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BEST-EVIDENCE CONSENSUS

American Academy of Periodontology best evidence consensus statement on modifying periodontal phenotype in preparation for orthodontic and restorative treatment

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INTRODUCTION

In 2016, the American Academy of Periodontology (AAP) embarked on a best evidence consensus (BEC) model of scientific inquiry to address questions of clinical importance in the treatment of periodontal and peri-implant diseases and conditions. For each focused clinical question addressed below, there is a critical mass of evidence. However, by itself, that evidence is, in the judgment of an expert panel convened by the AAP, insufficient to support broad conclusions and/or clinical practice guidelines. Members of the expert panel assembled for this BEC have extensive knowledge of gingival phenotype and the effects of phenotype modification therapy (PhMT) on periodontal health, on soft tissue around fixed dental prostheses, and in concert with orthodontic treatment. Specific clinical questions were posed, and systematic reviews were performed on each of these questions. The expert panel debated the merits of published data and experiential information and developed a consensus statement based on the best evidence available.

The purpose of this BEC was to define parameters for periodontal and peri-implant health and arrive at a consensus regarding whether PhMT can help maintain or improve dental health, particularly prior to extensive restorative and orthodontic treatment. Recent literature has defined periodontal and peri-implant health based on anatomic characteristics of components of the masticatory complex, including (1) gingival thickness (GT) or peri-implant tissue thickness and keratinized tissue width (KTW); (2) bone morphotype; and (3) tooth dimension. However, with the publication of the 2018 Classification of Periodontal and Peri-Implant Diseases and Conditions, a new term—periodontal phenotype—was adopted to describe the combination of gingival phenotype (three-dimensional gingival volume) and bone morphotype (thickness of the bone plate).[1,2] This term has been extended to include peri-implant dimensions to describe the peri-implant phenotype[3] (see Appendix 1 at the end of this consensus statement for a list of acronyms used throughout the paper and Appendix 2 in the online *Journal of Periodontology* for definitions of terms and relevant background).

This BEC focused on the characteristics of thick and thin gingival/peri-implant phenotype, with thin phenotype having increased risk for pathosis (recession, inflammation, periodontitis/peri-implantitis). The dimensions of periodontal and peri-implant phenotype differ in healthy patients and those at risk for development of recession and marginal bone loss (see Table 1 for dimensions of thick and thin periodontal/peri-implant phenotype and potential therapeutic interventions). Improvement of the soft tissue component by augmenting GT and KTW was previously reviewed.[4–6] Recent advances in professional oral care and surgical interventions such as PhMT can improve therapeutic outcomes in patients undergoing maintenance and in those requiring restorative, implant, and orthodontic treatment. PhMT intervention can involve modification of soft tissue, bone, or a combination of both.

The expert panel acknowledges the challenges in assessing potential applications and benefits of PhMT based on an analysis of current evidence. However, it looks forward to future clinical studies that may provide answers where there are limitations in the current evidence.

FOCUSED CLINICAL QUESTION 1

Does the modification of gingiva from a thin to a thick phenotype contribute to maintaining periodontal health?

In a comprehensive attempt to address the broader question above, three clinically relevant questions were considered: (1) What factors influence gingival phenotype? (2) What is the influence of the gingival phenotype (thin versus thick) on gingival health? (3) Does the modification of gingiva from a thin to a thick phenotype in sites without mucogingival defects contribute to maintaining periodontal health?

GT, KTW, and bone morphotype are three important parameters used to categorize periodontal phenotype. It is well known that areas exhibiting a thin gingival phenotype, as well as a lack of attached gingiva, are more susceptible to the occurrence of gingival recession. Two systematic reviews from the 2014 AAP Workshop on Enhancing Periodontal Health Through Regenerative Approaches outlined the indications for, and assessed the efficacy of, soft tissue non-root coverage and root coverage procedures.[4,5] Both reviews noted that autogenous gingival graft and subepithelial connective tissue graft-based procedures provided the best clinical outcomes, respectively. However, there was a lack of selected studies that evaluated both components of the gingival phenotype—GT and gingival width. The systematic review for focused clinical question 1 (above) concluded that subjects with thin and narrow gingiva tend to have more gingival recession than those with thick and wide gingiva. Currently, there is no published evidence to support that modification of thin to thick gingival phenotype will maintain periodontal health in sites without gingival recession or mucogingival deformity.

