

# Effect of Periodontal/Gingival Phenotype on Long-Term Outcomes of Implant-Supported Prostheses: An Umbrella Review

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## ABSTRACT

### Background:

The periodontal/gingival phenotype has emerged as a significant factor contributing to peri-implant soft tissue stability, biological success and esthetics. Nonetheless, implant survival rate alone might not be sufficient to evaluate the impact of the unfavourable phenotype on the clinical consequences, and the evidence related to prosthodontics remains scattered.

### Objective:

To present evidence synthesis from systematic reviews on the influence of periodontal/gingival phenotype on the results of rehabilitation of implants with respect to implant survival, peri-implant diseases, marginal bone level changes, soft tissue recession, papillary presence and effectiveness of soft tissue augmentation procedures.

### Methods:

Umbrella review methodology was used, adhering to the PRISMA 2020 guidelines. Five electronic bibliographic databases (PubMed/MEDLINE, EMBASE, Cochrane CENTRAL, Web of Science, Scopus) were used for searches until September 2025. Systematic reviews addressing the topic of gingival/periodontal phenotypes, presence of keratinised mucosa, soft tissue augmentation and their effects on implants were included. AMSTAR-2 was used to assess methodological quality of systematic reviews; GRADE certainty rating was used where available. Owing to overlaps between primary studies and variations in the definition of phenotypes and outcome measures, evidence synthesis was performed narratively without meta-analysis.

### Results:

Search yielded 650 studies, out of which 192 duplicate studies were excluded. After screening, 58 full text articles were evaluated, out of which 21 systematic reviews fulfilled the inclusion criteria and 6 were selected after methodological and eligibility assessment. 6 selected reviews included approximately 70 primary studies and more than 5,000 implants. Implant survival was good in both phenotypes with survival rates ranging approximately between 90.9% to 100%. However, unfavorable biological and esthetic outcomes were observed in thin phenotype. Meta-analysis demonstrated greater midfacial recession in thin peri-implant tissues when compared with thick peri-implant tissues by 0.62 mm (95% CI, 0.18–1.06;  $p=0.006$ ). Increased risk of peri-implantitis (OR 3.8; 95% CI, 2.1–6.9) along with greater marginal bone loss by 0.27–0.35 mm was observed in thin phenotype. Dose response association existed between tissue thickness and papilla presence with approximately 55% increase in odds with each millimeter of tissue thickness (OR 1.55; 95% CI, 1.08–2.22). Soft tissue augmentation, mainly connective tissue grafting, contributed towards increasing tissue thickness and improving soft tissue stability.

### Conclusion:

Available evidence supports the fact that periodontal/gingival phenotype affects the biological and esthetic outcomes of implants more than implant survival. The thin phenotype must thus be included in the implant risk assessment, especially in esthetically critical areas. It is clear that connective tissue grafts can work to make

tissue thickness increase and stabilize soft tissues. The problem lies in the lack of information on phenotypic-specific mechanical complications in prosthetic treatment.

**Keywords:** periodontal phenotype; gingival phenotype; gingival thickness; keratinized mucosa; dental implants; implant-supported prosthesis; peri-implantitis; marginal bone loss; soft-tissue augmentation; connective tissue graft.

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## 1. Introduction

Long-term success of the implant-supported prosthesis is dependent upon osseointegration, marginal bone levels, peri-implant soft tissues, function, esthetics, and prosthetic stability. While the implant survival rates can be very high, the existence of the implant does not sufficiently describe the stability of rehabilitation. Recession, inflammation, marginal bone loss, papillary defect, and increasing esthetic failure can develop without leading to the loss of the implant. Therefore, the current assessment of the treatment of implant includes not only implant survival but also biological and esthetic stability.

The notion of periodontal phenotype has changed from the former one called periodontal biotype. As was described at the World Workshop in 2017, the periodontal phenotype comprises not only gingival thickness and dimensions of the keratinized tissue but also properties of the underlying periodontal structures rather than being a single isolated tissue dimension [1]. In implantology, both tissue thickness and keratinized mucosa become highly significant since they affect peri-implant tissue architecture and can influence susceptibility to recession and inflammation.

Thinness of peri-implant soft tissues is related to mucosal recession and bone remodeling.

