GRADUATION PROJECT

Degree in Dentistry

CRITERIA FOR POSITIONING SINGLE IMPLANT IN THE ESTHETIC AREA

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RESUMEN

Introducción: La colocación de implantes unitarios en el maxilar anterior es un procedimiento exigente en implantología. Los clínicos deben lograr la osteointegración, la estabilidad de los tejidos periimplantarios y un resultado estético. Aunque este tratamiento es frecuente, no existe un marco basado en la evidencia que integre todos los criterios de posicionamiento ideal.

Objetivo: El objetivo fue identificar y resumir los criterios para el posicionamiento óptimo de implantes unitarios en la zona estética, centrándose en condiciones anatómicas, la colocación tridimensional y el diseño protésico.

Materiales y Métodos: Se realizó una revisión sistematizada de la literatura utilizando PubMed y MEDLINE. La estrategia se basó en una pregunta PICO con vocabulario controlado y términos libres. Se incluyeron estudios primarios publicados en inglés, sobre la colocación de implantes unitarios en el maxilar anterior. También se realizó búsqueda manual de referencias.

Resultados: Veinticuatro estudios cumplieron los criterios de inclusión. Los resultados mostraron que un grosor óseo vestibular de al menos 2 mm, un grosor mucoso suficiente y un adecuado espacio mesiodistal son factores anatómicos clave. En cuanto al posicionamiento, la colocación palatina, un gap vestibular ≥2 mm, una profundidad subcrestal de 1–2 mm y una angulación correcta se asociaron con mejores resultados. Un perfil de emergencia cóncavo también se relacionó con una mayor estabilidad de los tejidos blandos.

Conclusiones: Los resultados en la zona estética dependen de una planificación cuidadosa y la aplicación combinada de criterios anatómicos, quirúrgicos y protésicos. El CBCT preoperatorio desempeña un papel esencial en este proceso.

PALABRAS CLAVE

Odontología, implante unitario, zona estética, posicionamiento del implante

ABSTRACT

Introduction: Single implant placement in the anterior maxilla is a demanding procedure in implant dentistry. Clinicians must achieve not only osseointegration but also stable peri-implant tissues and an esthetic result that blends with the adjacent teeth. Although this treatment is widely performed, there is still no evidence-based framework that integrates all the criteria for ideal implant positioning.

Objective: The aim of this study was to identify and summarize the main criteria for optimal positioning of single implants in the esthetic zone, focusing on anatomical conditions, three-dimensional placement, and prosthetic design.

Materials and Methods: A literature review was conducted using PubMed and MEDLINE. The search strategy was based on a PICO question and included both controlled vocabulary and free-text terms. Only primary studies published in English, addressing single implant placement in the anterior maxilla, were included. A manual search of reference lists was also performed.

Results: Twenty-four studies met the inclusion criteria. The results showed that a buccal bone thickness of at least 2 mm, sufficient mucosal thickness, and appropriate mesiodistal spacing are key anatomical factors. In terms of positioning, palatal placement, a buccal gap ≥2 mm, subcrestal depth of 1–2 mm, and correct implant angulation were consistently associated with better outcomes. A concave emergence profile was also linked to improved soft tissue stability.

Conclusions: Successful outcomes in the esthetic zone depend on careful planning and the combined application of anatomical, surgical, and prosthetic criteria. Pre-operative CBCT plays an essential role in this process.

KEY WORDS

Dentistry, single implant, esthetic zone, implant positioning

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1. INTRODUCTION

1.1. Historical background

Modern implantology began with the work of Professor Brånemark during the second half of the 20th century when he first introduced the fundamental concept of osseointegration (1), which allowed the functional rehabilitation of fully edentulous patients (2). Later studies started to follow cases about partial edentulous treatment and finally single implant-supported restorations (3). Initially the main focus was on preserving the bone stability and achieving biologic integration of the implants, often to the detriment of esthetic outcomes (3,4).

1.2. Evolution and current state of the topic

Over the last two decades patients expectations regarding esthetic outcomes have increased (5), and rising number of dental implant placements (6) has led to new criteria for defining treatment success (7). The harmonious integration of the implant into the surrounding soft and hard tissues is currently considered a key determinant of success (8) .

1.3. Key concepts and definitions

1.3.1. Single implant

A single implant-supported restoration refers to the replacement of one missing tooth by means of a solitary dental implant and a single crown (9). This modality has become a standard option in modern prosthetic implantology because it preserves neighboring teeth and supports function and esthetics in single-tooth gaps (1). Recent long-term data indicate that single implant treatment offers high survival and success rates over decades (10).

1.3.2. Esthetic area

The esthetic area is generally defined as the portion of the dental arch visible during smiling or normal social interactions, most commonly extending from maxillary canine to canine (11). Depending on the individual's smile line and lip dynamics, it may also include the first or second premolars or any area visible(12). This zone encompasses both the white esthetics, related to the shape, color, and alignment of the teeth or prosthetic crowns, and the pink esthetics, which concerns the surrounding gingival tissues and their harmony with the dental structures (11).

1.3.3. Anatomical and clinical considerations in the esthetic zone

The esthetic area presents unique biological constraints: the buccal bone is frequently thin (often ≤1 mm) and highly prone to resorption following extraction, which compromises soft-tissue support and implant masking capacity (13). Even with minimally invasive extraction and immediate implant placement, the buccal plate typically undergoes horizontal and vertical remodeling that cannot be fully prevented (14). In addition, the peri-implant mucosa in the anterior maxilla is strongly influenced by the patient's gingival phenotype, with thin biotypes being significantly more at risk of recession, even under ideal surgical conditions (15).

1.3.4. Three-dimensional axis

Mesiodistal axis: the horizontal distance between the implant and the root surfaces of adjacent natural teeth (16,17).

Buccolingual (labiopalatal) axis: the anterior-posterior positioning of the implant platform relative to the buccal bone wall and the ideal emergence profile of the final restoration(16)

Coronal-apical axis: the vertical depth of the implant platform relative to the gingival margin and the crestal bone level of adjacent teeth (18).