Evidence search strategy

For the focused question above, an electronic search of the Medline database from its inception until March 2019, as well as an extensive manual search, yielded a total of 1129 citations. A total of 996 relevant articles were identified and, following careful screening, 30 articles were included in the review.

Clinical question 1: Sub-question 1: What factors influence gingival phenotype?

Evidence evaluated

A total of 25 studies[7–31] met the inclusion criteria and provided data for this question. All studies had a cross-sectional design.

Evidence-based conclusions

Current evidence supports the following:

- GT varies among different individuals as well as in different areas of the mouth within the same individual.[7]
- There was a positive correlation between KTW and GT in maxillary anterior teeth; however, evidence is lacking for other locations.[8–11]
- Maxillary central incisors presented with the greatest mean GT, followed by lateral incisors and canines.[7–10]

TABLE 1 Phenotype dimensions and possible therapeutic interventions

Dimensions	Dental thick phenotype	Dental thin phenotype	Dental PhMT	Peri-implant thick phenotype	Peri-implant thin phenotype	Peri-implant PhMT
KTW	5.09–6.65 mm (mean 5.72 mm) ≥ 2 mm[a]	2.75–5.44 mm (mean 4.15 mm)	FGG, SCTG	SxD ≥ 2 mm[a]	SxD < 2 mm	SCTG, FGG
GT	1.24–1.79 mm — ≥ 1 mm[a]	0.63–1.24 mm (mean 0.80 mm)	FGG, SCTG, filler substitutes	SxD ≥ 2 mm[a]	SxD < 2 mm	SCTG, FGG, filler substitutes
BT	AD (mean 0.75 mm)	AD (mean 0.34 mm)	CAOT, CAOT + bone augmentation (PAOO, SFOT, Wilckodontics)	SxD ≥ 2 mm[a]	SxD < 2 mm	GBR, filler substitutes, bone grafting, combination of above

AD, anatomic dimension as defined by range of variations in individuals and respective dental anatomical locations (i.e., incisors, canine, molars); BT, bone thickness (thickness of the buccal plate); CAOT, corticotomy-assisted orthodontic therapy; FGG, free gingival graft; GFR, guided bone regeneration; PAOO, periodontally accelerated osteogenic orthodontic; SCTG, subepithelial connective tissue graft; SFOT, surgically facilitated orthodontic therapy; SxD, surgically determined/modified at the time of placement.
[a]Therapeutic goals.

- Maxillary lateral incisors had the greatest KTW, followed by central incisors and canines.[8–10]
- Gingival phenotype does not appear to be influenced by either age or sex[10,12–15]; however, some studies report higher prevalence of thin gingival phenotype in females than males.[16–18]
- Asian subjects have been reported to have thin gingival phenotype compared with Caucasian subjects.[14,19,20] Though this suggests a population characteristic, other populations cannot be assessed because of lack of studies.
- There is disagreement regarding whether tooth shape predicts gingival phenotype and the role of labial plate thickness on periodontal phenotype.[12,13,18,21–26]

Clinical question 1: Sub-question 2: What is the influence of the gingival phenotype (thin versus thick) on gingival health?

Evidence evaluated

A total of 11 studies[10,12–14,17,21,32–36] met the inclusion criteria and provided data to address this question. One study had a prospective cohort design; the other studies had a cross-sectional design.

Evidence-based conclusions

Current evidence supports the following:

- Pocket depth was greater in subjects with thick gingival phenotype.[34]
- There is disagreement regarding the association of bleeding on probing (BOP) and thin gingival tissue.[17,33,34]
- Subjects with thin tissue and narrow gingival width tend to have a higher incidence of gingival recession.[12,14,17,35,36] Periodontal health can be maintained in sites exhibiting a thin gingival phenotype, provided good oral hygiene is performed and iatrogenic factors are absent.