Prospectively, Linkevicius et al. found that soft tissue thickness affected the changes in crestal bone levels, providing evidence for the importance of the tissue thickness in the clinic setting [2]. Later, systematic reviews focused on the consistency of this finding in other clinical scenarios and if soft tissue augmentation had any effect on the risk of such association.

Avila-Ortiz et al. presented the topic of peri-implant phenotypes and stressed its relevance in implant dentistry [3]. Bienz et al. later conducted a systematic review on the comparison of the characteristics of thin and thick peri-implant soft tissues, and the difference was especially pronounced when it came to esthetics [4]. In turn, Suárez-López Del Amo et al. examined the effect of soft tissue thickness on peri-implant marginal

bone loss [5], whereas Lin et al. studied the importance of keratinized mucosa in implant health [6]. The role of soft tissue augmentation and the stability of the architecture of the tissue after the procedure were examined in two systematic reviews [7,8].

The clinical significance of the research evidence presented above is not limited to the field of periodontology. Successful prosthodontic rehabilitation requires intact peri-implant soft tissues that are essential for proper emergence profile design, aesthetic integration, cleanliness, restoration margins management, and maintenance. However, at the moment, there is no evidence in prosthodontic literature; the information is scattered in the periodontal, implant-surgical, and aesthetic literature. Moreover, it is unknown whether the patient's periodontal phenotype is associated with mechanical complications, such as screw loosening, abutment fracture, porcelain fracture or chipping, and prosthesis replacement. Therefore, an umbrella review of the systematic-review evidence on the impact of periodontal/gingival phenotype on prosthodontic rehabilitation is conducted. In particular, the present review will focus on the following issues: whether there are differences between thin and thick phenotypes in terms of implant survival, peri-implant diseases, marginal bone loss, gingival recession, papilla preservation, and esthetics, as well as soft tissue augmentation.

## 2. Materials and Methods

### 2.1 Review design and reporting

This work is an umbrella review of systematic reviews about periodontal/gingival phenotype and implants. The methodology of this study was performed using the PRISMA 2020 Statement guidelines [9]. The provided review protocol includes the search of PubMed/MEDLINE, EMBASE, Cochrane CENTRAL, Web of Science, and Scopus databases up until September 2025.

### 2.2 Eligibility criteria

The target population included adults older than 18 years who received dental implants or implant-prostheses. The exposure of interest was an

unfavorable or thin periodontal/gingival phenotype, which was predominantly defined in the provided review as a thickness of gingiva/mucosa not more than 2.0 mm. A thick phenotype is a thickness more than 2.0 mm. In studies with an analysis of keratinized mucosa, the criterion of insufficient tissue is a width of keratinized mucosa less than 2.0 mm. A thick phenotype or sufficient peri-implant soft tissue condition is used as a comparator.

Eligible evidence was related to the survival rate of implants, peri-implant mucositis or peri-implantitis, bone loss, soft tissue changes/recession, papillae formation, bleeding on probing, esthetic outcome, patient-reported outcomes, and soft tissue augmentation. Eligible evidence included systematic reviews containing at least five primary studies and clinical studies such as randomized controlled trials, prospective or retrospective cohort studies, and case series where relevant to the synthesis.

### 2.3 Search and study selection

The search process yielded 650 citations. Upon removal of 192 duplicates, 458 citations remained unique. Title/abstract screening led to exclusion of 400 citations, resulting in 58 full-text articles being evaluated for eligibility. Twenty-one systematic reviews fulfilled the initial eligibility criteria. Of these 21, fifteen systematic reviews were further excluded on account of methodologically low-quality design, inclusion of fewer than five primary studies or non-phenotype stratification of data. Six systematic reviews were thus available for synthesis.

These six systematic reviews included approximately 70 primary studies and over 5,000 implants. Yet these primary studies were not independent in each systematic review; rather, these numbers constitute the entire body of evidence and cannot be considered as an independent sample of 5,000 implants studied in a unique manner. The underlying studies included randomized controlled trials, prospective cohort studies, retrospective studies and case series with follow-up ranging from short-term to approximately 10 years in some of the evidence streams.

### 2.4 Data extraction

Data from the systematic reviews comprised study characteristics, definition and measurement of phenotype, keratinized mucosa width, timing of implant placement, technique of soft tissue augmentation, follow-up period, implant survival, peri-implant disease, marginal bone loss, changes in soft tissue margin, esthetic results, patient-centered outcome, and potential confounders such as plaque control and maintenance.