1.3.5. Emergence profile

The emergence profile describes the contour of the restoration from the implant platform to the crown. It is divided into two components: the subcritical contour, which lies apically and influences soft tissue support and thickness, and the critical contour, located coronally, which defines the position of the gingival margin and contributes to the esthetic integration of the restoration (19,20).

1.4. Clinical challenge

Esthetic outcomes are influenced by multiple factors, including the timing of implant placement and loading (21,22), the characteristics of the soft and hard tissue biotype (15), the use of guided bone regeneration (23), prosthetic design (24). Among these factors, three-dimensional implant positioning is consistently identified as a primary determinant of outcome, this is why this paper focuses on these criteria (2,25).

Unlike posterior implants, where functional and biomechanical considerations (such as occlusal load distribution, bone volume) predominate (26), implant placement in the esthetic zone requires meticulous positioning across three axes (mesiodistal, buccolingual, coronal-apical).

Deviation from the ideal position in any of these dimensions can result in esthetic and biological complications of varying severity, ranging from gingival recession and loss of papillae to bone resorption, implant thread exposure, and ultimately implant failure (27,28). These complications are not only clinically significant but may also be psychologically distressing for patients, who frequently cite esthetic outcomes as a primary driver of their satisfaction with implant therapy (6).

The concept of prosthetically driven implant placement has become central to contemporary implant planning. This approach dictates that the implant should be positioned to allow for the ideal emergence profile of the final restoration, rather than being placed solely according to available bone (29). The introduction of digital technology including cone beam computed tomography (CBCT), digital impressions, computer-aided design/manufacturing (CAD/CAM), and computer-guided surgical systems has substantially enhanced the clinician's ability to plan and execute precise three-dimensional positioning, with documented improvements in accuracy compared to conventional freehand approaches (30,31).

1.5. Justification

The growing volume of clinical research, combined with the increasing prevalence of single-tooth implant treatment in the anterior maxilla driven by rising patient demand and improving implant technologies, highlights the need for an evidence-based synthesis that clinicians can apply directly in practice (32,33). This review aims to provide guidance for single implant placement in the esthetic area contributing to improved clinical decision-making, reduced complication rates, and better patient outcomes.

2. OBJECTIVE

2.1. Primary objective

To identify and summarize the key criteria for optimal positioning of single implants in the esthetic zone to maximize esthetic and functional outcomes.

2.2. Secondary objectives

- To analyze the anatomical and biological criteria (buccal bone thickness, interproximal bone crest, gingival phenotype) required before single-implant placement in the esthetic zone.
- To define the three-dimensional positioning criteria (mesiodistal space, buccolingual position, apicocoronal depth, inclination) that preserve peri-implant hard and soft tissue architecture.
- To evaluate the influence of emergence profile design on esthetic outcomes and peri-implant tissue health.

3. MATERIAL AND METHODS

3.1. Study design

This study was conducted as a bibliographic review following evidence-based dentistry principles. Electronic databases including PubMed and MEDLINE were searched. A structured and reproducible methodological approach was used to ensure transparency and scientific rigor.

The clinical question was formulated using the PICO method:

Population (P)**:** adults patients requiring a single-tooth implant in the esthetic zone.

Intervention (I): correct positioning of a single implant in the esthetic zone.

Comparison (C): variations in the anatomy, position of the implant and prosthetic parameters.

Outcome (O): clinical, radiographic, and esthetic outcomes including peri-implant bone levels, soft tissue recession, papilla height.

What are the key criteria for optimal positioning of single implants in the esthetic zone to maximize esthetic and biological outcomes?

3.2. Search equation

Initial electronic search was conducted in January 2026 on PubMed and MEDLINE using a combination of medical subject headings (MeSH) terms and free-text keyword combined with Boolean operators: (("dental implant" OR "single implant") AND ("anterior maxilla" OR "esthetic zone" OR "aesthetic zone" OR "maxillary incisor" OR “maxillary canine”) AND ("implant positioning" OR "implant placement" OR "buccal bone" OR "gingival phenotype" OR "emergence profile")). A manual search of reference lists from relevant articles was also performed to identify additional eligible records.

3.3. Eligibility criteria

3.3.1. Inclusion criteria

- Primary evidence studies (randomized clinical trials, prospective or retrospective cohort studies, case-control studies, case series)
- Participants undergoing single implant placement in the anterior maxilla (canine to canine)

- Publication in English
- Reporting of at least one clinical or radiographic outcome relevant to implant positioning, anatomical assessment, or prosthetic design.

3.3.2.Exclusion criteria

- Secondary evidence studies (systematic reviews, meta-analyses, and narrative review articles)
- Editorials, expert opinions or conference abstracts
- Studies not specifically addressing the anterior maxilla or esthetic zone
- Animal studies or in vitro research.
- Studies focusing solely on implant parameters (shape, size, materials or surface modifications)
- Studies that focused on criteria for special patients (having systemic disease, metabolic problems)
- Lack of full-text availability
- Study reporting exclusively on posterior regions (premolars, molars) or exclusively on mandibular area

3.4. Selection process

The study selection process was conducted in two stages: title and abstract screening against the inclusion/exclusion criteria and full-text review of potentially eligible articles

The selection process is summarized according to the PRISMA flowchart (Figure 1. presented in section 4.1. Overview of included studies).

3.5. Data extraction

For each included study, the following variables were recorded: authors and year of publication, study design and follow-up duration, sample size (number of patients and implants), major findings and clinical recommendations, and methodological strengths and limitations. The extracted data were organized into evidence tables according to the thematic section of the review (presented in section 4. RESULTS).

4. RESULTS

4.1. Overview of included studies

A total of 1046 articles were identified through MEDLINE and PubMed complete database searching and manual identification. After removal of 82 duplicates, 964 articles were screened based on titles and abstract. Of these, 455 articles were excluded due to not being relevant for this paper. 213 full-text articles were assessed for eligibility, and 189 studies were excluded due to inappropriate study design or for other exclusion criteria (Figure 1.).

