Universidad Europea

# GRADUATION PROJECT

## Degree in Dentistry

# THE INFLUENCE OF EMERGENCE PROFILE DESIGN AND THE MATERIAL OF THE FINAL CROWN ON THE QUALITY AND QUANTITY OF SURROUNDING SOFT TISSUE AND PERI-IMPLANT HEALTH OUTCOMES

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## ABSTRACT

**Introduction:** Peri-implant soft tissue health is critical for the long-term success of implant-supported prostheses. The emergence profile design and crown material are key prosthetic factors that may influence susceptibility of peri-implant soft tissue to inflammation; **Objectives:** To investigate the influence of emergence profile design and final crown material on peri-implant soft tissue health and the prevalence of peri-implant mucositis in single-unit implant restorations; **Methodology:** After the establishment of a research question, a literature review was conducted through PubMed and Cochrane, utilising descriptors and Boolean operators. The search was limited to empirical in-vitro studies investigating emergence profile or crown material and peri-implant soft tissue health, published from 2017 to 2024. Fourteen studies meeting the inclusion criteria were selected and independently analysed; **Results:** Crowns with convex emergence profiles or angles greater than 30° were frequently associated with higher plaque scores, increased bleeding on probing, and deeper probing depths. Zirconia crowns were generally linked to reduced plaque accumulation and improved soft tissue response compared to porcelain-fused to metal crowns, though some findings were inconsistent. Several studies did not control for confounding variables such as oral hygiene habits, abutment design, or prosthesis retention type; **Conclusions:** A concave emergence profile and an emergence angle ≤30° may support better peri-implant soft tissue outcomes. Zirconia crowns demonstrated superior biocompatibility and reduced plaque retention in several studies. However, variability in study design and confounding factors limit definitive conclusions. Further research is necessary to clarify the independent influence of emergence profile and crown material on peri-implant health.

## KEYWORDS

Dentistry, peri-implant mucositis, emergence profile, crown material

## RESUMEN

**Introducción:** La salud de los tejidos blandos periimplantarios es fundamental para el éxito a largo plazo de las prótesis sobre implantes. El diseño del perfil de emergencia y el material de la corona son factores clave que pueden influir en la susceptibilidad de los tejidos blandos a la inflamación; **Objetivos:** Investigar la influencia del diseño del perfil de emergencia y del material de la corona definitiva sobre la salud de los tejidos blandos y la prevalencia de mucositis periimplantaria en restauraciones unitarias; **Metodología:** Tras la formulación de la pregunta de investigación, se realizó una revisión mediante PubMed y Cochrane, utilizando descriptores y operadores Booleanos. La búsqueda se limitó a estudios empíricos in-vitro sobre perfil de emergencia o material de la corona y salud de los tejidos blandos periimplantarios, publicados entre 2017 y 2024. Según los criterios de inclusión, se analizaron de forma independiente catorce estudios; **Resultados:** Coronas con perfiles de emergencia convexos o ángulos >30° se asociaron con mayores niveles de placa, sangrado y profundidad al sondaje. Las coronas de zirconio mostraron menor acumulación de placa y mejor respuesta de los tejidos blandos que las de metal-porcelanas, aunque algunos resultados fueron inconsistentes. Sin embargo, varios estudios no controlaron factores como la higiene oral, el diseño del pilar o el tipo de retención protésica; **Conclusiones:** Un perfil de emergencia cóncavo y un ángulo ≤30° podrían favorecer mejores resultados en los tejidos blandos. Las coronas de zirconio demostraron mejor biocompatibilidad y menor retención de placa, aunque se necesitan más estudios para establecer conclusiones firmes.

## PALABRAS CLAVE

Odontología; mucositis periimplantaria; perfil de emergencia; material de la corona

# Contents

# 1. INTRODUCTION

Edentulism results in numerous functional complications, such as difficulties in mastication, phonation, and resorption of the alveolar crests. Additionally, there is a loss of soft tissue support, resulting in changes to the facial appearance (1). Implant therapy is currently regarded as the optimal treatment for edentulism, particularly in the aesthetic zone (2). The placement of implants permits restorations with exceptional aesthetics, a natural sensation for the patient and most importantly, a high rate of long-term success (3). The treatment planning for implant therapy and prosthesis rehabilitation is individualized to meet the needs of the patient and their specific case.

## 1.1. Theoretical framework

The individualising factors of the case are utilised to select the design, site and time of placement of an implant depending on the existing bone and future prosthetic treatment (4).

Implant treatment may be categorised by the time of placement – whether placed immediately post-extraction or a few months later to allow bone healing – and by the time of loading with prosthesis, which may be immediate or delayed (5). In some cases, it may be deemed necessary to perform pre-implant treatments, such as bone grafting, in order to successfully place an implant in the position necessary for the future prosthesis (6).

Macroscopic design elements of an implant include the shape, size, and abutment connection. Microscopic design elements may dictate the smoothness of the surface of an implant, and depend on the fabrication process of the implant as well as the prosthesis and connection. A rougher surface may facilitate osseointegration at the level of the bone, but also lead to bacterial accumulation closer to the gingiva (7).

The design of the prosthesis over an implant also varies depending on the number of pieces to be restored, mechanical forces that will be exerted over the prosthesis, and the functional and aesthetic demands of the restored area (8). According to these needs, the material and design of the prosthesis is elected. Additionally, a prosthesis may also be screw retained or cemented, determined by factors such as the angulation of the implant and prosthesis. The variation of these factors not only conditions the interaction between the various parts of an implant and its prosthesis, but also the health of the tissues surrounding them (9,10).

The success of dental implants is closely related to the health of the surrounding soft tissues and overall peri-implant conditions (9). With an ever-increasing demand for aesthetically pleasing and functionally effective prostheses, emergence profile design and the choice of material for final crowns are critical considerations influencing both biological and aesthetic outcomes (3,11).

## 1.2. Current state of the subject

### 1.2.1. Peri-implant health

Peri-implant health is key to the success of an implant (12). Peri-implant pathology describes peri-implant mucositis and peri-implantitis. Peri-implant mucositis is the soft tissue inflammation surrounding an implant that precedes peri-implantitis, similar to the way in which gingivitis precedes periodontitis (13). They are caused by the host's immunological response to the presence of bacterial biofilm (14).

Plaque accumulation causes an inflammatory response in the gingiva and surrounding soft tissues, resulting in visible signs like oedema and erythema (13). A study conducting biopsies of peri-implant tissues after plaque was allowed to accumulate for 3 weeks demonstrated an increase in inflammatory T and B-lymphocytes as compared to normal, healthy tissue (15).