Clinical question 1: Sub-question 3: Does the modification of gingiva from a thin to a thick phenotype in sites without mucogingival defects contribute to maintaining periodontal health?

Evidence evaluated

Reviewers were not able to find any relevant articles that met the inclusion criteria to address this question. Studies focusing on treatment of existing gingival recession or mucogingival defects were excluded because the goal of this question was to assess whether modification of thin to thick gingival phenotype in sites without mucogingival involvement offers clinical value for maintaining periodontal health.

Evidence-based conclusions

Reviewers were not able to find any relevant articles that met the inclusion criteria for this question.

Expert opinion on thick versus thin gingival phenotypes and their influence on a patient's gingival health

The expert panel acknowledges the difficulty in drawing specific conclusions from the data in the systematic reviews it considered.

The panel further recognizes that there are certain areas for which there is limited evidence. As a result, the panel spent considerable time in discussion to arrive at a consensus on the current status of gingival phenotype and its influence on gingival health, as well as to make recommendations for

future research. The following sections summarize the consensus of the panel of experts.

Potential benefits of PhMT on gingival health

- Biotype defines a specific genetic trait, whereas phenotype is a multifactorial combination of genetic traits and environmental factors. Gingival phenotype is site specific, contains components (GT, KTW, and bone morphotype) that may change over time depending on environmental factors, and can be modified by PhMT. These modifications can create a more favorable environment for the prevention of disease and the maintenance of periodontal health.
- There are variations in gingival phenotype among individuals, patterns of bilateral symmetry within individuals, and variation by tooth location. It is misleading to refer to individual cases as thick versus thin. Rather, each individual area should be assessed based on genetic and environmental factors. Therapeutic intervention should be based on the proposed treatment and the need for PhMT in that individual area.
- Patients with thin gingiva (<1 mm, measured from within the coronal one-third of the periodontal soft tissue) are more prone to future gingival recession.
- In patients with a thin gingival phenotype, PhMT may contribute to the maintenance of periodontal tissue health and stability, especially in some Asian populations.[14,19,20] More studies are needed to characterize population characteristics.
- Any amount of gingiva is enough to maintain periodontal health in the presence of optimal oral hygiene. However, whether the thickness and width of keratinized gingiva (KG) impact health in the absence of adequate oral hygiene remains to be determined.
- Sites with mucogingival defects and soft tissue thickness < 1 mm would benefit from PhMT intervention and may require a secondary procedure to achieve optimal outcomes.
- Sites exhibiting soft tissue thickness ≥ 1 mm, measured from within the coronal one-third of the periodontal soft tissue, are associated with more predictable mucogingival surgery outcomes, as compared with sites presenting thinner tissue.

Limitations of PhMT on gingival health

The body of evidence supporting the statements above emanates mostly from cross-sectional studies with limited outcome analysis.

Potential risks of PhMT on gingival health

The expert panel did not enumerate any risks other than those normally encountered with surgical procedures, which may include postoperative bleeding, infection, and poor healing.

Future research recommendations

Further research is needed:

- To refine existing and develop new methods for measuring GT. Ideally, GT measuring techniques should be easily performable and standardized.
- To identify indications for and optimal timing and GT for interceptive PhMT.
- To identify populations and sites exhibiting specific anatomical features that would benefit from interceptive PhMT.

FOCUSED CLINICAL QUESTION 2

What is the effect of surgically modifying soft tissue phenotype around fixed dental prostheses?