### 2.5 Assessment of methodological quality

The methodological quality of the included systematic reviews was assessed by the use of AMSTAR-2 [10]. Methodological quality

assessment involved the main criteria related to research question and PICO statement, registration of the protocol, search strategy, duplication of the study selection and data extraction process, description of excluded studies, characteristics of included studies, risk of bias assessment, funding, and adequacy of the meta-analysis.

It has been shown that there was a proper assessment of the research question, inclusion criteria, search strategy, selection of the study, data extraction, study characteristics, risk of bias assessment, and synthesis of the quantitative analysis. However, protocol registration, exclusion of the studies, and funding of the studies have not been described properly. Therefore, the six systematic reviews have been included in the meta-analysis.

**Table 1. AMSTAR-2 domain assessment of included systematic reviews**

| AMSTAR-2 domain           | Bien et al., 2022 | Stefanini et al., 2023 | Avila-Ortiz et al., 2020 | Thomas et al., 2014 | Lin et al. | Suárez-López Del Amo et al., 2016 |
|---------------------------|-------------------|------------------------|--------------------------|---------------------|------------|-----------------------------------|
| Research question         | Yes               | Yes                    | Yes                      | Yes                 | Yes        | Yes                               |
| PICO components           | Yes               | Yes                    | Yes                      | Yes                 | Yes        | Yes                               |
| Protocol registered       | Yes               | Yes                    | Yes                      | No                  | No         | Yes                               |
| Search strategy           | Yes               | Yes                    | Yes                      | Yes                 | Yes        | Yes                               |
| Duplicate study selection | Yes               | Yes                    | Yes                      | Yes                 | Yes        | Yes                               |
| Duplicate data extraction | Yes               | Yes                    | Yes                      | Yes                 | Yes        | Yes                               |
| List of excluded studies  | Yes               | Yes                    | No                       | No                  | No         | Yes                               |
| Study characteristics     | Yes               | Yes                    | Yes                      | Yes                 | Yes        | Yes                               |

|                                |     |     |     |     |     |     |
|--------------------------------|-----|-----|-----|-----|-----|-----|
| <b>istics</b>                  |     |     |     |     |     |     |
| <b>Risk-of-bias assessment</b> | Yes | Yes | Yes | Yes | Yes | Yes |
| <b>Funding sources</b>         | Yes | Yes | Yes | No  | No  | Yes |
| <b>Meta-analysis methods</b>   | Yes | Yes | Yes | Yes | Yes | Yes |

## 2.6 Certainty of evidence

GRADE assessments reported in the source evidence were extracted for the principal outcomes. Certainty was considered across risk of bias, inconsistency, indirectness, imprecision, and publication bias. The available assessments classified most principal phenotype-related outcomes as moderate certainty, while the comparison concerning connective tissue grafting versus no augmentation was classified as low certainty because of indirectness.

## 2.7 Data synthesis

However, due to the similarities of the included systematic reviews in terms of the overlapping primary studies and differences in phenotype definitions, interventions, outcome definitions, and follow-up times, a meta-analysis was not conducted over the systematic reviews. The estimated results of the individual systematic reviews were maintained as reported. This method aimed to reduce double-counting of primary studies and inappropriate statistical pooling.

## 3. Results

### 3.1 Characteristics of the included evidence

The six systematic reviews studied the complementary issues concerning the correlation between the peri-implant soft tissue characteristics and implant outcomes. In their systematic review, Bienz et al. concentrated mostly on the differences between thin and thick peri-implant soft tissues and the esthetic outcomes [4]. In turn, Stefanini et al. analyzed the stability of soft tissue augmentation and esthetic outcomes [8]. Avila-Ortiz et al. provided a systematic review on the peri-implant phenotype [3]. Thoma et al. analyzed the effectiveness of soft tissue augmentation [7]; Lin et al. studied the importance of keratinized mucosa [6]; and Suárez-López Del Amo et al. investigated the impact of soft tissue thickness on marginal bone loss [5].

Geographic diversity characterized both the studies selected for the evidence base and the range of study designs, including randomized controlled trials, prospective and retrospective cohorts, and case series. There were wide differences among the studies regarding follow-up time periods. The

literature that formed the basis of this review was heavily weighted toward anterior implants.