While the determinants that contribute to the transition from peri-implant mucositis to peri-implantitis are not clearly defined, the transition is understood to be a result of the interactions of a complex of intrinsic and extrinsic factors affecting the host (13). A history or the existence of active periodontitis and the use of tobacco are known risk factors in the development of peri-implant disease (16).

The use of tobacco can change the composition of the oral microbiome, resulting in an increase in the bacterial load of pathogens associated with peri-implant disease (17). Furthermore, various studies demonstrate that the oral microbiome becomes less reactive to treatments such as scaling, local antibiotics and antiseptics when exposed to smoke (18–24).

While diabetes mellitus is a known and significant risk factor for periodontal disease, its relationship with peri-implant disease, though suggestive, is not as well defined (25). It has been put forward that diabetes mellitus affects the osseointegration of implants through the suppression of osteoblastic activity. Additionally, the microangiopathy caused by hyperglycaemia may result in delayed healing and a hyperinflammatory state; known factors resulting in the association with periodontitis (26,27).

The presence and bacterial load of certain pathogens is another potential risk factor in the development of peri-implantitis. While it appears that the simple accumulation of plaque – regardless of its constitution – is enough to provoke peri-implant mucositis, a meta-analysis studying the microbiota in patients with peri-implantitis found that the presence of S. epidermidis, P. gingivalis, T. forsythia, T. denticola, F. nucleatum, and P. intermedia were associated with peri-implant disease (28).

Peri-implant mucositis is characterised by bleeding on probing (BOP) without evidence of marginal bone loss (14). It is important to note that according to the European Federation of Periodontology, following the modification of the Implant Dentistry Core Outcome Set and Measurement (ID-COSM) initiative consensus, BOP refers to the "presence of a line of bleeding or profuse bleeding at any location", rather than at a single point, which is considered acceptable in peri-implant health (14,29,30). Though peri-implant probing depth or probing pocket depth (PPD) is dependent on factors such as soft tissue height and the placement of the implant, it is generally accepted that peri-implant probing depth should be ≤5mm (29,30).

Additionally, other clinical signs including erythema, tumefaction and even suppuration in some cases may also be noted. However, the lack of bone loss is the key differentiation between mucositis and peri-implantitis. Therefore, if mucositis is adequately treated, it may be possible to reverse the damage caused (7).

#### 1.2.2.Emergence profile

The emergence profile plays a pivotal role in guiding soft tissue architecture and ensuring optimal adaptation (12). It is defined as the contour and transition of a natural tooth or prosthetic crown as it emerges from the gingival sulcus. In order to meet the functional and aesthetic needs of a patient, the emergence profile of a crown should resemble that of a natural tooth as closely as possible (2). It also conditions the ease with which the peri-implant area can be cleaned and maintained (11).

The emergence profile typically describes two distinct though interrelated concepts – The emergence angle and the emergence contour. The emergence angle refers to the angle formed by the longitudinal axis of the implant-prosthesis complex and the tangent of the emergence profile (32).

The emergence contour is divided into two distinct regions, the critical and sub critical area. The critical contour describes the superficial zone at the level of the cervical margin. As a result, it holds influence over the level of the gingiva and location of the zenith (33). The zenith is the most apical point along the free gingival margin, a focal point characterising the aesthetics of the individual tooth and smile as a whole. The subcritical contour describes a deeper area of the restoration above the connection with the implant and below the cervical margin, responsible for creating a smooth transition between the implant platform and the critical contour. Consequently, it conditions the soft tissue support and colour of the gingiva. An apical or coronal displacement of the critical contour will affect the length of the subcritical contour, thus impacting the tissues conditioned by both areas (33). The existence of the subcritical contour is dependent on there being sufficient “running room” or distance between the implant platform and gingival margin (34). Changes to it should not alter the level of the gingival margin, provided that they are within a physiological range. That said, if the implant was not placed with enough depth, the subcritical contour will not be present (35). Implants should ideally be placed with the platform at a depth of 3-4 mm apical to where the gingival zenith is projected to be, in order to permit adequate distance for the crown to be appropriately contoured (36,37). The critical and subcritical contour may be convex, flat or even concave depending on the position of the implant and restoration, and the aesthetics of the tooth that is to be restored. These modifications can be made to improve the aesthetics of the soft tissue surrounding the implant. However, in certain cases it may not be ideal to alter the critical contour, as it may affect the aesthetics of the crown. The subcritical contour may be altered independently to achieve the desired appearance without changing the critical contour. As such, it is important to understand that any alteration made may condition the response of the peri-implant soft tissues (34).

### 1.2.3. Abutments in dental implant restoration

Abutments are a critical component in dental implant restorations. They serve as an intermediate physical connector between the dental implant and the prosthetic crown. Their design, material, and mode of attachment can significantly influence both the mechanical stability of the restoration and the biological response of the surrounding peri-implant tissues(38).

The two principal methods by which abutments secure the prosthesis are screw retention and cementation (39–43). In a screw retained restoration, a screw passes through the prosthesis and into the abutment or implant body. This permits retrievability in the future, as well as a reduced risk of cement-induced peri-implantitis (40). Cement retained restorations, on the other hand, forego the use of a screw, using dental cement to fix the prosthesis to the abutment. This offers better aesthetics, but presents a greater risk of biological complications if excess cement remains in the subgingival area (43,44). The election of one technique over the other typically depends on the implant angulation, aesthetic demands, and retrievability requirements (39).

Abutments themselves vary widely in angulation, material, and surface design. Angled abutments may be used to compensate for misaligned implant placement and optimize the path of insertion for the prosthesis. This is especially common in the anterior aesthetic zone (45). Abutments may be fabricated out of titanium, zirconia, or more recently, hybrid combinations. Titanium abutments exhibit good mechanical strength and long-term performance. On the other hand, zirconia abutments are becoming favoured for their aesthetic properties and biocompatibility with peri-implant soft tissues (46–48). Some abutments may also be veneered with feldspathic porcelain to support the gingival aesthetics by matching its colour, especially in cases of patients with a thin biotype (49).

Platform switching is a critical concept in abutment design and selection (50). It involves the use of an abutment with a narrower diameter than the implant platform to which it is to be fixed, thereby creating a horizontal offset. This design facilitates the preservation of crestal bone by shifting the implant–abutment junction inward and away from the bone crest (51). In doing so, it increases the distance between the bacterial micro gap and the bone. Consequently, there is a reduction in the infiltration of inflammatory cells and marginal bone loss over time (52,53). Clinical studies have consistently shown that platform switching contributes to improved peri-implant tissue stability and soft tissue volume maintenance (50).