Several studies[37–39] have examined the differences in the soft tissue complex between a natural tooth and an implant. Adjacent to the implant, oral epithelium has similar keratinization characteristics which merge into non-keratinized peri-implant sulcular epithelium (PISE).[40] Similar to the structure around a tooth, a peri-implant supracrestal tissue attachment (old term: biological width)[1] consists of junctional epithelium (JE) and connective tissue adhesion apical to PISE.[40] However, when looking at the connective tissue component, the fibers that insert in cementum in a perpendicular orientation are absent around implants. Instead, these connective tissue fibers run in parallel and circumferential directions to the implant. The inner zone of this connective tissue compartment contains fewer fibroblasts and blood vessels and is densely packed with collagen fibers. Because there are no Sharpey's fibers and cementum around dental implants, this weak coronal seal renders implants more susceptible to pathogenic challenge and tissue inflammation.[41] Therefore, a wide KTW and a thick peri-implant soft tissue phenotype may be more crucial to promote peri-implant tissue health[42,43] than the conditions around a natural tooth.[44] In addition, decades of clinical experience indicate that surgical modification of a thin-to-thick soft tissue phenotype around tooth-supported restorations is a best practice for preventing gingival recession and future loss of attachment. However, there is a lack of published data regarding the clinical benefits of this conversion.

The systematic review for focused question 2 concluded that surgical modification of peri-implant soft tissue phe-

notype from thin to thick may decrease the occurrence of mucosal recession around implants.

Evidence search strategy

Electronic and hand searches yielded 1831 entries. After screening titles and abstracts, 32 articles were selected for full-text evaluation. Twenty-six articles were further excluded from the qualitative and quantitative analyses. After full-text review, no literature regarding tooth-supported prostheses was identified. For implant-supported prostheses, six articles[45–50] were included for qualitative/quantitative analyses.

Evidence-based conclusions

Current evidence supports the following:

- Surgical modification of peri-implant soft tissue phenotype from thin to thick may decrease the amount of mucosal recession around implants.[49,50]
- An average gain of tissue thickness of ≈≥1 mm can be expected after soft tissue grafting procedures using autogenous connective tissue grafts.[47,50]
- Thin buccal peri-implant soft tissues are associated with an increased risk of future mucosal recession.[49,50]
- Increasing the width of keratinized mucosa using autogenous grafts may improve bleeding indices and prevent interproximal marginal bone loss around dental implants.[43]

Expert opinion on the effect of PhMT around fixed dental prostheses

The expert panel acknowledged the difficulty in drawing specific conclusions from the data in the systematic reviews it considered.

The panel recognized that there are certain areas for which there is limited evidence. As a result, the panel spent considerable time in discussion to arrive at a consensus on the effect of surgically modifying the soft tissue phenotype around fixed dental prostheses as well as to make recommendations for future research. The following sections summarize the consensus of the panel of experts.

Potential benefits of PhMT around fixed dental prostheses

- Thick tissue phenotype has been associated with more favorable outcomes following corrective periodontal procedures, such as root coverage.
- Soft tissue PhMT to increase thickness can improve:

Esthetics

- Predictably increases soft tissue thickness by 1 mm which decreases show-through of restorations, abutments, and/or implants.[47,50]
- Corrects ridge deficiencies to provide a more harmonious soft tissue architecture with adjacent teeth and prosthesis.[51–54]
- Is often helpful in pontic sites to create a thicker tissue that can be contoured for improved esthetics.[55]

Hygiene and maintenance

- Provides soft tissue volume to develop more esthetic restoration contours and decreases the potential need for restorations with ridge-lap design.[51–54]
- When placing implant-supported restorations with a subgingival margin or a restoration that limits access to peri-implant tissues, soft tissue PhMT to increase KTW may improve patient comfort and oral hygiene compliance.[42,43]

Comfort

- Implant sites with a narrow band of KTW exhibited higher levels of brushing discomfort.[56,57]

Function

- Patients with implant-supported maxillary prostheses should be evaluated in a long-term provisional to assess esthetics and speech. Patients with a thin tissue phenotype may benefit from PhMT in order to create displaceable tissue, allowing better pontic adaptation, less air leakage, improved speech, and less food impaction.[58]

Limitations of PhMT around fixed dental prostheses

- Literature has focused on buccal or lingual soft tissue, but not interproximal.
- There is a lack of data on long-term (>5 years) stability after PhMT.
- There is a lack of studies on midfacial bone levels after PhMT.

Potential risks of PhMT around fixed dental prostheses

The expert panel did not identify any risks regarding surgical modification of soft tissue phenotype around fixed dental prostheses other than those normally encountered with surgical procedures which may include postoperative bleeding, infection, and poor healing.