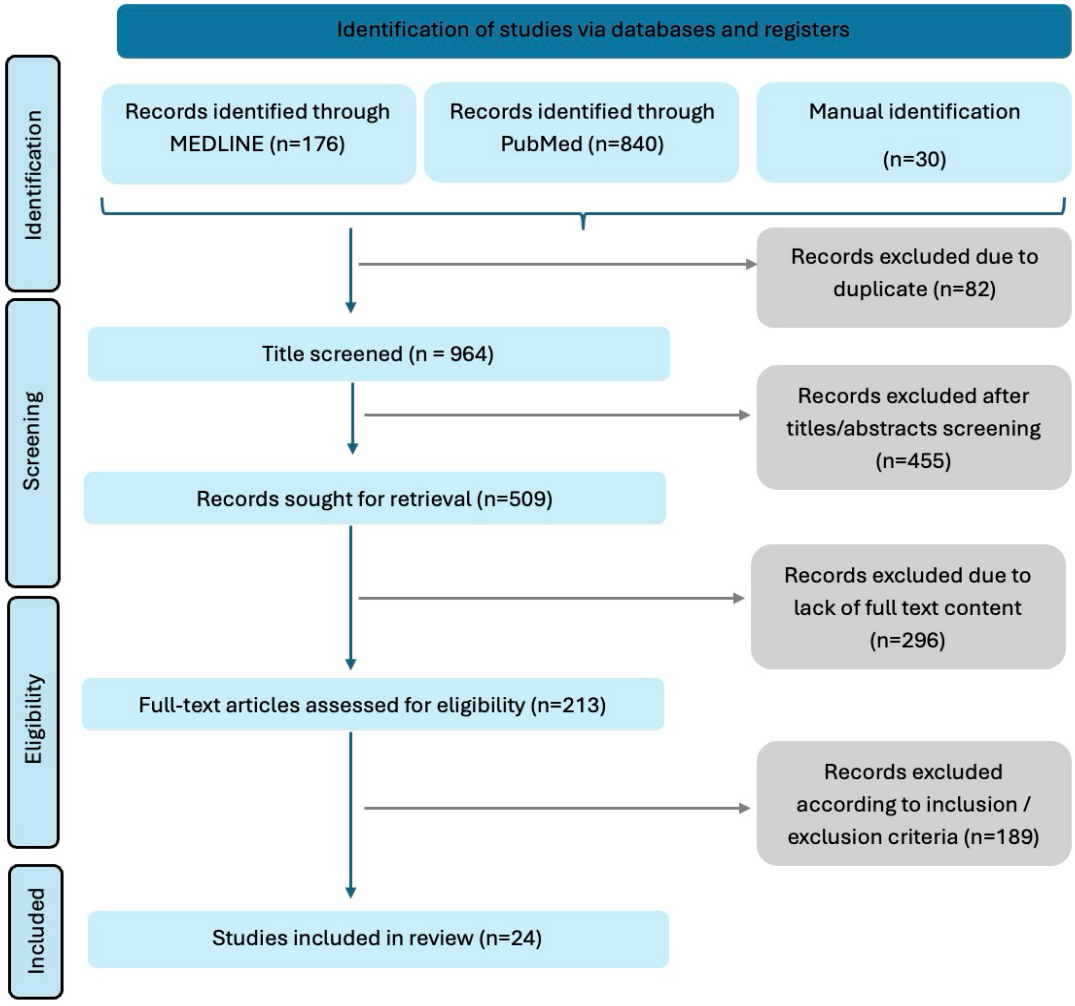


Figure 1. Prisma flow diagram of study identification and selection.

After applying the inclusion and exclusion criteria, a total of 24 primary studies were included in this bibliographic review. One study (Wilson & Johnson, 2019) contributed findings to two sections (4.1.1. and 4.3.2.), as it evaluated both spatial dimensions simultaneously. The studies were stratified according to the section of the review to which their findings contributed: 5

studies addressed buccal bone phenotype, ridge morphology, and the influence of pre-existing bony defects (Section 4.2.1.1); 3 studies addressed interproximal bone level, bone-to-contact-point distance, and papilla height (Section 4.2.1.2); 3 studies examined gingival phenotype and soft tissue thickness (Section 4.2.2); 4 studies addressed mesiodistal implant positioning (Section 4.3.1); 4 studies on buccolingual (labiopalatal) positioning criteria (Section 4.3.2); 2 studies on coronal-apical positioning (Section 4.3.3); 2 studies on implant inclination and axis orientation (Section 4.3.4); and 2 studies addressed prosthetic considerations (Section 4.4).

Study design	**n =**
Randomized clinical trial (RCT)	3
Clinical trial	1
Cohort study	16
Cross-sectional study	2
Case series / pilot study	2
TOTAL =	24

Table 1. Distribution of included study design (n=24).

4.2. Anatomical and biological criteria required before single-implant placement in the esthetic zone

4.2.1.Bone

4.2.1.1. Buccal bone thickness and ridge morphology

Author Year	**Purpose of study**	**Type of study**	**Sample**	**Major findings**	**Recommendations**
Staas et al. (2022) (34)	Evaluate whether initial buccal crest thickness (BCT) predicts final BCT after immediate implant placement and provisionalization.	Prospective cohort	100 patients	Moderate positive correlation between initial and final BCT. Initial BCT ≤0.5 mm led to significantly thinner final BCT (higher recession risk).	ensure ≥1 mm residual buccal bone at placement through palatal positioning; very thin initial BCT (<0.5 mm) = highest risk.

