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CONSENSUS REPORT

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Importance of keratinized mucosa around dental implants: Consensus report of group 1 of the DGI/SEPA/Osteology Workshop

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Abstract

Objectives: To assess the literature on (i) the relevance of the presence of a minimum dimension of keratinized peri-implant mucosa (KPIM) to maintain the health and stability of peri-implant tissues, and; (ii) the surgical interventions and grafting materials used for augmenting the dimensions of the KPIM when there is a minimal amount or absence of it.

Material & Methods: Two systematic reviews complemented by expert opinion from workshop group participants served as the basis of the consensus statements, implications for clinical practice and future research, and were approved in plenary session by all workshop participants.

Results: Thirty-four consensus statements, eight implications for clinical practice, and 13 implications for future research were discussed and agreed upon. There is no consistent data on the incidence of peri-implant mucositis relative to the presence or absence of KPIM. However, reduced KPIM width is associated with increased biofilm accumulation, soft-tissue inflammation, greater patient discomfort, mucosal

recession, marginal bone loss and an increased prevalence of peri-implantitis. Free gingival autogenous grafts were considered the standard of care surgical intervention to effectively increase the width of KPIM. However, substitutes of xenogeneic origin may be an alternative to autogenous tissues, since similar results when compared to connective tissue grafts were reported.

Conclusion: Presence of a minimum width of KPIM should be assessed routinely in patients with implant supported restorations, and when associated with pathological changes in the peri-implant mucosa, its dimensions may be surgically increased using autogenous grafts or soft-tissue substitutes with evidence of proven efficacy.

KEYWORDS
autogenous grafts, connective tissue attachment, dental implants, keratinized mucosa, oral epithelium, soft-tissue substitutes, xenogeneic grafts

1 | INTRODUCTION

Peri-implant mucosa (PIM) refers to the soft tissue that surrounds dental implants. The PIM is established during the early stages of wound healing following implant surgery or abutment connection and serves as a seal that prevents the downgrowth of the biofilm and other macro molecules from the oral cavity. The PIM is composed of an epithelial compartment, in which most of the time the outer surface consists of a keratinized oral epithelium that extends apically to the mucosal junction, where it continues as alveolar mucosa. However, the epithelium around an implant may also be non-keratinized lining mucosa. Coronally, it connects at the mucosal margin with a thin sulcular epithelium that faces the abutment part of the implant, forming a barrier epithelium. This barrier epithelium extends apically and adheres to the abutment/implant surface via hemidesmosomes. The connective tissue compartment forms the implant surface–tissue interface separating the bone from the epithelial compartment, and it is mainly composed of fibroblasts and collagen fibres that extend between the periosteum to the mucosal margin in directions parallel to the surface of the implant/abutment (Araujo & Lindhe, 2018).

This connective tissue component is consistently reported with a dimension of about 1.5 mm. However, the barrier epithelium component may vary, depending on the thickness of the mucosa, between 2–3 mm. While the structure and dimensions of the PIM are well established and the stability of the soft-tissue attachment around implants has been associated with the maintenance of stable marginal bone levels, the clinical significance of the width of keratinized tissue and its attachment to the underlying bone is still a matter of controversy.

Therefore, the purpose of this consensus report was to evaluate the scientific evidence from two systematic reviews elaborated for the present workshop (Montero et al., 2022; Ramanauskaite et al., 2022), complemented by expert opinion from the participants, regarding the clinical relevance of the presence of a minimum dimension of keratinized peri-implant mucosa (KPIM) to maintain the health and stability of peri-implant tissues. Furthermore, this report has evaluated the main surgical interventions and grafting materials used for augmenting the dimensions of the KPIM in situations where there is a minimal amount or absence of KPIM.