### 1.2.4. Crown material

The condition of the peri-implant area may also be influenced by the material of the crown placed for the final restoration (54). Crown materials are continually being enhanced to develop materials with superior mechanical performance, aesthetics, and biocompatibility (55). At present, there are various final crown materials — ranging from ceramics to metals — with each brand creating their own variation with unique properties (56). Traditionally, porcelain-fused to metal (PFM) crowns have been regarded as the gold standard material for prosthetic crowns. However, more recent advancements have led to the rise of zirconia crowns as a new gold standard (57). PFM crowns typically utilise a chromium-cobalt core, which is covered with an opaquer to mask the dark colour, then layered manually with feldspathic porcelain. The manual technique employed for feldspathic layering results in a crown where the quality and aesthetic is highly dependant on the technician, leading to the potential for human error (56). Furthermore, feldspathic porcelain layered over metal is also susceptible to chipping as a result of various factors such as occlusal forces, a difference in the thermal expansion of the metal core compared to the porcelain, etcetera (58) . Imperfections near the gingiva could result in a surface that is more prone to bacterial and plaque accumulation (56). That said, feldspathic porcelain is known to have a number of desirable properties, including flexural strength, a modulus of elasticity similar to that of enamel, and excellent aesthetics. Feldspathic porcelain is highly translucent, and capable of closely recreating and mimicking the optical properties of natural teeth when utilised artfully by the technician (59).

On the other hand, monolithic zirconia crowns are exclusively manufactured by computer aided design-Computer aided manufacturing (CAD-CAM) techniques. Typically, this is conducted through a subtractive process called milling, where a computer controlled machine removes material from a sintered or un-sintered block to reveal the crown's desired shape as a singular piece (56). If the utilised block was not previously sintered, it would then be sintered at a high temperature after the milling process. In this case, the prosthetic restoration is milled approximately 25% larger than the design is intended to be, in order to counteract the shrinkage induced during sintering (60). As a result of the CAD-CAM process, the final crown does not sustain the typical errors that a PFM crown may have due to human error (61). It is highly polished and thus potentially less retentive to plaque. Furthermore, zirconia has been found to be more biocompatible than chromium-cobalt. Some individuals may present with an allergy to chromium-cobalt, while others may develop an immunological response with the persistent exposure to the crown in the mouth (62).

Zirconia used in dentistry has undergone an evolutionary period with many different variants being used today to meet different functional and aesthetic needs. Pure zirconia presents in its monoclinic phase at room temperature, the tetragonal phase above ≈1,170°C, and the cubic phase above ≈2,370°C. The introduction of dopants partially stabilises the zirconia in its tetragonal phase at room temperature, providing excellent mechanical and physical properties, such as high fracture toughness and flexural strength. Yttria ($Y_2O_3$) has been found to be the most effective dopant to stabilise zirconia in its tetragonal phase, forming the stabilized tetragonal zirconia polycrystal (Y-TZP) typically utilised in dentistry. There are three groups of Y-TZP utilised in dentistry based on the concentration of yttria contained. 3 mol.% Y-TZP (3Y-TZP) is the hardest with approximately 85-90% of the zirconia in its tetragonal state. Despite its excellent physical characteristics, 3Y-TZP presents limited aesthetics due to its opacity. 5 mol.% Y-TZP (5Y-TZP), or transparent zirconia presents approximately 50% of the zirconia in its cubic phase, increasing its translucency, but consequently also compromising the mechanical characteristics. 4 mol.% Y-TZP (4Y-TZP) serves as an intermediate between 3Y-TZP and 5Y-TZP. (60,63).

### 1.3. Justification

This study will explore the influence of emergence profile design, crown material, and their potential to affect peri-implant soft tissue health and cause mucositis. By establishing a clearer connection between these elements, the findings aim to contribute valuable insights to the field of prosthetic and implant dentistry, which may guide clinicians towards more extensive considerations in the manufacturing of restorative prosthesis, enhancing patient outcomes.

### 1.4. Hypothesis

Proper design of the emergence profile and appropriate material choice of the final crown have a positive influence on the quality and quantity of surrounding soft tissue and improve peri-implant health outcomes. Crowns with a more anatomically contoured emergence profile and biocompatible materials will result in better soft tissue stability, and improved peri-implant health markers, such as reduced inflammation and lower probing depths.

## 2. OBJECTIVES

### 2.1. Primary objective

To investigate the influence of emergence profile design on peri-implant soft tissue health and stability.

### 2.2. Secondary objective

To analyse the influence of final crown material on peri-implant soft tissue health and inflammation.

## 3. MATERIALS AND METHODS

Based on the objectives, the following research question was constructed, utilising the PICO framework:

In patients with single-unit crowns over implants, do crowns fabricated with PFM and/or with an over-contoured emergence profile result in a higher rate of peri-implant mucositis?

### 3.1. Information sources

The review of supporting concepts was executed utilising sources from MEDLINE Complete, Academic Search Ultimate, Dentistry & Oral Sciences Source via Biblioteca Crai for Universidad Europea de Madrid for all relevant articles published prior to November 2024. Relevant articles were then analysed individually to extend the review to articles referenced within them. All articles included within the review were referenced using Zotero software (Vers. 6.0.36).

Data was collected and analysed from studies published on PubMed and Cochrane. The search focused on studies regarding single-unit crowns placed in the anterior sector, their emergence profile, and crown material – particularly PFM or zirconia – and their relation to peri-implant mucositis.

### 3.2. Eligibility criteria

#### 3.2.1. Inclusion Criteria

All articles included within this study were published in English from 2017 onwards.

Studies involving the following concepts:

- Single-unit implants in the aesthetic area
- Crown material and peri-implant health
- Emergence profile and peri-implant health

All selected articles presented first hand findings of their investigations.

Relevant randomised clinical trials were given preference in the selection of articles.

#### 3.2.2. Exclusion Criteria

Articles published prior to 2017.

Articles regarding multi-unit implants and prosthesis.

Systematic reviews or meta-analyses.

Articles reporting on periodontal health.

Articles that did not report a relevant analysis or conclusion.

Clinical cases, due to the lack of a control group, thus a lower scientific credibility.

In-vitro studies due to the lower scientific credibility.

