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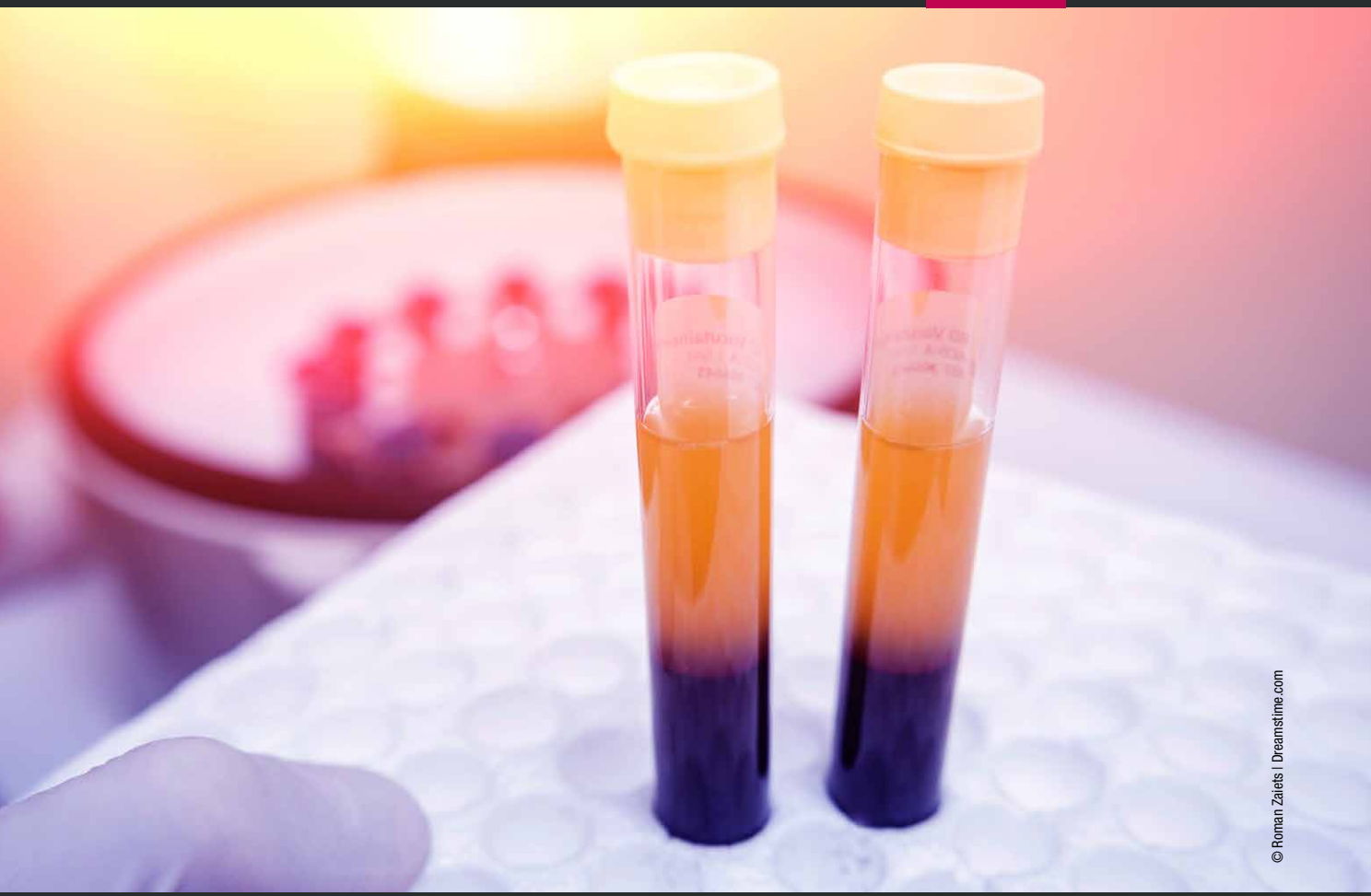

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Stick to your gums! Platelet concentrates and soft-tissue grafting

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Abstract

Gingival recession is a prevalent oral condition and can result in esthetic compromise, dentinal hypersensitivity (DH), and an increase in radicular caries rates. Thin periodontal phenotype is a common predisposing factor for gingival recession and many surgical interventions aim to both achieve root coverage and alter the periodontal phenotype through soft-tissue grafting. While many of these grafting procedures are predictable in improving soft-tissue quality and quantity around teeth and dental implants, patients often complain of discomfort at both the donor and recipient sites. Free gingival grafts (FGGs) and coronally advanced flaps (CAF) alone or in combination with subepithelial connective tissue graft (sCTG) and/or acellular dermal matrix (ADM) are among the most common surgical procedures employed to achieve root coverage and enhance periodontal phenotype. Platelet concentrates (PCs) have been used to improve the outcomes of soft-tissue grafting and postoperative morbidity. PCs contain platelets, growth factors, leukocytes, and stem cells that contribute to cell mitosis, collagen production, and angiogenesis, leading to healing and regeneration of hard and soft tissue. While data continue to emerge on the effects of PCs on the outcomes of soft-tissue grafting, there is a keen interest in the utilization of autologous products to enhance clinical outcomes. This course seeks to explore the biological and physiological properties, as well as the clinical characteristics of PCs that contribute to their role in wound healing and application to periodontal soft-tissue grafting.