2 | SYSTEMATIC REVIEW 1: INFLUENCE OF KERATINIZED TISSUE ON PERI-IMPLANT TISSUE HEALTH OR DISEASE

This systematic review aimed to evaluate the influence of the width of keratinized tissue (KT) in the PIM on the prevalence of peri-implant diseases and on the stability of the peri-implant soft and hard tissues (Ramanauskaite et al., 2022). Clinical studies including ≥10 patients with dental implants in function for at least 6 months, reporting on the prevalence of peri-implant diseases (primary outcome), plaque index (PI), modified plaque index (mPI), bleeding index (mBI), bleeding on probing (BOP), probing depths (PD), mucosal recession (MR), and marginal bone loss (MBL) and/or patient-reported outcomes measures (PROMs), (secondary outcomes), published until September 2020 were searched. An additional search for relevant articles published between October 2020 and January 31, 2022, was performed.

2.1 | PECO question/Outcomes

In patients with dental implants (Population), what is the influence of a reduced width of KT in the peri-implant mucosa (i.e. KT < 2 mm) (Exposure) compared to peri-implant sites with a width of KT ≥ 2 mm (Comparison), on the prevalence of peri-implant diseases (Outcome), and on the stability of peri-implant soft-and hard-tissues, as reported in cross-sectional, case–control, cohort, controlled clinical trials (CCTs) and randomized clinical trials (RCTs),

Population: Patients with dental implants.

Exposure: Presence of peri-implant mucosa KT < 2 mm.

Comparison: Presence of peri-implant mucosa KT ≥ 2 mm.

Outcomes: primary outcome: Occurrence of peri-implant mucositis and/or peri-implantitis based on case definitions used in respective studies.

As secondary outcomes: PI, PD, BOP/BI, MBL changes, and PROMs.

2.2 | Results

Twenty-two articles describing 21 studies (15 cross-sectional, five longitudinal comparative studies, and one case series with pre–post design) with an overall high to low risk of bias were included. Peri-implant mucositis affected 20.8% to 42% of implants and peri-implantitis affected 10.5% to 44% of implants with a reduced amount (<2 mm) or absence of KT. The corresponding values for implant sites with KT width ≥2 or >0 mm were 20.5% to 53% for peri-implant mucositis and 5.1% to 8% for peri-implantitis. Significant differences between implants with KT <2 mm and those with KT ≥ 2 mm were revealed for weighted mean differences (WMD) for BOP, mBI, PI, MBL, and MR all favouring implants with KT ≥2 mm.

An updated literature search, following acceptance of the systematic review and prior to the consensus meeting, yielded 2 cross-sectional studies with an overall low risk of bias, of which one reported on a significantly higher prevalence of peri-implant mucositis and peri-implantitis at implants with KM < 2 mm when compared with control sites exhibiting KT ≥2 mm (46.6% vs. 34.1%, and 42.1% vs. 17%, respectively).

2.3 | Conclusions

Reduced KT width is associated with an increased prevalence of peri-implantitis, biofilm accumulation, soft-tissue inflammation, mucosal recession, marginal bone loss, and greater patient discomfort.

3 | CONSENSUS REPORT

3.1 | How should the width of PIKM be measured in the clinic?

Based on the studies investigated ($n = 17$ studies), PIKM width was commonly measured at the mid-buccal aspect of the implant site by means of a periodontal probe. Assessments were conducted from the peri-implant mucosal margin to the mucosal junction. Only a few studies ($n = 4$) addressed the KT width at the lingual aspect employing the same reference points.

In daily clinical practice, measurements of KT width should be assessed using a millimetre scaled periodontal probe at buccal and lingual aspects. If identification of the peri-implant mucosal margin is hampered by the prosthesis, removal of the prosthesis may be considered.

3.2 | How often should the PIKM measurements be performed?

Measurements of PIKM should be made routinely during the patient's follow-up since changes might be expected over time.

3.3 | What is the minimum width of peri-implant keratinized tissue suggested to reduce the risk of peri-implant diseases?