				Palatal implant positioning critical to preserving buccal bone.	
Arora & Ivanovski (2017) (35)	Evaluate correlation between pre-operative buccal bone thickness (BBT) and soft tissue changes after immediate implant placement.	Prospective study (2-year follow-up)	18 patients Maxillary anterior single implant	Sites with BBT ≥2 mm: mean recession 0.2 mm. Sites with BBT <2 mm: mean recession 0.9 mm. BBT ≥2 mm is a critical threshold for protecting the buccal soft tissue. The thin-bone phenotype (BBT ≤1 mm, the most common in the anterior maxilla) consistently produced worse esthetic outcomes.	CBCT mandatory to classify bone phenotype before surgery. BBT ≥2 mm required for implant placement without augmentation.
Yi et al. (2024) (36)	Evaluate the pattern and predictors of facial-coronal ridge crest remodeling after immediate implant placement and	Radiographic case series	50 patients Maxillary single incisor implant with thin buccal	In thin buccal plate phenotype (<1 mm), the buccal crest consistently remodeled inward and apically within 6 months.	pre-operative CBCT landmark analysis can predict risk. Thin buccal plate (<1 mm) mandates grafting of the buccal gap and

	provisionalization in the anterior maxilla.		plate (<1 mm))	Thin phenotype sites required implant palatal positioning and a minimum 2 mm buccal gap to reduce remodeling.	palatal implant positioning.
Pohl et al. (2020) (37)	Evaluate whether immediate implants with small buccal bone dehiscence in the anterior maxilla can heal without simultaneous bone augmentation.	Pilot study	12 patients Immediate implants in anterior maxilla Bone with small buccal dehiscence	Small dehiscence (≤3 mm) showed spontaneous re-ossification when implant was positioned palatally with ≥2 mm buccal gap and primary stability was achieved. Larger dehiscence required augmentation.	Palatal positioning and adequate gap ≥2 mm are prerequisites for non-augmented healing.
Meijer et al. (2019) (38)	Evaluate buccal bone thickness changes after implant placement in presence of large pre-existing bony defects.	Prospec tive cohort	40 patients 40 implants Anterior maxilla with large bony defects) 20 test / 20 control	Defect size correlated with residual marginal bone loss. Implants with simultaneous guided bone regeneration (GBR) achieved bone stability at 1 year. Esthetic outcomes acceptable.	GBR mandatory for large defects, implant survival high despite defects.

Kamperos et al. (2016) (39)	Evaluate the effect of buccal bone defect type on pink esthetic score (PES) at maxillary anterior single implant.	Retrospective study (5 years archive review)	91 patients Maxillary anterior single implant	Mean PES = 10.5. Buccal bone defects had a statistically significant negative effect on PES. Patients with major buccal bone defects showed significantly lower PES than those with minor or no defects.	Defect classification pre-operatively determines the augmentation strategy required.

Table 2. Primary studies on influence of buccal bone thickness and ridge morphology on single implants positioning in the esthetic zone.

4.2.1.2. Interproximal bone level and the interdental papilla

Author Year	Purpose of study	Type of study	Sample	Major findings	Recommendations
Guarnieri et al. (2016) (40)	Evaluate clinical predictors of peri-implant soft tissue level (papilla and mucosal margin) around single implants in the anterior maxilla.	Retrospective study (5 years follow up)	39 implants Anterior maxilla	Interproximal bone crest level of the adjacent tooth is the primary predictor of papilla level. Each 1-mm increase in adjacent tooth's interproximal bone height corresponded to a significant increase in papilla height. The marginal mucosal level was	Maintaining healthy periodontal bone at adjacent teeth is essential for papilla preservation. Adjacent tooth bone levels must be evaluated and stabilized before implant surgery.

				additionally affected by peri-implant biotype, facial bone crest level, and crestal implant exposure.	
Khoshhal et al. (2018) (41)	Evaluate the relationship between contact-point-to-crestal-bone distance and interdental papilla presence index at single-tooth implants in the anterior maxilla.	Historical cohort study	18 patients 18 implants 36 interproximal papillae assessed Anterior maxilla single implant	Statistically significant inverse relationship between contact-point-to-bone-crest distance and papilla index. Shorter distance = higher papilla index. The bone-to-contact-point distance, not implant type, is the primary determinant of papilla presence.	Plan the prosthetic contact point as close as possible to the interproximal bone crest of adjacent structures (target: ≤3–5 mm).
Gholami et al. (2022) (42)	Evaluate the average and maximum papilla height around anterior maxillary implants and its relationship to the distance from interproximal bone crest to the prosthetic contact point.	Retrospective clinical study	63 patients 92 implants Anterior maxilla Minimum 1-year loading	Mean papilla height: 2.8 mm (range 1–5.5 mm) at implant-tooth sites. Papilla height was directly influenced by bone-to-contact-point distance: the shorter the crestal bone-to-contact-point distance, the	The bone crest-to-contact-point distance must be minimized at treatment planning. A mean of ≤3–5 mm is required to achieve papilla fill of ≥50%.

				more complete the papilla fill.	

Table 3. Primary studies on influence of interproximal bone level, bone-to-contact-point distance, and papilla height on positioning of single implants in the esthetic zone.

4.2.2.Gingival phenotype and soft tissue thickness

Author Year	Purpose of study	Type of study	Sample	Major findings	Recommendations
Akshaya et al. (2023/2024) (43)	Evaluate the association between gingival biotype (thick vs thin) and peri-implant crestal bone loss in the anterior maxilla.	Retrospective study	96 patients Single implant anterior maxilla	Thick biotype: 59.3% showed no crestal bone loss. Thin biotype: significantly greater crestal bone loss (1–3+ mm).	Assess gingival biotype pre-operatively. Thin-biotype patients could require soft tissue augmentation to reduce bone loss risk.
Breunig et al. (2024) (44)	Evaluate the long-term influence of gingival phenotype on peri-implant crestal bone loss and peri-implant disease over 2–20 years.	Long-term cohort study	57 patients 162 implants	Phenotype 1 (thin, scalloped, narrow attached gingiva AG): significantly greater rate of crestal bone loss. Phenotype 2 (thick, flat gingiva wide AG): higher risk of peri-implantitis, greater probing depth. Phenotype 3 (thick, scalloped, narrow AG): most stable.	Phenotype 3 is the most favorable. Phenotype 1 patients could require preventive augmentation.

				First-year bone loss: 1.3 ± 0.7 mm overall.	
Linkevicius et al. (2009) (45)	Evaluate the influence of soft tissue thickness on crestal bone change around implants.	Prospective controlled trial	19 patients 46 implants (23 test 23 control)	Initial gingival tissue thickness at the crest may be considered as a significant influence on marginal bone stability around implants. If the tissue thickness id 2mm or less, crestal bone loss up to 1,45mm may occur.	Augment to ≥2 mm mucosal thickness to prevent compensatory bone resorption.

Table 4. Influence of gingival phenotype and soft tissue thickness on peri-implant crestal bone loss and tissue stability while positioning single implants in the esthetic zone.