**Table 2. Principal systematic reviews included in the umbrella synthesis**

| <b>Systematic review</b>                     | <b>Primary focus</b>                            | <b>Principal findings reported in the source material</b>                                  |
|----------------------------------------------|-------------------------------------------------|--------------------------------------------------------------------------------------------|
| <b>Bienz et al., 2022 [4]</b>                | Thin versus thick peri-implant soft tissue      | Greater midfacial recession and marginal bone loss in thin phenotype                       |
| <b>Stefanini et al., 2023 [8]</b>            | Soft-tissue augmentation and esthetic stability | Augmentation associated with increased tissue thickness and improved soft-tissue stability |
| <b>Avila-Ortiz et al., 2020 [3]</b>          | Peri-implant phenotype                          | Associations between soft-tissue phenotype, inflammation and marginal tissue outcomes      |
| <b>Thoma et al., 2014 [7]</b>                | Soft-tissue augmentation                        | CTG produced greater tissue-thickness gain than some substitute materials                  |
| <b>Lin et al., 2013 [6]</b>                  | Keratinized mucosa and implant health           | Inadequate keratinized mucosa associated with less favorable peri-implant parameters       |
| <b>Suárez-López Del Amo et al., 2016 [5]</b> | Soft-tissue thickness and MBL                   | Thin phenotype associated with greater marginal bone loss                                  |

The source manuscript had previously listed Lin et al. as 2018 in some sections; this has been corrected here to **2013**, consistent with the complete reference supplied in the source document.

### 3.2 Implant survival

High survival rates were consistently observed in the available literature. Survival rate was approximately between 90.9% and 100%, and no statistically significant difference between survival in thin and thick phenotypes was identified by source synthesis.

It is of particular importance since it suggests that thin phenotype is not a predictor of implant loss. Instead, it is primarily connected to the state of

peri-implant soft tissues and esthetic and biological quality of the rehabilitation.

The difference between survival and success is especially meaningful in this case since implant can be osseointegrated while there will be mucosal recession, peri-implant inflammation, marginal bone loss, and esthetic complaints of the patient. High survival rates in phenotypes cannot prove the equivalence of clinical outcomes.

### **3.3 Peri-implant mucositis and peri-implantitis**

The consistent correlation between thin peri-implant soft tissue and poor results in inflammation was observed in the available literature. According to Suárez-López Del Amo et al., the odds ratio for peri-implantitis in patients with thin peri-implant soft tissue is 3.8, and the 95% confidence interval is 2.1–6.9 [5].

The synthesis provided stated that thin tissue phenotype accounted for approximately 75–83% of peri-implantitis conditions in the available data sets.

Keratinized mucosa is another characteristic to consider. Avila-Ortiz et al. stated a relationship between keratinized mucosa <2.0 mm width and greater bleeding on probing with 72% BOP compared to 31% in the better mucosa group according to the existing evidence [3].

These findings confirm the significance of soft-tissue phenotype as a component of peri-implant risk assessment, yet they do not prove that thin tissue is a causative agent of peri-implantitis condition. Variables such as plaque formation, oral hygiene, history of periodontitis, smoking, implant placement, prosthesis contour, and maintenance compliance may affect the results. These factors were not controlled consistently in the original studies, while some data showed a correlation between improper maintenance and the disease progression regardless of the phenotype.

### **3.4 Marginal bone loss**

Higher marginal bone loss was found with thinner or insufficient peri-implant soft tissue. The summary estimate for marginal bone loss associated with thinner or insufficient peri-implant soft tissue was around 0.27–0.35 mm, with moderate certainty in the principal comparison.

There is biological plausibility for the relationship between soft-tissue thickness and marginal bone changes and it is consistent with prospective clinical evidence that has shown higher crestal bone changes with thinner peri-implant soft tissue [2]. However, there are multiple factors that may affect the observed effect.

In the augmentation literature there is some further information available. Marginal bone loss after CTG procedures on average was 0.63 mm over a period of follow-up averaging 5 years. Excluding an outlying study, the weighted average was 0.18 mm over 4.5 years. In non-augmented sites, the weighted average marginal bone loss was 0.88 mm,

reducing to 0.33 mm by excluding an outlying study. APF plus FGG sites showed average marginal bone loss of around 0.28 mm over 7 years.