To define inadequate PIKM, the studies from this systematic review have used different threshold values ranging from 0 mm ($n = 4$ studies) to 1 mm ($n = 1$ study) and 2 mm ($n = 18$ studies). Based on the meta-analyses, the presence of KT < 2 mm was associated with a higher frequency of clinical signs of inflammation and marginal bone loss as opposed to sites exhibiting a KT ≥ 2 mm. However, the incidence of peri-implant mucosal inflammation does not seem to be markedly influenced by wider bands of KT (i.e. 2 up to 11 mm) (Schwarz et al., 2018).

3.4 | Is inadequate PIKM associated with increased mucosal inflammation?

Peri-implant mucosal inflammation appears to be increased when the KT width is <2 mm. However, these results are inconclusive due to variations in the reported indices (BOP, mBI, suppuration).

3.5 | Is inadequate PIKM associated with an increased incidence and prevalence of peri implant mucositis?

There is no data on the incidence of peri-implant mucositis relative to the presence or absence of KT. The prevalence of peri-implant mucositis ($n = 5$ studies) ranged between 20.8% to 46.6% at implants exhibiting a reduced KT width (defined as absence of KT or presence of KT <2 mm), and between 20.5% to 53% at implants in the control group (defined as presence of KT or presence of KT ≥ 2 mm). Due to heterogeneity in methodologies (i.e. different threshold values and case definitions), the available evidence remains inconclusive regarding the role of KT on the occurrence of peri-implant mucositis.

3.6 | Is inadequate PIKM associated with increased incidence and prevalence of peri-implantitis?

There are no data reporting on the incidence of peri-implantitis relative to the presence or absence of KT. The prevalence of peri-implantitis in the studies (using different case definitions) evaluated in the systematic review ($n = 5$ studies) ranged between 10.5% to 44% at implants with a reduced width of KT (defined as absence

of KT or presence of KT < 2 mm), while a lower prevalence of peri-implantitis (5.1% to 17% of the implants) was reported in the control group (defined as presence of KT or presence of KT ≥ 2 mm).

3.7 | Is inadequate PIKM associated with higher plaque scores?

Plaque scores were significantly higher at implants exhibiting a KT width of <2 mm, as shown by longitudinal ($n = 3$) and cross-sectional ($n = 6$) studies.

3.8 | Is inadequate PIKM associated with increased probing depths?

The reduced width of KT (i.e. <2 mm) was not associated with differences in PDs, as shown by longitudinal ($n = 3$) and cross-sectional ($n = 10$) studies.

3.9 | Is inadequate PIKM associated with increased mucosal recession?

During a follow-up period of 4–5 years, longitudinal studies ($n = 2$) revealed no differences between groups regarding the extent of mucosal recession. Cross-sectional studies ($n = 6$) showed a significant association between the presence of KT <2 mm and increased mucosal recession.

3.10 | Is inadequate PIKM associated with the level of the marginal bone?

A KT width of <2 mm was shown to be significantly associated with bone loss, based on longitudinal ($n = 2$) and reduced MBL in cross-sectional studies ($n = 6$).

3.11 | Is inadequate PIKM associated with increased mobility of the peri-implant mucosa?

The studies included in this systematic review have measured KT width rather than the presence of mucosal attachment. However, there is some evidence that associates KT > 2 mm with absence of mucosal mobility (Monje et al., 2019).

3.12 | Is inadequate PIKM associated with increased pain and brushing discomfort?

The level of brushing discomfort and pain appears to be higher at implants lacking KT or presenting a KT width of <2 mm ($n = 4$ studies). This was particularly noted in the posterior regions of the mandible in one study.

3.13 | Is inadequate PIKM associated with patient's oral health-related quality of life?

There is no evidence associating reduced KT and patient's oral health-related quality of life ($n = 5$ studies).

3.14 | What is the association between vestibular depth and KT width?

Evidence from one cross-sectional study suggested a positive association between a deep vestibulum of >4 mm and an increased width of KT.

3.15 | Is the lingual band of KT equally relevant as the buccal band in reducing the risk for peri-implant diseases?

None of the included studies specifically addressed the relevance of lingual KT on the occurrence of peri-implant diseases. However, based on expert opinion there, is a suggestion that the presence of a band of KT on the lingual aspect is of equal clinical relevance.