4.3. Three-dimensional implant positioning criteria

4.3.1.Mesiodistal positioning criteria

Author Year	Purpose of study	Type of study	Sample	Major findings	Recommendations
Wilson & Johnson (2019) (16)	Evaluate frequency at which adequate mesiodistal space and faciolingual alveolar width exist for anterior implants using CBCT.	Cross-sectional CBCT analysis	205 CBCT images Anterior maxillary and mandibular positions	22–27% of maxillary lateral incisor positions offered <2 mm mesiodistal clearance on each side of the implant.	CBCT mandatory before anterior implants. Narrow implants should be planned when space is limited.

Liu et al. (2025) (17)	Evaluate the impact of mesiodistal clearance on bone loss around single anterior maxilla implants and establish evidence-based distance thresholds.	Retrospective cross-sectional study (mean follow-up 3.8 years)	161 implants Anterior maxilla	Clearance <1.5 mm: 0.95 mm bone loss 1.5–2.0 mm: 0.62 mm ≥2.0 mm: 0.48 mm Papilla loss and tissue recession highest in <1.5 mm group.	Clearance between the implant and adjacent root surface ≥2.0 mm is the target. Use narrow implants (3.3–3.5 mm) when space is constrained.
Mijiritsky et al. (2021) (46)	Evaluate long-term clinical, radiographic, and esthetic outcomes of immediate single implants placed with strict 3D positioning criteria (including mesiodistal ≥1.5–2 mm from adjacent roots) in the anterior esthetic zone.	Retrospective cohort study (follow-up up to 18 years)	15 patients 23 implants Anterior maxillary esthetic zone	When mesiodistal distance of ≥1.5–2 mm from adjacent roots was respected along with buccolingual and coronal-apical criteria, marginal bone levels (MBL) remained stable long-term, survival rate was high, and esthetic scores were favorable. Mesiodistal centering within the edentulous space was identified as critical to achieving symmetrical interproximal papilla.	Place implant at the center of the edentulous space. ≥1.5 mm bilaterally from adjacent root surfaces.

Han et al. (2022) (47)	Evaluate the occurrence and clinical consequences of dental implant placement in proximity (<1.0 mm or direct contact) to adjacent tooth roots, with subgroup analysis of anterior sites.	Retrospective study	43 patients Implant-tooth proximity ≤1.0 mm or direct contact Mixed anterior and posterior sites	In the anterior zone, implant-tooth proximity was associated with higher risk of peri-implantitis, adjacent root resorption, increased probing depths, and compromised papilla were recorded.	Surfaces CBCT pre-operative planning is essential at anterior positions. Maintain ≥1.5 mm mesiodistal clearance from adjacent root.

Table 5. Mesiodistal positioning criteria: spatial adequacy, minimum clearance thresholds, and clinical outcomes on single implants of the esthetic zone.

4.3.2.Buccolingual (labiopalatal) positioning criteria

Author Year	Purpose of study	Type of study	Sample	Major findings	Recommendations
Wilson & Johnson (2019) (16)	Evaluate frequency at which adequate mesiodistal space and faciolingual alveolar width exist for anterior implants using CBCT.	Cross-sectional CBCT analysis	205 CBCT images Anterior maxillary and mandibular positions	+ 50% of maxillary incisor site offered <4 mm beyond implant diameter (labiopalatal axis).	CBCT mandatory before anterior implants.

Staas et al. (2022) (34)	Evaluate whether initial buccal crest thickness (BCT) predicts final BCT after immediate implant placement and provisionalization.	Prospective cohort	100 patients	Moderate positive correlation between initial and final BCT. Initial BCT ≤0.5 mm led to significantly thinner final BCT (higher recession risk). Palatal implant positioning critical to preserving buccal bone.	Ensure ≥1 mm residual buccal bone at placement through palatal positioning.
Levine et al. (2022) (48)	Evaluate whether the width of the buccal gap between the implant and the buccal bone wall determined by the buccolingual implant position predicts final buccal bone wall thickness at the anterior maxilla.	Retrospective CBCT analysis (follow-up 5 ±4 years)	42 patients 51 maxillary central incisor sites	Wide buccal gap (>2 mm, reflecting more palatal implant placement): final buccal bone 1.9 ±0.9 mm thick, 95% of implant height covered by bone. Narrow gap (≤2 mm): 0.5 ±0.6 mm thick, only 59.4% coverage ($p<0.05$). Buccal gap width was the sole independent predictor of final buccal bone wall thickness.	Position the implant palatally to achieve a buccal gap ≥2 mm. This directly determines the long-term thickness of the buccal bone and its associated soft tissue support.

Fürhauser et al. (2022) (49)	Evaluate the relationship between buccopalatal implant position (digital scan superimposition) and peri-implant soft tissue outcomes in the esthetic zone.	Clinical cross-sectional analysis (≥1-year follow-up)	66 implants esthetic zone	Buccal deviation ≥1 mm from ideal position: 0.8 ± 0.3 mm apical soft tissue migration and significantly higher buccal soft tissue dehiscence (BSTD: 45% vs 12%).	Use guided surgery to keep implant within ≤1 mm of ideal buccopalatal position. Platform should be 0.5–1 mm palatal to ideal emergence line.

Table 6. Buccolingual (labiopalatal) positioning criteria: optimal implant position and esthetic impact at anterior maxillary single implants.

4.3.3.Coronal-apical positioning criteria: depth-related outcomes

Author Year	Purpose of study	Type of study	Sample	Major findings	Recommendations
Ercoli et al. (2017) (50)	Evaluate the influence of apico-coronal implant placement position on post-surgical crestal bone loss in humans.	Retrospective clinical study	55 patients 134 implants Multiple locations including anterior maxilla	Subcrestal placement reduced odds of implant thread exposure vs supracrestal/equicrestal. 47% implants placed supracrestally showed highest thread exposure risk.	Subcrestal placement (1–2 mm) reduces thread exposure, preferred for esthetic-zone implants.
Pellicer-Chover et al. (2019) (51)	Evaluate whether apico-coronal insertion depth (subcrestal vs	Randomised clinical	128 patients	Subcrestal placement showed significantly less radiographic	Subcrestal placement of 1–2 mm is biologically advantageous.

	equicrestal) influences peri-implant marginal bone loss at 36 months.	trial (RCT)	265 implants Multiple locations including anterior maxilla	marginal bone loss at 3 years. Similar clinical outcomes (probing depth, bleeding, survival).	