However, these statistics cannot be used to draw comparisons between augmentation methods due to different populations, indications, follow-up periods, and study designs.

### **3.5 Midfacial soft-tissue recession**

The most quantitatively proven esthetic disparity between two phenotypes was midfacial recession. Bienz et al. found 0.62 mm more midfacial recession in thin than in thick peri-implant soft tissues, which had 95% CI of 0.18–1.06 mm and  $p=0.006$  [4]. The degree of certainty for the evidence was moderate.

While the magnitude of this difference is less than 1 mm, its clinical significance depends on the position of implants and esthetic requirements. Changes in mucosal height are particularly noticeable when they happen in the anterior region, where they affect the symmetry and relationships of peri-implant soft tissues to the natural dentition. Consequently, the significance of this finding is higher in esthetically visible locations rather than posterior teeth.

The existing augmentation evidence implies that an increase in tissue thickness will result in better stability of soft-tissue margins. Bilaminar CTG resulted in reported weighted mean apical shift of about  $-0.06$  mm over 4.8 years in the synthesis.

### **3.6 Papilla preservation**

Dose-response relationship between tissue thickness and the presence of the papilla was mentioned in the supplied evidence. Each 1-millimeter increment in tissue thickness corresponded to about 55% higher likelihood of papilla presence (OR 1.55; 95% CI, 1.08–2.22;  $p=0.03$ ).

According to the source synthesis, complete papilla fill was observed significantly more often at tissue thicknesses around 3.0 mm or above than at lower thicknesses. Nevertheless, this result needs to be taken with caution. Current evidence is not sufficient to claim that 3.0 mm can be regarded as a universally validated clinical threshold or as an alternative to the traditional 2.0-mm classification threshold. It is rather possible that approximately 3.0 mm might be considered as a possibly desirable tissue size for certain esthetic outcomes.

This difference matters since the categorization of thin and thick phenotype and the prediction of papilla fill are two distinct issues. A threshold for the categorization of phenotypes cannot be treated automatically as a threshold for esthetic outcomes prediction.

### **3.7 Keratinized mucosa**

Keratinized mucosa is another related but different element in peri-implant soft-tissue evaluation. The

systematic review by Lin et al. identified correlations between lack of keratinized mucosa and worse health indices for the implants [6]. The provided synthesis found the same trends with increased bleeding on probing and marginal bone alterations in areas with lack of keratinized mucosa. Thus, gingival thickness and keratinized mucosa cannot be considered as similar factors. An area can have sufficient thickness but insufficient keratinized mucosa, and vice versa. Both variables may be important in relation to the patient's periodontal condition, the position of the implant, prosthetics, and capacity for maintaining good oral hygiene.

#### **4. Soft-Tissue Augmentation**

There was a consistent link between soft-tissue augmentation and greater peri-implant tissue thickness as well as better soft-tissue stability. The main techniques included connective tissue grafts, free gingival grafts, acellular dermal matrix, and various substitutes.

CTG was the procedure which showed the most consistently favorable tissue thickness results. According to Thoma et al., tissue thickness gain amounted to about 0.87 mm for CTG, and about 85% of initial gain was preserved for 5 years [7]. For acellular dermal matrix, tissue thickness gain was about 0.34 mm.

Nonetheless, CTG should be evaluated in view of limitations inherent to the evidence used. Different treatments were performed in different clinical conditions; various studies employed different surgical techniques, different timing of implantation, various initial tissue thickness, different follow-up periods, and different measurements of outcomes. Therefore, CTG should be considered a well-validated approach in terms of tissue thickness increase, but the evidence cannot be used to claim its universal necessity or superiority.

FGG and APF can be viewed as especially appropriate for cases where increasing keratinized mucosa is the main aim. Provided evidence contained results of studies which showed increased keratinized tissue size and fairly stable soft tissue margin after the procedures.

Augmentation thus should be based on a case-by-case basis. Thin anterior gingival tissues in combination with high aesthetic demands or any other biological risk factors are an environment in which augmentation can become very relevant. On the contrary, the augmentation of each implant site cannot be justified based on existing scientific data.

#### **5. Discussion**

The major conclusion from the present umbrella review is that the periodontal/gingival phenotype influences biological and aesthetic outcomes more often than implant survival. Among all systematic reviews, survival rates remained very high among both thin and thick phenotype sites, while thin

phenotype sites experienced higher recession, peri-implant inflammatory complications, and bone loss.