### 3.3. Search strategy & equation

The search was executed using a PICO-style approach:

| **P** | **I** | **C** | **O** |
|---|---|---|---|
| Population | Intervention | Comparison | Outcome |
| Partially edentulous patients | Single-unit crowns over implants | Over-contoured crowns and different crown materials (PFM vs. Zirconia) | Prevalence of peri-implant mucositis |

The following search pattern utilising Boolean operators was used to obtain a refined list of sources:

(((Dental Implant) AND (Crown material)) OR (emergence profile)) AND (peri-implant)

The search conducted on the 6th of December 2024, was limited to articles published in English, from 2017 onwards, full texts, excluding any systematic reviews or meta-analyses.

The research and article selection process is displayed in the flow chart below.

## 4. RESULTS

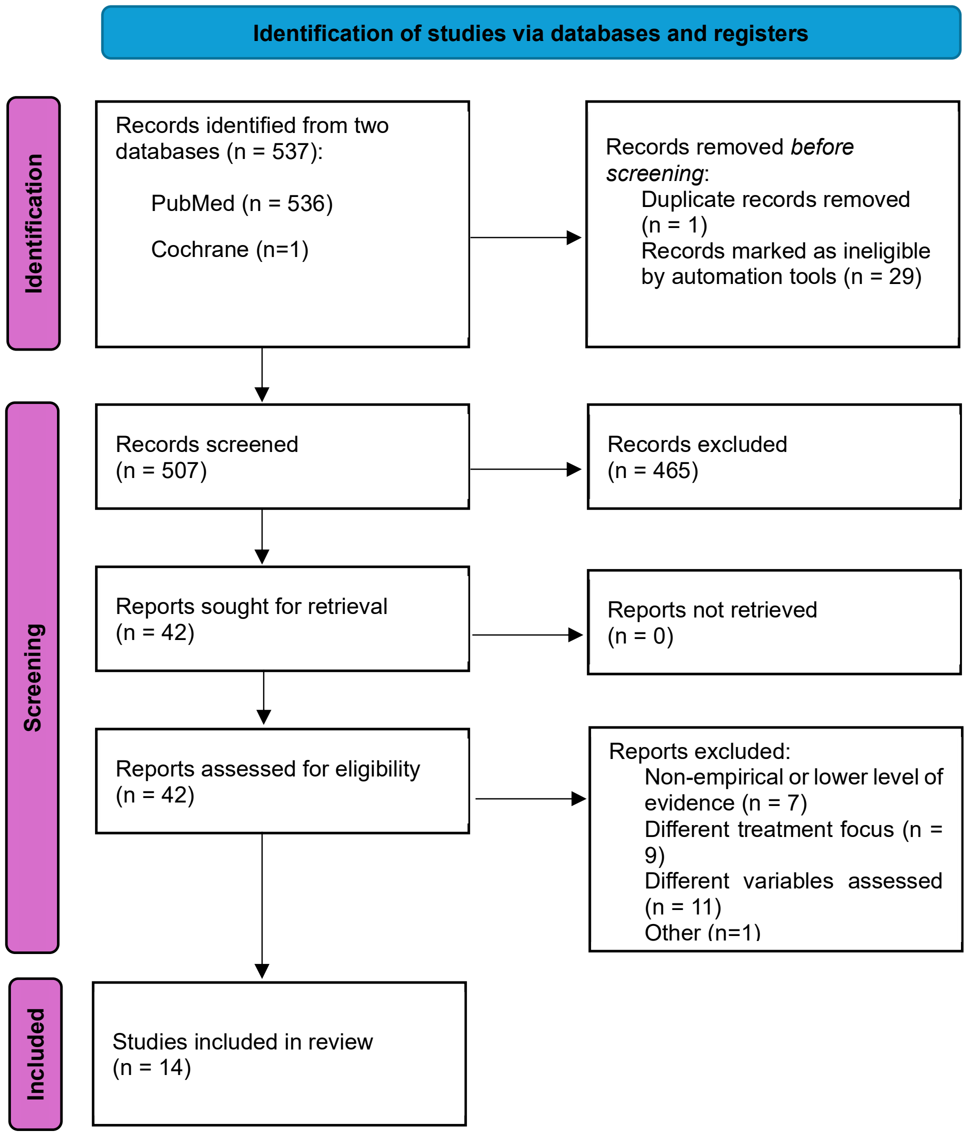

**Figure 1.** PRISMA systematic search flow diagram (64).

**Table 1.** Study types

| | Author and Publication Year | Study Type |
|---|---|---|
| 1. | Pelekos et al. 2023 (32) | Cross – sectional study |
| 2. | Rungtanakiat et al. 2024 (65) | Cross – sectional study |
| 3. | Chanthasan et al. 2022 (66) | Cross – sectional descriptive study |
| 4. | Lops et al. 2022 (67) | Retrospective cohort study |
| 5. | Hentenaar et al. 2020 (68) | Cross – sectional study |
| 6. | Camacho-Alonso et al. 2024 (69) | Randomised clinical trial |

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|---|---|---|
| 7. | Volp Junior et al. 2024 (70) | Retrospective cohort study |
| 8. | Lops et al. 2022 (71) | Retrospective cohort study |
| 9. | Papalou et al. 2022 (72) | Cross – sectional study |
| 10. | Shen et al. 2022 (73) | Retrospective cohort study |
| 11. | Bittencourt et al. 2023 (74) | Randomised controlled clinical trial |
| 12. | AlJasser et al. 2021 (75) | Retrospective cross – sectional study |
| 13. | Yu et al. 2017 (76) | Prospective randomized single-blind preliminary clinical trial |
| 14. | Thoma et al. 2018 (77) | Randomised controlled clinical trial |

The articles included in this review primarily analysed one of two concepts – The material of the prosthesis utilised, or its emergence angle and profile.