Educational objectives

Upon completion of this course, the dental professional should be able to:

1. Understand the prevalence, etiology, and treatment options for gingival recession.
2. Discuss the applications of platelet concentrates for enhancing the outcomes of soft-tissue grafting procedures.
3. Select the appropriate preparation protocol to achieve good and predictable results utilizing soft-tissue grafting and platelet concentrates.
4. Evaluate the gaps in our current scientific knowledge regarding platelet concentrates and soft-tissue grafting procedures.

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Introduction

Gingival recession and its ideal treatment present concerns for patients and practitioners alike. Root exposure associated with gingival recession can cause esthetic compromise, increased rates of radicular caries, and/or dentinal hypersensitivity.[1] The incidence of gingival recession is linked to periodontal phenotype, tooth position/prominence, gingival trauma, and periodontitis.[2] Many treatment modalities exist to improve root coverage with free gingival graft (FGG), coronally advanced flap with subepithelial connective tissue graft (CAF + sCTG), and CAF with acellular dermal matrix (CAF + ADM) being the most common techniques employed.[3-5] These techniques may face patient resistance, however, due to fear of postoperative bleeding and/or other concerns centered around perioperative surgical complications. To combat these concerns and increase patient acceptance, a number of alternative surgical approaches including the use of microsurgical techniques, adjunctive growth factor, alternative graft materials, and enhanced surgical approaches have been considered.

Platelet concentrates (PCs) are derived from autogenous blood, and the biomaterials are obtained through centrifugation. These materials include first-generation PCs, including platelet-rich plasma (PRP), and second-generation PCs, including leukocyte-rich platelet-rich fibrin (L-PRF).[6] Furthermore, alterations in preparation protocols and additions of bioactive materials have led to emerging forms of platelet-rich fibrins that may have advantages in particular clinical scenarios.[6] While differences exist in the preparation and clinical properties of PCs, namely the use of coagulant in the preparation of PRP and the different handling capabilities of various PCs, all of these materials have commonalities. These patient-derived materials require venipuncture and blood draw, but allow for high levels of accessibility and patient acceptance, which has led to an increase in their use as adjuncts during soft- and hard-tissue grafting in dentistry. The centrifugation process produces materials with increased concentrations of the growth factors and cytokines that are critical to wound healing and repair. Additionally, the handling capabilities of these are based upon their biological scaffolds that may stabilize and allow release of these blood-derived biomarkers including: platelet-derived growth factor (PDGF), transforming growth factor-β (TGF-β), bone morphogenetic protein-2 (BMP-2), vascular endothelial growth factor (VEGF), and others.[7,8] The preparation protocols for various PCs have been described in detail in our last publication,[9] and it is important to understand the underlying preparation and how the resultant PCs differ in applications and contents so that the correct preparation can be utilized based upon the patient and clinical conditions.

Ideal components of materials to regenerate missing soft tissues

What are mucogingival deformities?

The American Academy of Periodontology's glossary of terms defines a mucogingival deformity as "a departure from the normal dimension and morphology of, and/or interrelationship between gingiva and alveolar mucosa; the abnormality may be associated with a deformity of the underlying alveolar bone."[10] Mucogingival deformities include gingival recession, lack of keratinized and/or attached gingiva, decreased vestibular depth, and aberrant frenum/muscle position.[11] Periodontal phenotype and lack of keratinized tissue are considered predisposing factors for the development of gingival recession and inflammation and are often treated around teeth and implants to improve long-term outcomes.[12-15]

The success of treatments for gingival recession are influenced by a number of clinical characteristics, most importantly: 1) recession depths, 2) gingival thickness, and 3) interdental clinical attachment level (CAL).[11] Increased recession depth is associated with a decreased possibility for complete root coverage, and this should be assessed preoperatively by measuring the distance from the cementoenamel junction (CEJ) and/or its reconstruction if it has been obliterated with lost hard tissue and the gingival margin.[16] Gingival thickness of less than 1 mm is associated with reduced root coverage in procedures that utilize coronally advanced flaps without additional soft-tissue graft materials.[17,18] Gingival thickness may be assessed by observing metal show-through of a probe inserted into the gingival sulcus. If this show-through is visible, the gingival thickness is generally <1 mm.[19,20] Root coverage procedures and their predicted outcomes are dependent upon intact interdental attachment, and loss of interdental attachment is associated with lack of complete root coverage.[21,22]