3.16 | Does the location of the implant correlate to the amount of keratinized tissue and occurrence of peri-implant diseases?

Evidence from the systematic review did not reveal any information on the implant location and preservation of peri-implant health. However, one cross-sectional study (Monje et al., 2019) suggested that posterior areas (i.e. molars and premolars) in the mandible lacking KT were more frequently associated with peri-implantitis compared to anterior sites.

3.17 | Implications for clinical practice

- Presence of keratinized tissue should be an important consideration during the surgical therapy of dental implants. Particular attention should be placed on the establishment of a proper peri-implant mucosal seal.
- Presence of keratinized tissue and attached mucosa should be assessed once the tissue remodelling around dental implants is completed.
- Evaluation of the width of PIKM should be part of the regular oral examination of peri-implant hard and soft tissues.
- Maintenance care should be intensified at implants exhibiting an

inadequate PIKM, since those sites are more prone to plaque accumulation and subsequent peri-implant mucosal inflammation.

3.18 | Implications for future research

- Appropriate primary and secondary outcome measures defining peri-implant health and disease should be established and globally agreed.
- Precise KT threshold levels associated with peri-implant tissue stability should be established.
- The clinical relevance of PIM mobility, together with an adequate appraisal of attached versus non-attached mucosa should be established, thus allowing a clear definition of adequate or inadequate PIKM.
- The application of imaging technologies to allow for the assessment of the PIKM volume and changes during follow-up, should be considered.
- The corresponding lingual KT values should be reported in addition or separately to the buccal KT values.
- The influence of relevant factors, such as the implant location, the vestibular depth, and the type and design of the suprastructure should be investigated.

4 | SYSTEMATIC REVIEW # 2: EFFICACY OF GRAFTING TO INCREASE THE WIDTH OF PERI-IMPLANT KERATINIZED MUCOSA. AUTOLOGOUS VERSUS SOFT-TISSUE SUBSTITUTES

The aim of this systematic review was to compare the efficacy of soft-tissue substitutes compared with autogenous grafts (FGG, CTG) in surgical interventions aiming at increasing the width of the PIKM around dental implants (Montero et al., 2022). Secondarily, this systematic review aimed to assess the impact of soft-tissue substitutes on peri-implant health (i.e. PIs, BOP, PD, and MBLs) and PROMs.

4.1 | PICOS questions

PICOS #1: "In patients with dental implants (Population), what is the efficacy of surgical interventions using soft-tissue substitutes (Intervention), as compared to those using autogenous grafts (Comparison), to increase the amount of PIKM (Outcome), in randomized clinical trials (RCTs) and controlled clinical trials (CCTs) with at least 6 months of follow-up (Study design)?"

PICOS #2: "In patients with dental implants (Population), what is the effectiveness of soft-tissue substitutes (Intervention and Comparison), to increase the amount of peri-implant keratinized mucosa (Outcome), in RCTs, CCTs, prospective/retrospective cohort studies or prospective/retrospective case series, with a minimum follow-up time of 6 months (Study design)?"

4.2 | Outcomes

The primary outcome was the change in width of the peri-implant keratinized mucosa (PIKM) around dental implants, expressed in mm. Secondary outcome variables were: (i) implant and prostheses survival (%); (ii) changes in clinical and radiographic peri-implant outcomes (PIs, BOP, PD, MBLs, keratinized mucosa [KM] thickness, marginal bone levels); (iii) incidence of biological complications; (iv) surgical time; and (v) PROMs, aesthetic evaluation, and economic factors.