The distinction between survival and clinical success is critical for implant-supported prosthodontics. Studies of implant success in the past usually concentrated on implant survival rates as the main parameter. However, even if the implant is still functional, the patient suffers from recession, inflammation, bone loss, papillae alterations, and maintenance of the implant. Success criteria should therefore include biological stability, soft-tissue architecture, esthetic results, functional performance, and maintenance.

Evidence that patients with thin phenotype have midfacial recession of 0.62 mm is another factor supporting this interpretation [4]. However, the magnitude of the difference should not be evaluated on its own, without considering the implant's location, smile line, adjacent teeth placement, the symmetry of tissues, and other parameters such as patient expectations and the restoration design. Anterior regions are usually more vulnerable to changes of soft tissues than the others.

Connection of thin phenotype with peri-implantitis is clinically relevant. The odds ratio of 3.8 means the existence of significant association between the two, but this does not mean that patients with thin phenotype necessarily have peri-implantitis because there are many factors that influence the inflammatory process in peri-implant area. Specifically, the source material indicated maintenance compliance and plaque control as important modifying factors.

This interpretation is especially important for the practical application of these results. For example, thin tissues in combination with good plaque control and other factors such as proper implant placement and bone anatomy and maintenance may result in a totally different prognosis than thin tissue with the history of periodontitis, poor plaque control, smoking, or bad implant placement.

Phenotype and marginal bone loss relationship can be seen as additional evidence in favor of taking into account soft tissue features during planning. The difference of 0.27–0.35 mm is small in the absolute value, but it may gain clinical importance after some time because of bone remodeling. Still, the evidence is prone to bias, and the relationship found cannot be taken as a direct cause-and-effect one for tissue thickness only.

What is especially interesting in the evidence regarding the presence of papilla is its relevance to prosthodontics. The dose-response relationship indicates that there may be an association between increasing tissue thickness and better results. At the same time, papilla creation depends on various anatomical and prosthetic factors, such as the interproximal bone level, tooth to implant distance,

implant to implant distance, contact point location, implant location, and soft tissue volume.

The proposal of a favorable tissue dimension in the order of 3.0 mm must be handled with care. The evidence provided suggests that there is a higher likelihood of the presence of the papilla with increased tissue thickness, but this evidence is not sufficient to define a 3.0-mm critical tissue dimension in all patients. Without prospective validation, the number must be regarded as a potential esthetic goal for specific situations.

#### **6. Prosthodontic Considerations**

The evidence presented supports the use of phenotypic assessment as part of the prosthodontic treatment planning process. When dealing with a thin phenotype, especially in the anterior area, it is likely that there will be greater likelihood of gingival recession. For this reason, it becomes important to preserve the volume of soft tissue as well as its cleansability.

But the currently available scientific data do not provide the necessary justification for some other recommendations contained in the draft of this paper. In particular, there is no evidence stratified by phenotype that would support obligatory use of supragingival or equigingival margin position in all thin phenotype cases, use of non-titanium abutments, specification of the particular dimension of the emergence profile, prescription of the particular crown height, or screw retention only on the grounds of phenotype.

The same rule can be applied to the maintenance intervals. The source materials recommended shorter intervals of maintenance in case of thin phenotype patients, but there is no scientific evidence to define a standard interval of three or four months on the sole grounds of phenotype. Maintenance should be personalized based on the entire risk profile of a patient in relation to periodontal inflammation.

There are data that support the need for phenotype evaluation prior to implant placement. In particular, tissue thickness and keratinized mucosa should be measured with a consistent clinical technique especially in the case of anterior implants in the aesthetic zone. Clinicians need to evaluate whether soft tissue augmentation can make a difference in the biological or aesthetic outcome of their patient.

#### **7. Mechanical Prosthetic Outcomes**

One of the key findings from the review was the lack of evidence on mechanical prosthodontic complications stratified by phenotypes. The systematic review included no evidence that compared screw loosening, screw fracture, abutment fracture, chipping or fracturing of ceramic, loss of retention, cement-based prosthodontic complications or long-term prosthesis replacement in relation to periodontal phenotype at baseline.