**Table 2.** Main characteristics of included studies

| | **Population** | **Methods and Materials** | **Measurement parameters** |
|---|---|---|---|
| *Pelekos et al. 2023* (32) | Total Patients: 122<br>Follow up: median duration of 5.6 years, with a range of 2.8–11.2 years | Inclusion criteria: Single screw retained implant restorations in anterior or premolar region.<br><br>Emergence profiles categorized as concave, straight, or convex. | Plaque score (disclosing agent), BOP, PPD, suppuration on probing, keratinized tissue measurement, periodontitis classification (based on clinical attachment level and PPD thresholds) |
| *Rungtanakiat et al. 2024* (65) | Total Patients: 47<br>Total implants: 103<br>Data collection at least 3 months post restoration | Inclusion criteria: Single-unit implant-supported crowns in the posterior sector. | Plaque index, BOP, suppuration, PPD. Radiographical examination. |

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|---|---|---|---|
| *Chanthasan et al. 2022* (66) | Total Patients: 178<br>Total implants: 286<br>Patients self reported presence or absence of food impaction at the restoration site | Single-unit implant-supported crowns in the posterior sector. | Plaque index, PPD, BOP. |
| *Lops et al. 2022* (67) | Total Patients: 57<br>Total Implants: 220<br>Follow up Duration: 3 years | Groups Based on Buccal Emergence Angle (EA):<br>• Group 1: 153 implants (EA ≥ 30°)<br>• Group 2: 67 implants (EA < 30°) | PPD, plaque index and gingival index. |
| *Hentenaar et al. 2020* (68) | Total Patients: 64<br>Total Implants: 67<br>Follow up Duration: Baseline, 5 years | Inclusion criteria involved patients with non-splinted, bone-level implants and platform-switched abutment connections placed in posterior sites 3 months post-extraction. | BOP, PPD, gingival index, radiographic analyses |
| *Camacho-Alonso et al. 2024* (69) | Total Patients: 37<br>Total Implants: 74<br>Follow up Duration: 3 months | Double-blind study, with both the patient and statistician unaware of the type of abutment to be received. | Percentage of submucosal abutment surface covered by biofilm, inflammatory intensity, vascular proliferation |
| *Volp Junior et al. 2024* (70) | Total Patients: 96<br>Total Implants: 148 | Two groups were analysed based on emergence angle:<br>• Group 1 (EA > 30°): Mean EA = 45° ± 4°<br>• Group 2 (EA ≤ 30°): Mean EA = 22° ± 7° | Plaque index, PPD, BOP, suppuration, periapical radiography. |

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|---|---|---|---|
| *Lops et al. 2022* (71) | Total Patients: 74<br>Total Implants: 312<br>Follow up: 3 years | Two groups were analysed based on emergence angle:<br>• Group 1 (EA > 30°): Mean EA = 45° ± 4°<br>• Group 2 (EA ≤ 30°): Mean EA = 22° ± 7° | Modified sulcus bleeding index and modified plaque index measured with a calibrated plastic probe. |
| *Papalou et al. 2022* (72) | Total Patients: 107<br>Total Implants: 310 | Implants analysed after at least one year of prosthetic function. | Full mouth plaque scores, PPD, BOP, clinical attachment level, implant plaque scores, suppuration |
| *Shen et al. 2022* (73) | Total Patients: 224<br>Total Implants: 327<br>Mean Follow Up: 30.4 months | Implants were restored either using metal-ceramic or monolithic zirconia single-unit crowns. | Plaque index, PPD, BOP, radiographical analyses. |
| *Bittencourt et al. 2023* (74) | Total Patients: 14<br>Total Implants: 26<br>Mean Follow Up: 95.2 ± 2.6 months | Patients received either a ceramic crown over a zirconia abutment, or a metal-ceramic crown over a titanium abutment | PPD, plaque index, bleeding index. |
| *AlJasser et al. 2021* (75) | Total Patients and implants: 484 | Crown type, retention, and implant-crown status were studied in relation to periodontal parameters | BOP, PPD, plaque index, gingival colour, crestal bone level |
| *Yu et al. 2017* (76) | Total Patients and restored implants: 196<br>Natural tooth controls: 51 | Participants received crowns fabricated from Co-Cr PFM, Au-Pt PFM, Ti PFM or Zirconia all-ceramic. Peri-implant parameters and crevicular fluid measurements were taken before restoration and 12 | Plaque index, BOP, PPD, crevicular fluid volume and composition. |

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|---|---|---|---|
| | | months after, as well as in the control group. | |
| *Thoma et al. 2018* (77) | Total Patients and Restored Implants: 44<br>Follow Up: Clinical examinations at 1 week, 6 months and 12 months after loading. Histological and microbiological at 6 months. | The data was analysed by two blinded examiners - one analysed histology, the other analysed clinical & microbiological results. | Plaque index, BOP, keratinised mucosal width, PCR pathogen analyses and bacterial count of subgingival plaque, soft tissue biopsy. |

**Table 3.** Results and limitations of included studies

| | Results | Limitations |
|---|---|---|
| *Pelekos et al. 2023* (32) | Crowns with a greater emergence angle and a convex profile were significantly associated with increased plaque accumulation ($p < 0.01$).<br>There was also a statistically significant association found between higher emergence angles and convex profiles, and BOP ($p < 0.02$).<br>These findings suggest that subtle modifications in the crown's emergence profile may affect the accumulation of biofilm and the inflammation of peri-implant tissue. That said, emergence angle was not identified to significantly influence PPD. | The study included both bone-level and tissue-level implants. There was no control for patient-specific oral hygiene habits or professional cleaning frequency. As a result, patient factors may have influenced plaque accumulation and inflammation outcomes. |

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|---|---|---|
| *Rungtanakiat et al. 2024* (65) | Wider emergence profile angles demonstrated a significant association with reduced peri-implant mucosal height (*$p < 0.001$*).<br>Implants with a higher mucosal height were less likely to present BOP (*$p = 0.001$*).<br>This suggests the emergence profile design of a prosthesis influences soft tissue dimensions, which in turn can affect the peri-implant inflammatory response. Narrow mucosal dimensions around the implant platform may contribute to a higher susceptibility of inflammation. | Factors such as oral hygiene habits, implant brand/design, and prosthetic material were not controlled, which could potentially influence the results.<br>The study was restricted to posterior bone-level implants. As such, the findings may not be relevant to anterior or tissue-level implants, and may be confounded by the mechanical forces to which the posterior teeth are subjected. |
| *Chanthasan et al. 2022* (66) | A longer contact length and lower level of the contact point were associated with higher rates of food impaction (*$p < 0.05$*).<br>This suggests that the proper interproximal design of a crown with tight contacts and an optimal emergence profile is essential in reducing peri-implant disease risk and improving patient comfort. | No control for patient related factors, such as oral hygiene habits, occlusal forces, or history of periodontitis. |
| *Lops et al. 2022* (67) | Probing Pocket Depth:<br>No significant difference between groups at 3 years (*$p = 0.238$*).<br>Plaque Index:<br>No significant difference between groups (OR = 0.78, *$p = 0.599$*).<br>Gingival Index:<br>No significant difference between groups (*$p = 0.76$*).<br>This suggests that emergence angle alone does not significantly influence peri- | The study did not differentiate between convex and concave emergence profiles, which may influence the soft tissue response. |