Table 7. Coronal-apical positioning criteria: influence of insertion depth on peri-implant crestal bone loss and implant thread exposure.

4.3.4. Implant inclination and axial orientation

Author Year	Purpose of study	Type of study	Sample	Major findings	Recommendations
Ren et al. (2024) (52)	Evaluate whether a labially inclined implant axis (imposed by large tooth-ridge angulation) compromises clinical outcomes in immediate implant placement and provisionalization (IIPP) in the anterior maxilla.	Prospective cohort study (1 year follow up)	39 patients 20 controls / 19 tests Anterior maxilla single implant	Labially inclined implants placed to avoid buccal bone fenestration, combined with CTG, did not produce significantly worse soft or hard tissue profiles at 1 year. Labially inclined axes increase the risk of buccal emergence deviations and should only be used when the anatomy (tooth-ridge angle) prevents ideal axis placement.	The ideal axis aims toward the cingulum/incisal edge. Labial inclination is acceptable only when anatomically unavoidable and must be compensated with CTG.

Kim et al. (2024) (53)	Evaluate the correlation between the magnitude of multidirectional implant angulation (axial vs non-axial) and peri-implant crestal bone loss over 5 years.	Retrospective (follow-up 5.1 years)	288 patients 506 implants Multiple position	Axial implants: mean crestal bone loss 0.10 ±0.39 mm. Non-axial implants: 0.22 ±0.48 mm. Greater bone loss in non-axial implants. Both mesiodistal and buccolingual tilt contributed independently to bone loss.	Align the implant axis with the functional occlusal load direction. Axial placement minimizes long-term crestal bone resorption.

Table 8. Implant inclination and axis orientation: biomechanical and esthetic consequences at single implants in the esthetic zone.

4.4. Prosthetic considerations and their influence on implant positioning

Author Year	Purpose of study	Type of study	Sample	Major findings	Recommendations
Siegenthaler et al. (2022) (19)	Compare the effect of convex vs concave implant crown emergence profile on peri-implant tissue stability and marginal bone loss at 12 months.	Randomised clinical trial (RCT) (12-month follow-up)	47 patients Single implant in the esthetic zone	Concave group: recession 0.09 ± 0.15 mm. Convex group: 0.41 ± 0.23 mm. Concave profile associated with significantly less marginal bone loss and lower bleeding on probing.	Concave/neutral subcritical contour strongly preferred in the esthetic zone; convex profiles should be avoided.

Endres et al. (2025) (20)	Evaluate 3-year outcomes of convex vs concave emergence profiles.	RCT 3-year extension	47 patients Cohort from original Siegenthaler 2022 RCT Single implant crowns in the aesthetic zone	Concave emergence profile maintained significantly lower recession and marginal bone loss than convex at 3 years.	Concave subcritical contour is recommended. The critical contour should reproduce natural tooth morphology.

Table 9. Prosthetic emergence profile design and its influence on peri-implant tissue stability at single implants in the esthetic zone.

5. DISCUSSION

The body of evidence is characterized by considerable heterogeneity in study design, sample size, and outcome measures. Only three of the included studies employed a randomized clinical trial (RCT) design (19,20,51) representing the highest level of primary evidence. The remaining studies were retrospective in design (the majority), with smaller prospective cohorts also contributing. This predominance of retrospective evidence reflects the inherent ethical and logistical difficulty of randomizing patients to different implant positions, particularly given the esthetic consequences of intentional positional deviations. These methodological limitations must be acknowledged when interpreting the recommendations that emerge from the evidence.

Despite these limitations, a high degree of consistency was observed across the reviewed studies: findings from different designs and time periods converged on a coherent set of positional and anatomical criteria that together define the conditions for predictable esthetic outcomes in the anterior maxilla. This convergence strengthens the confidence with which recommendations can be made.

From an anatomical perspective, several key factors must be considered. The buccal bone wall (BBW) of the anterior maxilla is an important anatomical structure in esthetic implant dentistry. The quantity and quality of the buccal bone at the time of implant placement are primary determinants of esthetic and biological outcome due to higher risk of recession (35,37–39).

A threshold of ≥2 mm was identified as critical: sites presenting with BBT below this value experienced significantly greater post-operative mucosal recession compared with thicker-bone sites (35,37). The paradox is that this threshold is rarely met in the natural anterior maxilla: the buccal cortex in this region is typically ≤1mm (35). This thin buccal plate phenotype was shown to consistently undergo inward and apical crest remodeling within six months of implant placement and provisionalization (35,36). Thin phenotype should trigger a pre-planned augmentation protocol combined with palatal implant positioning to limit volumetric bone loss (34).

In the presence of dehiscence, if they are small (≤3 mm), spontaneous re-ossification remained achievable with palatal positioning if a buccal gap ≥2 mm was preserved, and primary stability was obtained (37). In the presence of large-pre-existing bony defect regeneration is mandatory to achieve high survival rate and an acceptable esthetic outcome (37,38).

Taken together, these findings support the systematic use of pre-operative CBCT to classify BBT and define the augmentation strategy before implant placement is attempted in the esthetic zone.

In addition, the interproximal bone level plays a fundamental role in soft tissue esthetics. The interdental papilla is a visible and socially significant esthetic element of the anterior maxillary restoration. The height of the interdental papilla is principally determined by the vertical distance from the interproximal bone crest to the prosthetic contact point (BCP distance), and by the periodontal bone level of adjacent natural teeth (40–42).

The BCP ≤3–5 mm threshold for papilla fill is consistent across all three studies and across different implant systems (40–42). Its clinical implications are that the prosthetic contact point and therefore crown design must be positioned to respect this threshold from the pre-existing bone level. This places a premium on treating and stabilizing adjacent periodontal disease before implant placement since implant-supported papilla cannot compensate for bone loss at neighboring teeth (40).