This aspect was especially important because the topic of the systematic review is the mechanical complications of the implant-supported prostheses rather than just implant survival rate. Even though the phenotype can potentially affect the prosthesis design due to its impact on soft tissue thickness, emergence profile, margin position and cleansability, there were no data supporting increased risk of prosthodontic complications due to thin phenotype.

Consequently, the present evidence suggests a phenotype-based risk assessment approach, however, not a definite phenotypically-specific prosthodontic protocol. For instance, there are currently not enough data to claim that thin phenotype is associated with the requirement for the screw retention instead of cement retention, ceramic abutments instead of titanium abutments, or certain emergence profile shape. Therefore, the decision should continue to be based on general prosthodontic concepts and the patient's anatomical conditions until the mechanistic phenotype-specific data become available.

#### **8. Soft-Tissue Augmentation and Treatment Decisions**

The available evidence suggests the need for selective application of soft-tissue augmentation when the increase in tissue thickness or keratinized mucosa is expected to have an effect on the biological or esthetic prognosis. It is especially applicable for thin anterior sites and conditions of limited soft-tissue volume and high esthetic requirements.

Connective tissue grafting showed relatively stable results in terms of tissue-thickness gain and soft-tissue margin outcome parameters [7,8]. The weighted mean apical change of about -0.06 mm over 4.8 years demonstrates a good stability of the soft-tissue position within the evaluated groups.

However, augmentation cannot be recommended as an absolute requirement for thin phenotype in view of implant location, esthetic demands, original tissue thickness, presence of keratinized mucosa, alveolar bone level, implant location, periodontal status, and patient compliance with plaque control. Furthermore, the augmentation is not necessary in order to ensure implant survival since survival rates are high irrespective of treatment group. The main effects seem to be associated with soft tissue thickness, marginal stability and esthetics.

#### **9. Strengths and Weaknesses**

The main strength of the present umbrella review lies in synthesis of evidence obtained in several systematic reviews regarding different elements of peri-implant phenotype. There are more than 70 primary studies and 5,000 implants included in the evidence base and assessed with regard to methodological quality and GRADE certainty. The review separates the concept of survival from

biological and esthetic outcomes, which is especially important for prosthodontic restoration. There are several limitations of this review. Firstly, the primary evidence was heterogenous with regard to phenotypes' definition and measurement. Some studies were based on tissue thickness, other on keratinized mucosa and the rest on their combination. Different phenotypes' classification restricts the possibility of comparison.

Second, many of the primary studies were observational or single-center investigations with relatively small sample sizes. Although randomized studies were available, long-term randomized evidence remains limited. The source synthesis also reported heterogeneity in the diagnostic criteria used for peri-implantitis and in follow-up duration.

Third, a large percentage of the evidence comes from studies on anterior implants. The evidence suggested that about 70-75% of all the included studies were focused on anterior implants, which affected the generalization of the results towards posterior implant-supported prosthesis.

Fourth, there is an overlapping of primary studies in systematic reviews, which poses a danger of double counting in case the data is simply pooled together at the review level. That is why the current synthesis did not pool the included reviews in any way.

Fifth, esthetic outcome and evaluation of papilla and soft tissue is often done by non-blind measurement, leading to detection bias. Besides, there are not enough data on long-term outcomes over 10 years.

Last but not least, while the actual search strategy had been extended until September 2025, the actual source material included only reviews and selected primary studies, and not full datasets of all original investigations performed. Thus, the numerical estimates provided in the current report must be viewed as extracted estimates based on the evidence included, rather than calculations of pooled effects.

## 10. Conclusion

The results of the present umbrella review imply that periodontal/gingival phenotype affects biological and esthetic outcomes of implant rehabilitation to a great extent, while implant survival rates are high in both thick and thin phenotypes.

Thin phenotype was linked with about 0.62 mm more midfacial recession, higher probability of peri-implantitis, as well as about 0.27–0.35 mm more bone loss. The evidence presented in this review revealed the existence of a correlation between increasing tissue thickness and papilla presence. This means that the phenotype is a factor of clinical significance even in cases when implant survival is unaffected.

Soft tissue augmentation and connective tissue grafting, in particular, seem to be highly effective in increasing the tissue thickness of peri-implants.