Future research recommendations

- Clinical trials are needed to further explore the effect of soft tissue phenotype modification around tooth-supported fixed dental prostheses.
- Studies that focus on interproximal tissue are needed.
- Although broadly adopted in clinical practice, additional high-level studies are needed to determine whether thickening the peri-implant soft tissue positively influences periodontal and peri-implant health and esthetic parameters.
- More research is needed on mid-facial bone levels after PhMT.
- Studies are needed to determine long-term performance (>5 years) of soft tissue substitutes in PhMT in both thickness and KTW when compared to the outcomes using autogenous soft tissue grafts.

FOCUSED CLINICAL QUESTION 3

Is periodontal phenotype modification therapy beneficial for patients receiving orthodontic treatment?

Adult orthodontics has become a popular dental therapy, yet both patients and dental professionals are not fully aware of the potential risk for periodontal complications. It has been documented that about 20% to 25% of patients may develop facial gingival recession 2 to 5 years after orthodontic treatment.[59]

Recent publications[1,5,60,61] indicate a higher incidence of bony dehiscence and gingival recession in teeth exhibiting a thin periodontal phenotype and in teeth exposed to orthodontic forces intended to move the dentition outside of the alveolar housing, such as arch expansion. The systematic review for focused clinical question 3 concluded that periodontal PhMT via corticotomy-assisted orthodontic therapy (CAOT) combined with simultaneous bone augmentation (also termed periodontally accelerated osteogenic orthodontics, surgically facilitated orthodontic therapy, and Wilckodontics) may provide clinical benefits to patients undergoing orthodontic treatment. The benefits of soft tissue augmentation alone during orthodontic treatment cannot be assessed based on current evidence because of the limited number of studies available on this topic.

Evidence search strategy

There is a limited number of published high-quality studies that address this focused question. A total of eight studies[62–69] were included, two RCTs[62,63] and six retrospective studies (three cohort studies).[64–69] Six studies[62–67] investigated bone grafting with CAOT and two studies[68,69] performed free gingival grafts prior to orthodontic treatment. Most of the studies of interest were limited to mandibular anterior teeth.[62,63,65–67]

Evidence-based conclusions

Within the limitations of the studies included in this review, evidence supports the following:

- PhMT can be safely performed in the course of active orthodontic treatment via particulate bone grafting with interradicular corticotomy.[62–67]
- The use of CAOT in PhMT can accelerate tooth movement and may reduce total treatment time.[66,67]
- PhMT can contribute to maintain or increase the thickness of facial bone in order to withstand orthodontic tooth movement, especially in cases of mandibular decompensation.[64,67]
- PhMT can potentially expand the limits of tooth movement, especially mandibular incisors.[66,67]
- PhMT with CAOT may maintain or slightly increase the width of keratinized tissue.[66]

Expert opinion on the benefit of PhMT for patients receiving orthodontic treatment

The expert panel acknowledges the difficulty in drawing specific conclusions from the data in the systematic reviews it considered.

The panel further recognizes that there are certain areas for which there is limited evidence. As a result, the panel spent considerable time in discussion to arrive at a consensus on the benefits of periodontal PhMT for patients receiving orthodontic treatment, as well as to make recommendations for future research. The following sections summarize the consensus of the panel of experts.

Potential benefits of PhMT for patients receiving orthodontic treatment

Benefits include:

- Enhanced periodontal health through dentoalveolar augmentation along with increased GT and KT width to prevent future gingival recession/attachment loss associated with orthodontic tooth movement.
- Increased stability of orthodontic outcomes.
- Reduced periodontal complications, especially gingival recession/attachment loss, in some orthodontic patients.
- Shortened orthodontic treatment time.
- Increased achievement of more optimal periodontal and orthodontic outcomes.
- Expanded opportunities and increased boundaries for treating dentofacial malocclusions.