4.3 | Results

Eleven articles corresponding to ten investigations were selected. For the PICOS #1, five RCTs and one CCT were included, all of them with an unclear or high risk of bias. For the PICOS #2, in addition to the previous studies, three prospective case series and one retrospective case series were included. Overall mean risk of bias was 3.0 (ranging from 2.0 to 4.0) for the case series according to the Newcastle-Ottawa scale. KM augmentation was significantly greater for autogenous grafts than for soft-tissue substitutes ($n = 6$; WMD = 0.9 mm; 95% confidence interval (CI) [−1.4; −0.3]; $p < .001$). However, when only xenografts were compared with autogenous grafts no significant differences were observed ($n = 5$; WMD = -0.8 mm; 95% CI [−1.6; 0.0]; $p = .062$). Considering all studies, soft-tissue substitutes led to a statistically significant increase of KM ($n = 9$; weighted mean effect, WME = 3.0 mm; 95% CI [2.2; 3.7]; $p < .001$). If only xenografts ($n = 7$) were considered the WME was 3.5 mm (95% CI [2.4; 4.5]; $p < .001$). Surgical time and post-surgical pain seemed to be reduced using soft-tissue substitutes.

4.4 | Conclusions

Free gingival grafts (FGG) are more effective in the augmentation of PIKM than soft-tissue substitutes. However, substitutes of xenogeneic origin may be an alternative to autogenous tissues, as they provided similar results to connective tissue grafts (CTG) and were able to increase the width of KM by more than 2 mm. Furthermore, surgical time and post-operative pain were significantly reduced, and aesthetic appearance improved.

5 | CONSENSUS REPORT

5.1 | Which surgical intervention is the standard of care to increase the width of the PIKM?

Based on a previous systematic review (Thoma et al., 2014) and a consensus report (Tonetti & Jepsen, 2014), the standard of care for PIKM augmentation is a combination of apically positioned flaps/

vestibular extension procedures along with autogenous soft-tissue grafts.

5.2 | What is the efficacy of the autogenous free gingival graft to increase the width of the peri-implant mucosa?

Based on the systematic review, the range of PIKM augmentation observed after grafting with a FGG in comparative studies (RCTs and CCTs) ranged between 1.5–6.5 mm. Two comparative studies evaluating the gain of PIKM after a connective tissue graft reported a gain of 2.3–2.6 mm (Lorenzo et al., 2012; Sanz et al., 2009).

5.3 | What is the percentage of shrinkage in autogenous gingival grafts when used to augment the width of peri-implant keratinised mucosa?

Based on four studies (Sanz et al., 2009; Monje et al., 2022; Urban et al., 2015, 2019) not included in the systematic review, the percentage of shrinkage of surface area in autogenous grafs or combination of autogenous and xenogeneic grafts ranged between 42.4%–60% from baseline up to 12 months.

5.4 | What is the efficacy of the soft-tissue substitutes to increase the width of the peri-implant mucosa compared to autogenous grafts?

PIKM augmentation with autogenous grafts resulted in significantly greater width compared with soft-tissue substitutes ($n = 6$; WMD = 0.9 mm; 95%, (CI) [0.3; 1.4]; $p = .001$).

5.5 | What is the efficacy of allogenic soft-tissue substitutes to increase the width of the peri-implant mucosa compared to autogenous grafts?

One study included in the systematic review reported a significantly greater width of PIKM after grafting with autogenous grafts when compared to allogenic soft-tissue substitutes (WMD = 1.0 mm; 95% CI [0.7; 1.3]; $p < .001$).

5.6 | What is the efficacy of xenogeneic soft-tissue substitutes to increase the width of the peri-implant mucosa compared to autogenous grafts?

Based on five studies (RCTs/CCTs) PIKM augmentation with autogenous grafts resulted in no significant differences when compared to soft-tissue substitutes of xenogeneic origin (WMD = 0.8 mm; 95% CI [0.0; 1.6]; $p = .062$).

5.7 | What is the percentage of shrinkage of soft-tissue substitutes compared to autogenous grafts?

Based on five studies (RCTs/CCTs), the difference in the percentage of shrinkage (measured apico-coronally) between 1 to 6 months post-operatively after autogenous grafts compared to soft-tissue substitutes was not statistically significant (WMD = −3.7%; 95% [−10.1; 2.7]; $p = .256$). While no significant differences were observed between xenogeneic soft-tissue substitutes and autogenous grafts ($n = 4$; WMD = 0.0%; 95% CI [−6.6; 6.5]; $p = .990$), based on one study, the shrinkage of allogeneic soft-tissue substitutes was significantly higher than autogenous grafts (mean difference = −19.5%; 95% CI [−24.3; −14.7%]; $p = .009$).