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|---|---|---|
| | implant soft tissue health, so long as an appropriate emergence profile is maintained. | |
| *Hentenaar et al. 2020* (68) | Higher plaque accumulation was observed around crowns with convex emergence profiles. This is likely due to the impaired access for oral hygiene. There was a correlation between crown contour at the mesial 1-mm height and the deepest probing depth (*$p = 0.003$).* | There was a lack of standardization in oral hygiene practices. Confounding factors like implant position, keratinized mucosa width, and prosthetic material could influence BOP and plaque accumulation. However, they were not controlled for the analysis. |
| *Camacho-Alonso et al. 2024* (69) | Concave abutments demonstrated less inflammatory cell infiltration as compared to cylindrical abutments (*$p < 0.001$*). | The study only evaluated 12 week healing outcomes. Additionally, the data refers solely to the abutment profile. There was no data collected or analysed on probing depth, plaque accumulation, or bleeding on probing. |
| *Volp Junior et al. 2024* (70) | There was no significant increase in BOP or mucosal inflammation observed in implants with greater emergence angles (>30°), as compared to those with smaller angles. Thus, no significant association between EA and BOP was demonstrated (*$p > 0.05$*).<br>BOP prevalence was not greater surrounding restorations with convex emergence profiles compared to concave or straight profiles.<br>As a whole, the study did not find a strong correlation between emergence profile, | The study did not categorize cases of peri-implant mucositis separately from healthy peri-implant tissues. This makes it unclear whether emergence profile influences early-stage soft tissue inflammation.<br>The study did not control for confounding variables that could impact BOP and mucosal inflammation, such as smoking and diabetes, which |

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| | plaque accumulation and soft tissue inflammation. | affect vascularization and healing. |
| *Lops et al. 2022* (71) | Bleeding on Probing (BOP):<br>No statistically significant difference in BOP prevalence was noted between implants with greater vs. smaller emergence angles (*p > 0.05*).<br><br>Plaque Accumulation:<br>No significant correlation between emergence angle and plaque accumulation was noted (*p > 0.05*).<br><br>Soft Tissue Stability:<br>Both groups exhibited comparable soft tissue conditions. No significant increase in inflammation was noted in implants with larger emergence angles. | The study did not control for keratinized mucosal width, smoking, systemic conditions, or implant position.<br>The study reports on BOP and plaque scores but does not differentiate healthy peri-implant sites from those with active peri-implant mucositis. |
| *Papalou et al. 2022* (72) | Wider emergence profiles (>30°) were linked to shallower probing (*p < 0.05*). No significant increase in BOP was observed in implants with wider emergence profiles, contrary to previous studies suggesting convex profiles may increase plaque accumulation. | This study analysed peri-implant outcomes over both cemented and screw retained crowns. While the study identified the difference in peri-implant outcomes between the two retention methods, the results specifically pertaining to emergence profiles were not distinguished by retention method.<br>Other factors such as implant positioning, occlusal forces, and systemic conditions (e.g., |

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| | | diabetes, smoking) were not fully accounted for. |
| *Shen et al. 2022* (73) | Plaque Index:<br>• Metal-ceramic group: 0.46 (significantly higher, $p < 0.05$).<br>• Monolithic zirconia group: 0.37 (lower plaque accumulation).<br>Clinical interpretation: Monolithic zirconia was associated with better plaque control, which may be due to its smoother surface and lower potential for bacterial adhesion.<br><br>Bleeding on Probing (BOP):<br>No significant difference between the two groups ($p > 0.05$).<br><br>Peri-implant Probing Depth (PPD):<br>No statistically significant differences between the two groups ($p = 0.09$). | Implant surface type and oral hygiene habits were not standardized. |
| *Bittencourt et al. 2023* (74) | Plaque Index:<br>No statistically significant difference between groups ($p > 0.05$).<br><br>Bleeding on Probing (BOP):<br>No statistically significant difference between the groups ($p > 0.05$).<br><br>The probing depth around zirconia abutments with zirconia crowns decreased over time. This may be due to better soft tissue adaptation and epithelial attachment. | Oral hygiene, systemic health, and implant positioning were not standardized. |
| *AlJasser et al. 2021* (75) | Plaque Index (PI): | This study analysed both cemented and screw retained |

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| | • PFM crowns: Lower plaque accumulation (61.9% positive PI).<br>• All-ceramic crowns: Higher plaque accumulation (73.8% positive PI)<br>That said, *$p = 0.180$*, indicating lack of statistical significance.<br><br>Bleeding on Probing (BOP):<br>No statistically significant difference (*$p = 0.559$*)<br><br>Probing Pocket Depth (PPD):<br>• PFM crowns: Mean PPD = 4.61 ± 2.0 mm.<br>• All-ceramic crowns: Mean PPD = 5.15 ± 2.4 mm (*$p = 0.062$*).<br>All-ceramic crowns were associated with slightly deeper probing depths; however, the difference was not statistically significant.<br><br>PFM crowns were more frequently associated with pale pink gingival colour (67.5%), whereas all-ceramic crowns had a higher prevalence of redness (50.8%) (*$p = 0.005$*). | crowns. Although the study did measure the peri-implant health parameters around screw retained and cemented crowns separately, the results regarding crown material did not distinguish between the two retention methods.<br>Additionally, oral hygiene, systemic conditions (such as diabetes & smoking), and implant surface characteristics were not controlled.<br>No microbiological analysis was performed to explain why all-ceramic crowns had lower plaque accumulation but higher BOP. |
| *Yu et al. 2017* (76) | Plaque Index & Bleeding on Probing (BOP):<br>No significant differences in plaque index or BOP between the groups (*$p > 0.05$*)<br><br>Probing Depth (PPD):<br>PPD was significantly greater in the Co-Cr PFM group (*$p < 0.05$*), but there were no | Oral hygiene, systemic health, and implant positioning were not controlled in this study.<br><br>Surface roughness and polishing of different crown materials were not standardized, which could |