The evidence does not, however, support the use of rigid phenotype-specific prosthodontic protocols concerning abutment material, retention mechanism, restorative margin position, emergence-profile dimensions, or crown dimensions. Most importantly, there is currently insufficient evidence concerning mechanical prosthetic complications stratified by periodontal phenotype.

Hence, periodontal gingival phenotype should be considered an essential factor in implant risk assessment and not as an isolated determinant of failure of implants. Decisions made during clinical practice should take into account both phenotype as well as implant location, hard tissue structure, periodontal history, oral hygiene, maintenance, prosthesis design, and esthetics.

## Tables

**Table 3. GRADE assessment of principal outcomes**

| Out<br>co<br>me                                                     | Esti<br>mat<br>e of<br>effe<br>ct | N<br>o<br>.<br>o<br>f<br>S<br>R<br>s | R<br>is<br>k<br>of<br>bi<br>a<br>s | Inc<br>ons<br>iste<br>ncy | Ind<br>ire<br>ctn<br>ess | Im<br>pre<br>cisi<br>on | Pu<br>bli<br>cat<br>ion<br>bia<br>s | O<br>ve<br>ra<br>ll<br>ce<br>rt<br>ai<br>nt<br>y |
|---------------------------------------------------------------------|-----------------------------------|--------------------------------------|------------------------------------|---------------------------|--------------------------|-------------------------|-------------------------------------|--------------------------------------------------|
| <b>Mi<br/>dfa<br/>cial<br/>rec<br/>essi<br/>on</b>                  | +0.62 mm (95% CI 0.18 – 1.06)     | 3                                    | Serious                            | Not serious               | Not serious              | Serious                 | Not detected                        | <b>Moderate</b>                                  |
| <b>Per<br/>i-<br/>imp<br/>lant<br/>itis<br/>inci<br/>den<br/>ce</b> | OR 3.8 (95% CI 2.1–6.9)           | 2                                    | Serious                            | Not serious               | Not serious              | Not serious             | Not detected                        | <b>Moderate</b>                                  |
| <b>Ma<br/>rgi<br/>nal<br/>bon<br/>e</b>                             | +0.27–0.35 mm                     | 4                                    | Serious                            | Not serious               | Not serious              | Serious                 | Not detected                        | <b>Moderate</b>                                  |

| loss                          |                                                       |   |         |             |             |             |              |                 |
|-------------------------------|-------------------------------------------------------|---|---------|-------------|-------------|-------------|--------------|-----------------|
| <b>Papilla presence</b>       | OR 1.55 per additional mm tissue (95% CI 1.08 – 2.22) | 2 | Serious | Not serious | Not serious | Not serious | Not detected | <b>Moderate</b> |
| <b>Implant survival</b>       | Approximately 90–100% in both groups                  | 6 | Serious | Not serious | Not serious | Not serious | Not detected | <b>Moderate</b> |
| <b>CTG vs no augmentation</b> | Approximately –0.06 mm apical shift                   | 2 | Serious | Not serious | Serious     | Not serious | Not detected | <b>Low</b>      |

The GRADE classifications and effect estimates correspond to the evidence table supplied with the review material.

**Table 4. Summary of clinical interpretation of the evidence**

| Parameter        | Evidence-supported interpretation                                                      |
|------------------|----------------------------------------------------------------------------------------|
| Implant survival | High in both thin and thick phenotypes; no convincing survival difference demonstrated |
| Midfacial        | Greater in thin phenotype;                                                             |

|                                     |                                                                                             |
|-------------------------------------|---------------------------------------------------------------------------------------------|
| recession                           | pooled difference approximately 0.62 mm                                                     |
| Peri-implantitis                    | Higher odds associated with thin phenotype; OR approximately 3.8                            |
| Marginal bone loss                  | Approximately 0.27–0.35 mm greater in thin/inadequate tissue                                |
| Papilla presence                    | Increasing tissue thickness associated with increased odds of papilla presence              |
| Keratinized mucosa                  | Inadequate width associated with less favorable inflammatory parameters                     |
| CTG                                 | Consistent evidence for increased tissue thickness and improved soft-tissue stability       |
| ADM/substitute materials            | Can increase tissue thickness, but long-term maintenance may be less predictable than CTG   |
| Mechanical prosthetic complications | Insufficient phenotype-stratified evidence                                                  |
| Maintenance                         | Should be individualized according to overall peri-implant risk rather than phenotype alone |

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