5.8 | What is the difference between xenogeneic and autogenous soft-tissue grafts in terms of attaining an attached (non-mobile) PIKM?

Based on this systematic review, there is no evidence to compare attaining an attached (non-mobile) peri-implant mucosa between autogenous grafts and soft-tissue substitutes. Based on expert opinion, the attainment of an attached (non-mobile) peri-implant mucosa should be an objective of these surgical interventions.

5.9 | What is the difference between xenogeneic and autogenous soft-tissue grafts in terms of increasing the vestibular depth?

Based on this systematic review, there is no evidence on the effect of autogenous grafts versus soft-tissue substitutes in terms of increasing the vestibular depth. Based on an expert opinion, in situations with lack of PIKM and a shallow vestibule, deepening the vestibule should be considered in combination with autogenous grafting.

5.10 | What is the difference between xenogeneic and autogenous soft-tissue grafts in terms of patient's morbidity?

Based on five studies, soft-tissue substitutes led to significantly lower post-operative pain (visual analogue scales) than autogenous grafts. Furthermore, two studies reported a lower consumption of analgesics after the use of soft-tissue substitutes compared to autogenous grafts.

5.11 | What is the difference between xenogeneic and autogenous soft-tissue grafts in terms of patient's preferences?

Based on this systematic review, there is no evidence relating to patient's preferences. Three studies professionally evaluating the

aesthetic appearance provided better results for soft-tissue substitutes when compared to FGG, while no differences were observed with CTG.

5.12 | What is the difference between xenogeneic and autogenous soft-tissue grafts in terms of surgical time?

Based on two studies, surgical time was significantly lower for soft-tissue substitutes when compared to autogenous grafts (WMD = 18.5 min; 95% CI [10.3; 26.8]; $p \leq .001$). The range of surgical time for soft-tissue substitutes was 20–87 min while for autogenous grafts it was 40–87 min.

5.13 | Are there any graft-less surgical interventions that can provide an increase in keratinized peri-implant mucosa?

Different surgical interventions as the apically positioned flap and the vestibule extension procedure have been indicated for increasing the amount of PIKM, but there is no evidence of predictable results. A previous systematic review (Thoma et al., 2014), including comparative studies between these surgical interventions and the addition of a graft resulted in significantly wider band of PIKM with the addition of an autogenous graft or a xenogeneic soft-tissue substitute.

5.14 | Is the surgical procedure to use an autogenous graft more difficult than using a soft-tissue substitute?

Based on expert opinion, the avoidance of harvesting an autogenous graft would imply an easier surgical intervention; however, the handling of the substitute and its suturing may be more cumbersome and technique sensitive.

5.15 | Do we need a minimum amount of KT to augment PIKM using soft-tissue substitutes?

Based on expert opinion, a minimum amount of keratinized tissue with the ability to induce keratinization is needed for cell migration into the matrix. This keratinization may be induced from the marginal borders of the surgical bed.

5.16 | What is the difference in surgical complications associated with autogenous grafting versus soft-tissue substitutes?

Surgical complications related to the donor site and healing complications in the grafted site (loss of the graft/ soft-tissue substitute, etc.) have been reported. Evidence from four studies in the systematic review comparing autogenous graft with soft-tissue substitutes did not report a significantly higher probability of surgical complications (e.g. loss of the graft, paraesthesia, etc.)

5.17 | What is the performance of soft-tissue substitutes to augment the PIKM?