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| | significant differences between the Au-Pt PFM, Ti PFM, and Zirconia groups.<br><br>Gingival Crevicular Fluid (GCF) Volume: Higher GCF volume in Co-Cr and Au-Pt groups, which may be an indicator of greater inflammatory response.<br>There was increased GCF in all implant groups compared to natural teeth ($p < 0.05$), but the Co-Cr PFM group had the highest GCF volume, followed by Au-Pt PFM, with Ti PFM and Zirconia showing the least increase. | have influenced biofilm accumulation and the subsequent inflammatory response. |
| *Thoma et al. 2018* (77) | Plaque index, Probing depth, microbiological analysis, histological findings & bleeding on Probing:<br>No significant difference between veneered and non-veneered screw retained zirconia abutments.<br><br>Veneering zirconia abutments does not appear to negatively impact soft tissue response. | The histological analysis was limited by its sample size, thus reducing the statistical power of findings.<br>The study did not account for differences in keratinized mucosa width, which could influence BOP and soft tissue inflammation. |

## 5. DISCUSSION

### 5.1. Influence of emergence profile on peri-implant inflammation

The influence of the angle and contour with which a restoration emerges from its implant, and the surrounding gingiva has been documented and analysed through numerous studies (32,65,66,68,69). Pelekos et al. 2023 reported that crowns with a greater emergence angle and a convex profile had a significant association with higher plaque accumulation ($p < 0.01$). They also presented with higher scores of bleeding on probing ($p < 0.02$). Hentenaar et al. 2020 similarly noted higher prevalence of plaque retention as well deeper PPD surrounding implant-supported crowns with convex cervical contours at 1mm depth. Although not included in this review, Katafuchi et al. noted that an emergence angle above 30° was associated with a significantly increased risk of developing peri-implantitis in bone-level implants, though this was not consistent in tissue-level implants (78). That said, the study focused solely on radiographic evidence. Although probing depth was also used for diagnosis, the results were not presented. As such, conclusions cannot be drawn directly as to what the relationship between emergence profile and peri-implant mucositis may have been with bone or tissue-level implants. The systematic review conducted by Soulami et al. 2022 similarly found that an emergence angle greater than 30° held significant association with peri-implantitis, though the findings did not specify the prevalence of peri-implant mucositis and gingival inflammation (31).

That said, other studies challenged this theory. The two studies by Lops et al. 2022 did not find a statistically significant difference in BOP or PPD in crown restored implants with an emergence angle above or below 30° ($p = 0.238$). This suggests that emergence profile alone may not be an effective indicator of tendency for inflammation if other variables, such as hygiene and soft tissue adaptation, are optimised. Volp Junior et al. 2024 also found that the probing depths and soft tissue inflammation surrounding implant-supported crowns with greater emergence angles (>30°) were not increased. The meta-analysis conducted by Atieh et al. 2023 – though focused on marginal bone loss rather than soft tissue health – similarly concluded that an emergence profile greater or smaller than 30° did not seem to influence peri-implant outcomes. However, when accounting for the platform-abutment connection, they found that platform matched abutments with an emergence angle ≤30° may positively impact peri-implant bone levels. This brings into question the extent to which emergence profile influences the health of peri-implant tissues as compared to platform switching, and possibly other variables in prothesis design. The lack of specification as to whether or not platform switching was executed in various studies analysed in this review further compromises the clarity of the outcomes. Of the articles which included solely platform-switched implants, only Rungtanakiat et al. 2024 found increased inflammation secondary to reduced mucosal volume associated with a greater emergence angle, contradicted by the findings of Lops et al. 2022 and Hentenaar et al. 2020.

Although the results of the mentioned systematic reviews and meta-analyses regarding peri-implantitis cannot be extrapolated to hypothesise results regarding peri-implant mucositis without further confounding findings, the results give an interesting insight into the potential progression of the disease.

### 5.2. Influence of crown material on peri-implant inflammation

Evidence of the influence of crown material on periodontal health has been documented in a number of studies. Findings reveal a generally decreased inflammatory response of the periodontal tissues surrounding zirconia crowns over natural tooth abutments (79,80). This knowledge drives the question as to whether the results would be paralleled in implant-supported prosthetic restorations.

Some studies that evaluated crown material indicate that the choice of material utilised in the restoration can affect the accumulation of dental plaque. As a consequence, this may influence the risk of inflammation in the area. The findings of Shen et al. 2022 demonstrated that monolithic zirconia crowns accumulated less plaque as compared to PFM crowns ($p < 0.05$). This suggests that the zirconia surface – that is less prone to roughness and imperfections – may provide less retention for bacterial colonisation. Yu et al. 2017 found that deeper probing depths were associated with Co-Cr PFM crowns, as compared to other materials ($p < 0.05$). This may be a result of the poorer biocompatibility of the metallic component, negatively impacting the adaptation of peri-implant soft tissues.

On the other hand, Yu et al. 2017 found that scores for BOP did not present a statistically significant difference between zirconia and Co-Cr PFM ($p > 0.05$). This implies that peri-implant inflammation may not always increase in the presence of an accumulation of plaque. Shen et al. 2022 also reported that zirconia and metal-ceramic crowns resulted in comparable PPD values ($p = 0.09$). This reinforces the notion that crown material on its own may not significantly influence soft tissue stability.

Contradicting these previous findings, the cross-sectional study by AlJasser et al. 2021 observed a greater prevalence of erythema and oedema in the peri-implant soft tissues surrounding all-ceramic crowns as compared to PFM crowns ($p = 0.005$). The controversy of these findings and the presence of limited research focused entirely on implant-supported crown material, highlights the necessity of further investigation to improve understanding of the biological response of peri-implant tissues to different crown materials.

Although research regarding crown material over implants is restricted, numerous studies analysed the influence of abutment material on peri-implant health. The randomised controlled clinical trial by Bittencourt et al. 2023 found that zirconia abutments evoked a better peri-implant tissue response. However, it is critical to point out that the use of cement as the prosthetic retention method in the sample group of this trial raises doubts as to the extent of the role that the cement plays in inflammation of the peri-implant tissues. Despite this, a meta-analysis conducted by Sanz-Sanchez et al. 2018 supports the findings of Bittencourt et al. 2023, identifying that titanium abutments were associated with a higher inflammatory response, demonstrated more BOP and higher plaque indices as compared to zirconia abutments (81). As the primary transmucosal element, this highlights the importance of the abutment material when considering the materials utilised for implant prosthetic rehabilitation, and that the crown material independently may not condition the tissue response.

The contradictory findings regarding crown material, the influence of abutment design and material, and prosthetic retention method utilised within the sample groups of the literature analysed in this review demonstrate the interdisciplinary nature of implant prosthetic rehabilitation.

