2.33 mm (mesial 1.42 ±2.32 mm; distal 1.75 ±2.34 mm) for TG and 1.42 ±0.71 mm (mesial 1.24 ±0.76 mm; distal 1.59 ±0.82 mm) for CG.
Staas et al., 2021 ⁴⁵	Directly postoperatively (T1), mean BCT increased from 0.6 mm at baseline (SD = 0.5) to 3.3 mm (SD = 1.2). After 1 year (T3) mean BCT reduced to 2.4 mm (SD = 1.1). Mean BCH at T0 was 0.7 mm (SD = 0.5), which enlarged to 3.1 mm (SD = 1.2) directly postoperatively (T1). Over a period of 1 year (T3) BCH condensed to 1.7 mm (SD = 2.4).
Elaskary et al., 2020 ⁴⁶	Initial bone thickness (mean): intact wall – 0.76 ±0.42 mm/bone deficiency – 0 mm. 6 months: intact wall – 1.88 ±0.73 mm/bone deficiency – 2.34 ±0.78 mm. 13 months: intact wall – 1.84 ±0.74 mm/bone deficiency – 2.18 ±0.73 mm. At 13 months, the mean distance from the implant platform to the bone crest in socket with intact bone wall was significant less than in sockets with deficient facial bone. The soft tissue level score was 2 for all cases in both groups, though.
Frizzera et al., 2018 ⁴⁷	No bone loss >1.5 mm detected in periapical radiographs after 1 year follow up.
Noelken et al., 2013 ⁴⁸	Three implants showed a decrease of the marginal bone level of more than 1 mm apically to the reference level. Marginal bone height at the level of the implant shoulder averaged 0.1 ±0.55 mm (range: 1.25–1.47 mm) at the final follow-up. The mean interproximal bone level (as measured against the implant shoulder) changed from 0.82 ±0.96 mm at implant insertion to 0.24 ±0.58 mm at prosthesis delivery, and further to 0.14 ±0.57 mm at the 1-year follow-up. Finally, at the 2-year follow-up, 0.07 ±0.58 mm was recorded. The thickness of the facial bony lamellae at the condemned teeth as well as at the implants measured increased thickness of the facial bone dimension.
da Rosa et al., 2014 ⁴⁹	Not evaluated in the paper.
Groenendijk et al., 2021 ⁵⁰	Not evaluated in the paper.
Sicilia-Felechosa et al., 2019 ⁵¹	Average bone loss ranged from 0.47 mm at 8 weeks of follow-up to 1.45 mm for the case that has been monitored for 7 years. From 8 weeks to 1 year (initial adaptation period), the data from 36 patients showed an apical displacement of the interproximal bone level of 0.25 mm.

ABG – autogenous bone grafting; CTG – connective tissue graft; TG – test group; CG – control group; BCT – buccal crest thickness; SD – standard deviation; BCH – buccal crest height.

Quality assessment

Quality assessment was performed using 2 different risk assessment tools according to the study design. Three RCTs included in this review were assessed using the modified Cochrane risk-of-bias tool,⁴⁰ while all other papers were judged according to the ROBINS-I risk of bias tool. One paper was classified as high risk of bias, 3 had a moderate risk and 8 had a low risk of bias (Fig. 2).

Discussion

This study intended to guide clinicians and clarify the understanding of IIP procedures in esthetic areas, which can involve soft and/or bone tissue grafts to maintain and stabilize the position of the gingival margin. Then, this systematic study aimed to assess whether there is increased esthetic risk in oral rehabilitation with a partial or total absence of the buccal bone plate in esthetic areas when associated with IIP and immediate restoration.

Alveolar bone wall and IIP

Tooth loss leads to alveolar ridge changes in the apical-coronal and buccolingual directions, affecting and compromising the esthetic result of implant-supported rehabilitation. The presence of the marginal bone crest determines the final position of the gingival margin, and the extension of this bone defect can be an esthetic risk factor in IIP. Depending on the bone involvement level, such as in cases of large defects or those involving interproximal areas, alveolar preservation and delayed implant placement have been recommended.⁵² These types of defects can be classified as: 1. Involving the buccal bone wall, with greater or lesser extension restricted to the medial surface; 2. “V” or “U”-shaped defects; and 3. Defects affecting adjacent teeth, such as “UU” defects. In larger defects or those involving papillae, there is a recommendation to perform alveolar preservation and subsequent placement due to the accentuated risk of marginal recession and compromised final esthetic. However, all studies included in this review presented buccal-wall defects at the time of IIP, with various

Articles	Pre intervention	At intervention			Post intervention		
	Bias due confounding	Bias in selection of participant	Bias in classification of intervention	Deviation from intended intervention	Missing data	Measurements of outcomes	Reported results
da Rosa et al.	N	N	N	N	N	N	N
Staas et al.	Y	N	N	N	N	N	N
Groenendijk et al.	Y	N	Y	N	N	N	N
Noelker et al.	N	N	N	N	N	N	N
Pohl et al.	N	N	N	N	N	N	N
Elaskary et al.	N	N	N	N	N	N	N
Neolken et al.	N	Y	Y	N	N	N	N
Sicilia-Felochosa et al.	Y	Y	N	N	N	N	N
Frizzera et al.	N	N	N	N	N	N	N

N = no; Y = yes.