Furthermore, the gingival phenotype and soft tissue thickness represent additional critical determinants. The three studies addressing gingival phenotype and soft tissue thickness represent a converging body of evidence that establishes the soft tissue envelope as an independent determinant of peri-implant bone stability (43–45).

The thin biotype was significantly associated with greater crestal bone loss, with 59.3% of thick-biotype patients showing no measurable bone loss compared with substantially worse outcomes in thin-biotype patients (43). Over a follow-up of up to 20 years, phenotype 1 (characterized by thin, scalloped gingiva with narrow attached gingiva) consistently produced the highest crestal bone loss, while phenotype 3 (thick, scalloped, narrow attached gingiva) remained the most stable (44).

An explanation for these observations was provided by evidence showing that when mucosal thickness at the crestal level is ≤2 mm, compensatory crestal bone resorption of up to 1.45 mm occurs as the body re-establishes an adequate biological width. Sites with mucosal thickness ≥2 mm showed markedly less bone resorption (45). This 2 mm mucosal thickness threshold

therefore constitutes a biologically grounded criterion for soft tissue augmentation prior to or concurrent with implant placement, particularly in thin-phenotype patients (44,45).

Beyond anatomical considerations, implant positioning in three-dimensions is a key determinant of outcome. Mesiodistal implant positioning is constrained by the available interradicular space. More than one-quarter of maxillary lateral incisor sites offered less than 2 mm of mesiodistal clearance between the proposed implant platform and the adjacent root surfaces, underscoring the mandatory role of CBCT before implant selection and placement planning (42).

When clearance was insufficient, the clinical consequences were significant. A clearance <1.5 mm produced mean peri-implant bone loss of 0.95 mm, compared with 0.48 mm when clearance was ≥2.0 mm, papilla loss and mucosal recession were also highest in the closest-proximity group (17,46). The risk extended beyond bone loss: proximity at or below 1.0 mm was associated with a higher risk of peri-implantitis, with adjacent root resorption also recorded (47). Conversely, when strict mesiodistal clearance of ≥1.5–2 mm was maintained as part of a comprehensive 3D positioning protocol, marginal bone levels remained stable for up to 18 years and esthetic scores were favorable (46). A minimum clearance of ≥1.5 mm from each adjacent root surface is therefore required, with ≥2.0 mm recommended whenever anatomy permits. Narrow-diameter implants (3.3–3.5 mm) should be selected when mesiodistal space is anatomically constrained (17,46,47).

Similarly, the buccolingual (labiopalatal) position has a direct influence on hard and soft tissue stability. The buccolingual position of the implant has a direct impact on how much buccal bone is preserved over time, and therefore on the stability of the soft tissues. In the anterior maxilla, placing the implant slightly towards the palatal side is generally recommended(34). However, this is not always possible, as it depends on having enough alveolar bone width. In fact, more than half of maxillary incisor sites have been reported to present insufficient faciolingual bone volume, which highlights the importance of pre-operative CBCT evaluation (53).

CBCT-based analyses have also helped to better understand the underlying mechanism. The width of the buccal gap, which is influenced by how palatally the implant is positioned, appears to be a key factor in determining the final thickness of the buccal bone. For example, implants with a buccal gap greater than 2 mm showed a mean buccal bone thickness of 1.9 mm after

healing, whereas those with a gap of 2 mm or less had only around 0.5 mm of remaining bone (48).

Initial anatomical conditions are also important. Sites with a buccal crest thickness of ≤0.5 mm before implant placement were associated with a higher risk of bone loss, meaning these cases require more careful planning (34). Taken together, these findings suggest that aiming for a buccal gap of at least 2 mm, achieved through a controlled palatal positioning of the implant, can be considered a practical surgical guideline.

When the implant was placed too far buccally, even by 1 mm or more from the ideal position, the risk of complications increased significantly. In one study, buccal soft tissue dehiscence occurred in 45% of these cases, compared to only 12% when the implant was correctly positioned. This was also associated with an average apical shift of the soft tissue of about 0.8 mm (49).

The apicocoronal position also plays a crucial role in long-term tissue stability. The vertical position of the implant in relation to the crestal bone is another important factor that can be controlled during surgery, and it has a direct effect on both bone stability and the final prosthetic outcome. Placing the implant slightly below the bone crest (around 1–2 mm subcrestally) has been shown to reduce the risk of implant thread exposure. In contrast, implants placed at the crestal level were associated with a higher incidence of thread exposure, reported in up to 47% of cases (50).

These findings are supported by a randomized clinical trial with a 36-month follow-up, which showed that subcrestal placement resulted in significantly less marginal bone loss compared to equicrestal positioning. Importantly, no significant differences were found in clinical parameters such as probing depth, bleeding on probing, or implant survival between the two approaches (51).

In the esthetic zone, even small changes in marginal bone levels can have visible consequences on the soft tissues. A difference of as little as 0.5 mm may lead to noticeable recession. For this reason, placing the implant 1–2 mm below the crestal bone can be considered a more reliable approach to help maintain both bone and soft tissue stability over time (50,51).

Finally, implant inclination and axial orientation must also be considered within this three-dimensional framework. In the anterior maxilla, the ideal implant axis is usually directed towards the cingulum of the opposing tooth or the incisal edge. This orientation allows for a screw-retained restoration without creating a buccal cantilever or placing excessive lateral forces on the surrounding tissues (52).

However, in some cases, the natural angulation between the tooth and the alveolar ridge may force the implant into a more labial position. In these situations, studies have shown that immediate implant placement combined with connective tissue grafting can still achieve comparable soft and hard tissue outcomes at one year when compared to ideally aligned implants. That said, this approach should only be considered when anatomical limitations make ideal positioning impossible, and it requires careful soft tissue management to protect the buccal margin (52).

Long-term data further support the importance of correct implant angulation. Over a five-year follow-up, implants placed along the ideal axis showed less crestal bone loss (mean 0.10 mm) compared to implants with non-ideal angulation (mean 0.22 mm). Both mesiodistal and buccolingual deviations contributed to this difference (53).

These findings suggest that proper axial alignment is not only important from a prosthetic point of view but also plays a role in maintaining marginal bone stability over time.