Evidence from the systematic review evaluating pre-post results from nine studies, reported a weighted mean gain of 3.0 mm (95% CI [2.3; 3.8]) when assessing all soft-tissue substitutes. From seven studies, the xenogeneic soft-tissue substitutes reported a weighted mean gain of 3.5 mm (95% CI [2.5; 4.6]) while the two studies assessing allogeneic soft-tissue substitutes reported a weighted mean gain of 1.6 mm (95% CI [1.4; 1.7]). Five studies using soft-tissue substitutes have reported 16.5% (95% CI [8.4; 24.6]) shrinkage between one to 6 months, while two studies reported 52.5% (95% CI [37.2; 67.8]) shrinkage between baseline and 12 months, which implies that most of the shrinkage occurred during the first month.

5.18 | What is the performance of combining autogenous grafts and soft-tissue substitutes to augment the PIKM?

There is no evidence on the outcome of combining autogenous grafts and soft-tissue substitutes from studies included in this systematic review. However, two case series evaluating the combination of autogenous grafts (strip gingival grafts) and soft-tissue substitutes (collagen matrices) have shown enhanced amounts of PIKM (mean differences from baseline to 12 months ranging from 6–7 mm) (Urban et al., 2015, 2019).

5.19 | Implications for clinical practice

- When there is <2 mm of PIKM a surgical intervention to augment the width of keratinized tissue could be considered, especially when there is recurrent inflammation of the peri-implant mucosa, pain or disturbance on brushing, increased recession of the peri-implant mucosa, lack of attached mucosa or a shallow vestibular depth.
- Although the apically positioned flap in combination with an autogenous graft is the standard of care intervention to increase the width of PIKM, the decision to select the type of grafting material should be based on a variety of factors, such as the residual amount of PIKM, the extension of the surgical area and the ability of apically repositioning the flap, the aesthetic demand, the patient's preferences, the operator surgical skills and limitations from the donor area.
- Autogenous grafting should be favoured in sites with complete absence of keratinized tissue.

- Soft-tissue substitutes could be considered in patients with limitations in the donor area, or when a limited amount of KT is needed. The initial size of the graft should account for the expected shrinkage rates.

5.20 | Implications for future research

- New knowledge in wound healing and neo-vascularization, with development of effective soft-tissue constructs without the need of harvesting autogenous grafts
- New knowledge in wound healing and neo-vascularization, with development of biologically active molecules that improve our current surgical techniques
- Development of new soft-tissue substitutes, easy to handle surgically, volume stable, easily integrated with the adjacent tissues and resulting in minimal shrinkage
- Development of new soft-tissue substitutes able to promote not only keratinization, but also increasing the soft-tissue volume of the PIKM
- Evaluating the efficacy of combining autogenous and soft-tissue substitutes, specifically in indications requiring wide areas of PIKM augmentation
- Evaluating the efficacy of soft-tissue grafting on the outcome of the surgical management of periimplantitis.
- Evaluating the efficacy of improved oral hygiene methods and modification of the prosthetic profiles on the outcome of peri-implant soft-tissue health in areas with deficient amount of PIKM.

AUTHOR CONTRIBUTIONS

Mariano Sanz: Conceptualization (equal); writing – original draft (equal). **Frank Schwarz:** Conceptualization (equal); writing – original draft (equal). **David Herrera:** Conceptualization (equal); writing – original draft (equal). **Pamela McClain:** Conceptualization (equal); writing – original draft (equal). **Elena Figuero:** Conceptualization (equal); writing – original draft (equal). **Ana Molina:** Conceptualization (equal); writing – original draft (equal). **Alberto Monje:** Conceptualization (equal); writing – original draft (equal). **Eduardo Montero:** Conceptualization (equal); writing – original draft (equal). **Andrés Pascual:** Conceptualization (equal); writing – original draft (equal). **Ausra Ramanauskaite:** Conceptualization (equal); writing – original draft (equal). **Franck Renouard:** Conceptualization (equal); writing – original draft (equal). **Robert Sader:** Conceptualization (equal); writing – original draft (equal). **Eik Schiegnitz:** Conceptualization (equal); writing – original draft (equal). **Itsvan Urban:** Conceptualization (equal); writing – original draft (equal). **Ana Molina:** Conceptualization (equal); writing – original draft (equal).