Articles	Blinding participants and personnel	Blinding outcome assessment	Incomplete outcome data	Random sequence generation	Allocation concealment	Selective reporting	Other source of bias
Ferrantino et al.	High	Low	Low	Low	Low	Low	Low
Zuidervelt et al.	High	Low	Low	Low	Low	Low	Low
Lee et al.	High	High	Low	Low	Unclear	High	Low

Articles	Judgement
da Rosa et al.	Low risk of bias
Staas et al.	Low risk of bias
Groenendijk et al.	Moderate risk of bias
Ferrantino et al.	Low risk of bias
Zuidervelt et al.	Low risk of bias
Lee et al.	High risk of bias
Noelker et al.	Low risk of bias
Pohl et al.	Low risk of bias
Elaskary et al.	Low risk of bias
Neolken et al.	Moderate risk of bias
Sicilia-Felochosa et al.	Moderate risk of bias
Frizzera et al.	Low risk of bias

Fig. 2. Risk of bias assessment of non-randomized studies (above) (ROBIN-I), randomized studies (below) (modified Cochrane risk-of-bias tool), and result (judgment)

extensions, with analysis of this paradigm being the goal. Defects ranging from approx. 0.1 mm up to the absence of bone on the entire buccal surface were found, though there was no involvement of the interproximal bone crest.

Elevation of the vestibular flap and exposure of the bone defect can lead to greater procedure-related morbidity, more significant postoperative discomfort, decreased facial blood supply, and compromise the vitality of adjacent

tissues.⁴¹ Otherwise, flapless surgeries allow greater preservation of the buccal bone. Within these facts, most studies reported^{13,24–33,44,51,53} this approach for tooth removal, whereas Lee et al.⁴¹ used a minimally traumatic approach and flap elevation, randomizing the cases. The authors found a greater interproximal gingival recession in the group where the elevation flap was applied.

The need for an intact buccal wall with an unaltered gingival margin and a considerable buccal bone plate volume for IIP, as described by Buser et al.,⁵⁴ or the contraindication of IIP due to large and deep bone defects, as recommended by Kan et al.,⁵² were refuted by Sicilia-Felechosa et al.⁵¹ The latter approached IIP with immediate restoration in defects with more than 2/3 of the buccal bone wall compromised or a probing depth of more than 10 mm. Similarly, Pohl et al.⁴⁴ rehabilitated alveolar sockets with vertical defects ranging from 2.26 mm to 9.68 mm and horizontal defects between 3.2 mm and 5.91 mm, and showed that IIP without additional augmentation, but with immediate provisionalization, was a viable alternative even with the buccal wall missing in the esthetic maxillary zone.

Buccal space and bone grafts

The literature suggests that spaces of at least 2 mm between the implant surface and the buccal wall region, either from the remnant buccal-bone plate or from the buccal mucosa in patients with buccal-wall defects, must be filled by bone grafts to promote a thicker buccal bone wall when >2 mm-wide buccal gaps followed by IIP is done.⁵⁵ In addition, it can favor an adequate emergence profile of less than 30°.⁴⁵ The ideal, or more palatal, implant position could be achieved in a guided manner^{46,51} or by using the palatal wall as a reference. The correct 3D position of the implant consisted of an apical-coronal position 3–4 mm below the ideal gingival margin^{27,42,44–47} in the rehabilitations using conical connections. Meanwhile, in the rehabilitations using internal parallel connections, the implants were positioned at the bone crest level.⁴¹

The correct choice of grafting material to fill the gap allows the maintenance of ridge volume to minimize the losses arising from the facial wall remodeling.⁴⁵ The filling of this space was conducted in some studies^{43,45,47,51} using xenograft, while autogenous bone was the material of choice in other studies.^{42,46,51} Other authors^{13,47,48} chose only autogenous bone differing in particulates or bone lamina removed from the tuberosity; the final esthetic result was not negatively affected even though some decrease of marginal bone level occurred. The research with tuberosity bone did not evaluate the bone response through time, only the soft tissue aspect.