From a prosthetic perspective, emergence profile design represents an additional key factor. The emergence profile, which forms the interface between the implant and the crown plays an important role in how the surrounding soft tissues behave. It influences the mechanical environment at the level of the peri-implant mucosa and can affect both tissue stability and esthetic outcomes.

In the randomized clinical trial comparing different emergence profile designs in the esthetic zone, concave subcritical contours were associated with better results than convex ones. Specifically, they showed significantly less mucosal recession (0.09 ± 0.15 mm vs 0.41 ± 0.23 mm) as well as reduced marginal bone loss after 12 months. These results were maintained at three years in a follow-up study of the same cohort, suggesting that the benefits of a concave design are stable over time and not just a short-term effect (19,20).

From a biological perspective, this can be explained by the way different contours interact with the soft tissues. A convex subcritical profile tends to push outward on the peri-implant mucosa, which may compromise blood supply and increase the risk of recession. In contrast, a concave or neutral profile allows the tissues to adapt more naturally, helping to maintain their volume and position. At the coronal level, the critical contour must be carefully designed to support the gingival margin and harmonize with adjacent teeth.

Based on the available evidence, particularly from randomized studies, a concave subcritical emergence profile appears to be a more predictable approach and can be considered the preferred option for single implant restorations in the esthetic area (19,20).

Taken together, these findings have direct clinical implications. The different criteria identified in this review should not be considered separately, as they are closely interconnected and tend to influence each other (44). In clinical practice, patients often present with multiple risk factors at the same time. For example, a thin gingival phenotype combined with reduced buccal bone thickness and suboptimal implant positioning can significantly increase the likelihood of esthetic complications. The cumulative effect of these factors is more relevant than any single parameter alone (34).

On the other hand, when these criteria are properly respected, more predictable outcomes can be achieved. This includes having an adequate gingival thickness (around ≥2 mm) (45), sufficient buccal bone thickness at the time of placement (≥2 mm) (34,35), a slightly palatal implant position that creates a buccal gap of at least 2 mm and maintaining a minimum distance of 2 mm from adjacent teeth (16). In addition, placing the implant 1–2 mm below the crestal bone, aligning it with the cingulum of the opposing tooth, and designing a concave emergence profile all contribute to better tissue stability and esthetic integration (19,52). Long-term data, including studies with follow-ups of up to 18 years, support the reliability of this combined approach (46)

Furthermore, proper pre-operative planning is essential. CBCT imaging plays a central role, as it allows the clinician to evaluate bone dimensions, detect potential defects, and assess whether the ideal implant position can realistically be achieved. It also helps in planning the implant axis and its relationship with adjacent structures (16,35,36).

Several limitations of this bibliographic review should be considered when interpreting the results. First, most of the included studies were retrospective in nature, with only a small number of randomized clinical trials available (49,52,53). As a result, the overall level of evidence is limited, and the findings may be influenced by selection bias and confounding factors.

Another limitation is related to sample size. Many of the studies included a relatively small number of implants, in some cases fewer than 50 (31,33,34,36,37,41,44,45,50,52,53), which reduces the statistical power and makes it more difficult to detect differences between subgroups. In addition, the follow-up periods varied considerably, ranging from short-term evaluations of around 12 months (19) to long-term studies extending up to 20 years (44). This variability makes direct comparisons between studies challenging and means that some conclusions, particularly those based on short follow-up, should be interpreted with caution.

There was also a high level of heterogeneity in how outcomes were measured. Different studies used various parameters such as PES, WES, marginal bone loss, probing depth, and recession, as well as different implant systems. This lack of standardization made it difficult to directly compare results and did not allow for a quantitative meta-analysis.

It is also important to note that this review focused mainly on positioning criteria and did not consider other factors that may influence outcomes. Variables such as implant design (including size, shape, and surface characteristics), surgical technique, timing of implant placement and loading, as well as occlusal factors and patient habits, were not specifically analyzed. These aspects could play a relevant role in clinical outcomes and should be considered in future research.

6. CONCLUSIONS

- Anatomical criteria: buccal bone ≥ 2mm and mucosal thickness ≥2 mm are key to achieving peri-implant tissue stability, thinner tissues may require augmentation procedures. Papilla presence depends on a bone-to-contact-point distance ≤ 3-5mm. Adjacent periodontal health must be controlled before surgery.

- Three-dimensional positioning: mesiodistal clearance ≥2 mm from adjacent roots, palatal positioning creating a buccal gap ≥ 2mm, subcrestal depth 1-2mm are the key thresholds. Correct axial alignment reduces long-term bone loss. Buccal deviation ≥1mm from the ideal position significantly increases soft tissue complication risk.

- Emergence profile design: the subcritical contour must be concave or straight to avoid compressing peri-implant tissues and compromising blood supply. Convex subcritical design is associated with more recession and higher marginal bone loss and should be avoided. The critical contour must replicate natural tooth form.

- Combined approach: pre-operative cone beam computed tomography (CBCT) is essential to evaluate these parameters before surgery. Predictable outcomes require combined application of anatomical, positional and prosthetic principles. Long-term data confirm tissue stability over up to 18 years when these criteria are respected.

7. SUSTAINABILITY

The findings of this review contribute to sustainability across economic, social, and environmental dimensions, in alignment with the United Nations Sustainable Development Goals.

From a social point of view, complications or esthetic failures in the anterior maxilla can have a significant impact on patients, as the appearance of the smile is closely linked to self-confidence and overall well-being. By bringing together clear, evidence-based criteria for implant positioning, this work contributes to improving treatment outcomes and supports patient-centered care, in line with Sustainable Development Goal 3 (Good Health and Well-being).

Economically, implant complications and revision procedures can represent a considerable cost for both patients and healthcare systems. Identifying key clinical thresholds helps clinicians make better decisions during treatment planning, which may reduce the need for additional interventions and improve overall efficiency.

From an environmental perspective, avoiding unnecessary procedures also means reducing the use of materials such as grafts, membranes, and implant components. This contributes to a more responsible use of resources, in line with Sustainable Development Goal 12 (Responsible Consumption and Production).

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