- Possible reduced need for extraction therapy in cases with crowding of Class II malocclusion requiring orthognathic surgery.
- Reduced need for orthodontic camouflage and/or compromise during decompensation. Orthodontic camouflage is an alternative for the treatment of mild to moderate skeletal discrepancies. The therapeutic objective is to correct the malocclusion while trying to disguise the skeletal problem.
- Potential increase in oral cavity volume by optimizing dentoalveolar bone volume and orthodontic boundaries to allow for increased limits for arch expansion.

Limitations of PhMT for patients receiving orthodontic treatment

Limitations include:

- Acceptance by dental community and patent population because of potential additional adverse effects and cost of periodontal procedures.
- Increased complexity in interdisciplinary case management and oversight required for successful outcome.
- Increased cost, treatment time, and the possibility of requiring multiple surgical interventions. This is especially true in sites exhibiting extremely thin soft tissue thickness whereby soft tissue augmentation is needed as a preliminary procedure prior to the secondary corticotomy-bone augmentative procedure. This increases the treatment time, cost, and surgical procedures required.
- Despite successful outcomes, malocclusion because of skeletal discrepancies may, at times, require orthognathic surgery to be performed after PhMT to achieve optimal end results.

Potential risks of PhMT for patients receiving orthodontic treatment

Potential risks include:

- Root damage
- Pulpal devitalization
- Minor papillary recession may occur
- Infection associated with dentoalveolar surgery

Future research recommendations

More studies are needed to determine:

- The long-term outcome of PhMT on tissue health, stability, and tooth survival after orthodontic treatment.
- Which type of bone grafting material produces the most predictable clinical outcomes.
- How to reduce the degree of orthodontic relapse for mandibular anterior teeth after orthodontic treatment.
- The effect of PhMT through soft tissue grafting techniques, materials, and procedures on orthodontic treatment outcomes.
- When soft tissue PhMT or other soft tissue surgery is needed prior to bone PhMT to optimize the augmentation outcome.
- What monotherapeutic versus combination therapies can effectively permit orthodontic movement of teeth with thin gingival phenotype with the least amount of morbidity.
- Optimal timing and treatment protocols.

CONSENSUS CONCLUSIONS

- Subjects with thin tissue and narrow gingival width are more prone to recession. This risk is increased with orthodontic therapy and may be clinically apparent over time post-treatment.
- Bone PhMT should be pursued prior to orthodontic treatment in patients with thin phenotype when the necessary orthodontic tooth movement will compromise the bony housing. Similarly, soft tissue PhMT may be needed to perform CAOT or in conjunction with bone grafting. There will be situations in which both bone and soft tissue augmentation are necessary.
- The decision to perform the appropriate PhMT may require advanced imaging technology for comprehensive examination and interdisciplinary care defined by the orthodontist in terms of the extent of necessary orthodontic tooth movement and the periodontist in terms of tissue augmentation necessary for long-term gingival stability.
- Patients with thin gingival tissue and mucogingival defects may benefit from PhMT intervention and may require a secondary procedure to achieve optimal outcomes.
- Surgical modification of peri-implant soft tissue phenotype from thin to thick may slightly decrease the amount of mucosal recession around implants.
- Certain populations may be higher risk for needing PhMT, such as in some Asian populations. This is an area that needs validation.
- PhMT in orthodontic patients may enhance periodontal health and reduce complications, increase stability, and shorten orthodontic treatment time.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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APPENDIX 1: ACRONYMS USED IN THE CONSENSUS STATEMENT

AD	anatomic dimensions
BM	bone morphotype (thickness of the bony plate)
BOP	bleeding on probing
CAOT	corticotomy-assisted orthodontic therapy
FGG	free gingival graft
GBR	guided bone regeneration
GT	gingival thickness
JE	junctional epithelium
KT	keratinized tissue
KTW	keratinized tissue width
PAOO	periodontally accelerated osteogenic orthodontics (same as CAOO + PhMT, SFOT, and Wilckodontics™)
PhMT	phenotype modification therapy
PISE	peri-implant sulcular epithelium
RCTs	randomized controlled trials
SCTG	subepithelial connective tissue graft
SFOT	surgically facilitated orthodontic therapy (same as CAOO + PhMT, PAOO, and Wilckodontics™)
SxD	surgically determined