Immediate restoration and esthetic score

Recent studies reported results without augmentation to fill the gap or using a connective tissue graft. They

compared intact and defective alveoli walls in which IIP and immediate restorations were performed with a flap or flapless procedure; moreover, they verified the influence of the subgingival contour in the tissue response.^{41,44} There was an association between flap release and increased interproximal gingival recession,⁴¹ and, despite reporting that the esthetic result could be achieved in all cases regardless of the group, adjustments in the prosthetic margins of less than 0.2 mm had to be performed to make the definitive implant-supported restoration.⁴⁴

In general, preparation of the immediate restoration must respect the contours of the gingival architecture to promote soft tissue support without causing pressure on the gingival margin. In contrast, this contour must be concave below this margin in a subcritical space, allowing soft tissue growth. However, Groenendijk et al.⁵⁰ observed that in the presence of a more coronal position of the gingiva, the provisional restoration should compress the gingival margin and promote apical migration of the soft tissues. The temporary restoration must have no occlusal contact during the wound healing period. Noelken et al.¹³ considered splinting it with the adjacent teeth to prevent micromovements. The permanence of the provisional restoration can range from 3 to 6 months.

Although the recommendation for connective tissue grafts combined with IIP is found in the literature,⁴ increasing the predictability of results, some authors showed no difference in esthetics evaluation and patient satisfaction when comparing those with soft tissue grafts to a group without tissue augmentation.^{42,43} Ferrantino et al.⁴³ described that the complexity of the treatment might explain the different conclusions; the final result of the treatment can also be influenced by the correct development of the provisional restoration, which would help not only in assuring esthetic satisfaction of the patient but also in better healing of the post-extraction socket and the stability of the peri-implant soft tissue. Moreover, the more palatal positioning of the implant, the more influence it has on the maintenance of the gingival margin, allowing space for the creation of a thicker bone crest (after filling the gap) and soft tissue volume gain, even without the need for grafting,⁴⁴ leading to similar results when treating patients with or without gingival margin defects.⁵⁰

Elaskary et al.⁴⁶ demonstrated that the obtention of a buccal bone plate approx. 2 mm thick was possible, even with large bone defects at the time of tooth extraction; however, this was not associated with soft tissue defects. In that study, compensation for the lack of facial wall was provided by a mix of autogenous and xenograft biomaterials covered by a collagen membrane and subepithelial connective tissue graft. Also, both groups (without buccal-wall defects and partially lacking them) had a good score for the peri-implant soft tissue level. Pohl et al.⁴⁴ did not perform any soft or hard tissue graft augmentation to compare alveoli that had IIP with or without defects; therefore, they verified improvement or maintenance of the PES in most

cases. In addition, in all cases, regardless of the group, adjustments in the prosthetic margins were made to obtain the definitive prostheses.

The technique chosen by Sicilia-Felochosa et al.⁵¹ was autogenous or allogeneic connective tissue grafts combined with bone filling of the facial defect (autogenous bone grafts and/or deproteinized bovine bone mineral) without a collagen membrane. The authors obtained a 98% success rate over a 7-year follow-up. High success rates were associated with good esthetic results, with more than 70% of patients having a PES equal to or greater than 12 (PES index between 0 and 14). However, 8 out of 39 patients followed up (21.6%) had a 1–2 mm recession, compromising the final score.

Frizzera et al.⁴⁷ compared the results of 3 groups that received IIP, analyzing the different responses for connective tissue graft, collagen matrix and non-soft tissue augmentation. In all procedures, the gaps were filled with bone grafts covered by collagen membranes to isolate the buccal defect. The best result was found when utilizing an autogenous connective tissue graft, maintaining the volume obtained after 12 months. In addition, even though no recession was detected in the groups, the palatal position of the implant associated with a subcritical prosthetic contour allowed tissue growth. Therefore, soft tissue depression or color change was observed when the autogenous soft tissue was not used.

Limitations

The present systematic review had some limitations: 1. A low number of clinical studies were included ($n = 12$), which suggests that more well-standardized trials with long-term analysis are required to better verify tissue stability; 2. No other biomaterial was used to fill the gap between the implant and buccal wall or combined with the implant,¹⁷ such as bone graft with platelet-rich fibrin (PRF) or PRF alone. This fact can be considered in future investigations due to the potential of healing presented by PRF^{56,57}; 3. 33.3% of the studies ($n = 4$) had a moderate or high risk of bias; 4. Only 1 study showed long-term results (around 58 months); 5. Hexagon implants were sometimes used, which typically cause more marginal bone loss than morse-taper implants⁵⁸; and 6. There was some divergence in the type of tools used among the studies, which can cause impairment or confusion; 7. The effect of abutment disconnection, which is important for the maintenance of soft tissue height, was not evaluated in the included studies.

Conclusions

Considering the limitations of this systematic review, the consensus was that an esthetic result and increased final PES or patient satisfaction index in IIP treatments

associated with immediate restoration could be obtained even in the presence of buccal bone wall defects or gingival recession, regardless of their extension. Thus, there is no absolute contraindication for this type of treatment, but extreme attention to the treatment plan is recommended.

Supplementary data

The Supplementary materials are available at <https://doi.org/10.5281/zenodo.8410418>. The package includes the following files:

Supplementary Table 1. Inclusion and exclusion criteria used in the studies selected in this study.

Supplementary Table 2. Conclusions of the evaluated studies.

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