CONFLICT OF INTEREST

Workshop participants filed detailed disclosure of potential conflict of interest relevant to the workshop topics, and these are kept on file. Declared potential dual commitments included having received research funding, consultant fees and speaker fee from the industries with economic interests in the interventions dealt in this workshop.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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REFERENCES

Araujo, M. G., & Lindhe, J. (2018). Peri-implant health. *Journal of Clinical Periodontology*, *45*(Suppl 20), S230–S236.

Lorenzo, R., García, V., Orsini, M., Martin, C., & Sanz, M. (2012). Clinical efficacy of a xenogeneic collagen matrix in augmenting keratinized mucosa around implants: A randomized controlled prospective clinical trial. *Clinical Oral Implant Research*, *23*, 316–324.

Monje, A., Pons, R., Insua, A., Nart, J., Wang, H. L., & Schwarz, F. (2019). Morphology and severity of peri-implantitis bone defects. *Clinical Implant Dentistry Related Research*, *21*(4), 635–643. https://doi.org/10.1111/cid.12791

Monje, A., Blasi, G., Amerio, E., Sanz-Martin, I., & Nart, J. (2022). Dimensional changes in free epithelialized gingival/mucosal grafts at tooth and implant sites: A prospective cohort study. *Journal of Periodontology*, *94*, 1–10. https://doi.org/10.1002/JPER.21-0521

Montero, E., Molina, A., Matesanz, P., Monje, A., Sanz-Sanchez, I., & Herrera, D. (2022). Efficacy of soft tissue substitutes, in comparison to autogenous grafts, in surgical procedures aiming to increase the peri-implant keratinized mucosa. A systematic review. *Clinical Oral Implants Resesarch*, *33*(S23).

Ramanauskaite, A., Schwarz, F., & Sader, R. (2022). Influence of width of keratinized tissue on the prevalence of peri-implant diseases: A systematic review and meta-analysis. *Clinical Oral Implants Resesarch*, *33*(S23), 8–31. https://doi.org/10.1111/clr.13766

Sanz, M., Lorenzo, R., Aranda, J. J., Martin, C., & Orsini, M. (2009). Clinical evaluation of a new collagen matrix (Mucograft® prototype) to enhance the width of keratinized tissue in patients with fixed prosthetic restorations: a randomized prospective clinical trial. *Journal Clinical Periodontology*, *36*, 868–876.

Schwarz, F., Becker, J., Civale, S., Sahin, D., Iglhaut, T., & Iglhaut, G. (2018). Influence of the width of keratinized tissue on the development and resolution of experimental peri-implant mucositis lesions in humans. *Clinical Oral Implants Resesarch*, *29*(6), 576–582. https://doi.org/10.1111/clr.13155

Thoma, D. S., Buranawat, B., Hammerle, C. H., Held, U., & Jung, R. E. (2014). Efficacy of soft tissue augmentation around dental implants and in partially edentulous areas: a systematic review. *Journal of Clinical Periodontology*, *41*(Suppl 15), S77–S91. https://doi.org/10.1111/jcpe.12220

Tonetti, M. S., & Jepsen, S. (2014). Clinical efficacy of periodontal plastic surgery procedures:Consensus Report of Group 2 of the 10th European

Workshop on Periodontology. *Journal Clinical Periodontology*, *41*(Suppl. 15), S36–S43. https://doi.org/10.1111/jcpe.12219

Urban, I. A., Lozada, J. L., Nagy, K., & Sanz, M. (2015). Treatment of severe mucogingival defects with a combination of strip gingival grafts and a xenogeneic collagen matrix: A prospective case series study. *International Journal Periodontics Restororative Dentistry*, *35*, 345–353.

Urban, I., Nagy, K., Werner, S., & Meyer, M. (2019). Evaluation of the combination of strip gingival grafts and a xenogeneic collagen matrix for the treatment of severe mucogingival defects: A human histologic study. *International Journal Periodontics Restororative Dentistry*, *39*, 9–14.

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