### 5.3. Limitations

A number of articles reviewed in this study analysed the influence of emergence profile or crown material on peri-implant health in cemented and screw retained single-unit implant rehabilitations (72,74,75). While these articles identified a tendency of increased inflammation of the gingiva surrounding cemented prostheses, when analysing emergence angle or crown material, there was no differentiation made as to whether the crowns had been cemented or screw retained.

Research into the influence of crown material on peri-implant health appears to be a major gap in available studies and findings. A majority of information available on this topic is extrapolated from studies focused on adjacent concepts that permitted the analysis of the influence of crown material on peri-implant health. As a result, the control of confounding factors and measurement parameters were not consistent.

With all the limitations of this study, it cannot be used to draw definitive conclusions. However, it is useful in identifying the correlation between emergence profile or crown material and peri-implant mucositis, thus guiding clinical decision making.

### 5.4. Clinical implications

Current findings demonstrate either positive or statistically insignificant peri-implant soft tissue response to the use of a concave emergence profile design with a narrower emergence angle. As such, the emergence profile design and angle should be optimised, utilising an angle below 30° with a concave profile to provide ease of access for hygiene, reducing the risk of soft tissue inflammation (32,68). The prosthetic crown should have a running room of 3-4 mm to facilitate appropriate contouring (36,37).

Despite the need for more research, current information supports the utilisation of highly polished zirconia, which provides less retention for bacterial biofilm adhesion and greater biocompatibility, as compared to Co-Cr PFM (73,76).

### 5.5. Future research directions

There is a need for studies to be performed, assessing not just the correlation between emergence profile and crown material with peri-implant soft tissue health, but rather identifying whether they directly influence inflammation. To do so, there is a need for more randomised clinical trials to investigate this subject.

In order to retrieve meaningful results, future studies should control for confounding factors such as oral hygiene protocols, and patient systemic conditions, to more effectively isolate the effects of emergence profile and crown material on peri-implant soft tissue health.

Additionally, the participants selected for future studies should ideally be candidates for receiving implants using the same techniques. This would mean that the study controls for tissue or bone-level placement, platform switching, and other clinical decisions that may directly affect the soft tissue health.

A histological assessment of the crevicular fluid, while maintaining these controls would complement the clinical assessment parameters such as BOP and PPD.

Additional research could examine specific bacterial species associated with different crown materials and emergence profiles. This may give valuable insights into understanding their role in peri-implant disease.

## 6. CONCLUSIONS

This study set out to investigate how the design of the emergence profile and the choice of final crown material in screw retained single-unit implants influences peri-implant soft tissue health, with a particular focus on peri-implant mucositis. As implant therapy continues to evolve, understanding the biological response of peri-implant tissues to prosthetic components becomes critical in reducing complications and ensuring long-term success.

### 6.1. Key outcomes relative to research objectives

6.1.1.Influence of emergence profile design on peri-implant soft tissue health

Regarding the primary objective, the findings from the literature review suggest that a concave emergence profile and an emergence angle ≤30° may positively affect peri-implant health by facilitating hygiene access and reducing the risk of inflammation. Several studies consistently showed that convex or over-contoured profiles correlate with increased plaque accumulation and BOP, both of which are associated with mucositis (32,68). While certain studies did not demonstrate a statistically significant correlation between emergence profile and peri-implant mucositis, the majority of the literature reviewed indicated that wider or more convex emergence profiles were significantly associated with increased inflammation (67,70,71). Importantly, no study reported a greater inflammatory response associated with narrower or concave profiles. Therefore, it is advisable for clinicians to design prosthetic restorations with smaller angled, concave emergence profiles to promote peri-implant soft tissue health and reduce the risk of inflammation. That said, the lack of conclusive findings indicates that emergence profile alone may not be a definitive predictor of inflammation without considering factors like mucosal thickness, implant type, or oral hygiene.

6.1.2.Influence of final crown material on peri-implant soft tissue health

As per the secondary objective, crown material, though less extensively studied, also emerged as a potential factor in soft tissue health. Zirconia crowns were generally associated with lower plaque scores, possibly due to their smoother surface and superior biocompatibility as compared to metal-ceramic restorations. Zirconia crowns generally presented improved outcomes, including reduced probing depths and lower crevicular fluid volume (73,76). However, some contradictory results highlight the inconsistency in clinical findings and the potential impact of uncontrolled variables like abutment type and the use of cements (75).

### 6.2. Summary

The interdisciplinary nature of implant prosthetic rehabilitation makes it difficult to isolate the impact of single factors like emergence profile or crown material. Limitations across the included studies – such as heterogeneity in study designs, lack of standardisation in oral hygiene protocols, implant positions, retention methods, and systemic health factors – complicate interpretation.

Despite these limitations, this study supports a more refined approach to prosthetic planning. Clinicians should consider implementing concave emergence profiles with an angle ≤30° and selecting zirconia as a crown material when indicated, especially in patients with thin biotypes or high aesthetic demands. That said, this review of the existing literature highlights a substantial gap in the evidence regarding the causal relationship between these clinical decisions and their impact on peri-implant tissue outcomes.

To bridge this gap, future research should focus on well controlled randomised clinical trials that specifically assess the direct influence of crown design and material while eliminating confounding variables. Histological and microbiological analyses could further elucidate the biological interactions between crown material and peri-implant tissue. Ultimately, integrating prosthetic considerations into biological planning is essential in maximising implant longevity and ensuring favourable health and aesthetic outcomes.

## 7. SUSTAINABILITY

The prosthetic decisions surrounding crown material and emergence profile not only affect biological outcomes but also reflect the broader need for sustainable healthcare practices.

The utilisation of zirconia crowns, which have been demonstrated to be more biocompatible and less plaque retentive than metal-ceramic alternatives, supports long-term oral health and reduces the risk of recurrent inflammatory conditions. This directly contributes to the third sustainable developmental goal (SDG) of improved health and wellbeing (82). Additionally this also results in a reduction in the necessity of retreatment, thus minimising material and resource use. Moreover, CAD-CAM fabrication of zirconia allows for digitally optimised production, reducing waste associated with manual processes—supporting more sustainable clinical workflows (83).

From an environmental and economic standpoint, the strategic selection of durable and biologically favourable materials can extend the lifespan of implant restorations. This curbs the need for replacement and resource-intensive interventions, appealing to SDG 12, responsible production and consumption (84). Integrating sustainability into prosthetic planning recognises that ethical clinical decision making must now consider environmental, economic, and social dimensions for a healthier, more sustainable future in healthcare.

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