In order to make predictions about the likely success of root coverage procedures, classification systems have been proposed to outline various recession types that can be related to higher or lower predictability of root coverage[23] and may help inform the selection of treatment modalities, including the potential use of adjunctive growth factors or PCs (table 1). This classification from Cairo and colleagues assesses the clinical presentation and interproximal bone levels to better predict treatment outcomes.[23] For example, complete root coverage may be expected when recession type 1 (RT1) defects are treated with traditional root coverage approaches, and partial/no root coverage is expected for RT2-RT3 defects.[23] This may be helpful when assessing cases that may benefit from adjunctive growth factors and/or PCs as systematic reviews suggest that use of growth factors may improve root coverage outcomes at gingival recession sites when interdental bone loss is present.[24]

What types of cells participate in the wound healing process during soft-tissue grafting?

Overall, soft tissue at sites of wound healing follow similar patterns, and the phenotypic expression at the healed sites are a function of the origin of the native and transplanted tissues at those sites, rather than determined by functional stresses.[25] That is, donor tissue from a site of keratinized mucosa will result in a keratinized phenotype at the recipient site.[26] The presence and proliferation of fibroblasts, epithelial cells, and endothelial cells generally characterize normal wound healing, including the formation of immature

TABLE 1: Root coverage classification and expected treatment outcomes.[11,23]

Cairo recession type classification	Description of recession defects	Expected treatment outcomes
RT1	Gingival recession without interproximal attachment loss. Interproximal CEJ is not clinically detectable at both mesial and distal aspects of the tooth.	Complete root coverage can be expected with standard surgical techniques.
RT2	Gingival recession associated with loss of interproximal attachment, but the interproximal attachment loss is coronal to or equal to the buccal attachment loss.	Partial root coverage can be expected with standard surgical techniques.
RT3	Gingival recession associated with loss of interproximal attachment, and interproximal attachment loss is more apical than the buccal attachment loss.	Root coverage may not be anticipated, but soft-tissue grafting may still be warranted to alter periodontal phenotype.

fibrovascular tissue (i.e., granulation tissue) containing fibroblasts, collagen, and blood vessels that precedes mature angiogenesis.[27-29] At sites that are treated using graft materials, healing differs based upon the type of graft material and the preparation of the recipient bed. Autogenous grafts generally survive initially with plasmatic circulation, and both angiogenesis and anastomosis of existing capillaries occur early in healing to allow for reestablishment of blood supply to the graft.[30-32] In allogeneic graft materials, such as acellular dermal matrix, preparation of the graft materials may alter their degradation time frame, but these materials generally serve as a scaffold for new blood vessels, fibroblasts, myofibroblasts, and other cells to repopulate.[33,34]

What are the effects of platelet concentrates on cells associated with soft-tissue regeneration?

Growth factors released by platelet concentrates play an important role in wound healing.[7,8] PCs, specifically PRF, have demonstrated an upregulation of periodontal ligament fibroblasts (PDL-F), gingival fibroblasts (GF), and osteoblast proliferation, indicating that these biomaterials may speed up healing and/or improve early healing outcomes.[35] Furthermore, PCs may have antimicrobial properties: PRP and PRF were both shown to inhibit bacterial growth of *P. gingivalis* and *A. actinomycetemcomitans* for more than 24 hours in vitro.[36] This antimicrobial function could be important in preventing adverse healing outcomes of soft-tissue grafting, particularly if allograft and/or xenograft materials are used for soft-tissue augmentation. Finally, it has been suggested that PRP may suppress long-term expression of pro-inflammatory cytokines and reduce chronic inflammation, which could lead to longer-term stability of some of these soft-tissue grafts, which have demonstrated a propensity for relapse.[37]

Regenerative techniques for soft-tissue grafting

Gingival augmentation around natural teeth and implants have been proposed to achieve root coverage, improve esthetics, reduce dentinal hypersensitivity (DH), facilitate improved patient-delivered plaque control, and/or prevent future recession and attachment loss.[4,5,38] Given the myriad rationales for employing soft-tissue grafting procedures, the techniques that may predictably improve clinical outcomes are briefly reviewed.

What techniques are available to achieve root coverage?

Many treatment options are currently in use to achieve root coverage at sites of gingival recession. sCTG used in combination with CAF is generally considered the gold standard for improving both root coverage and width of keratinized tissue, but its utility may be limited in certain individuals based upon anatomic considerations at the donor site and patient preference to limit the number of surgical sites and interventions.[4,5,38] Given these concerns, it is imperative that practitioners understand the full armamentarium of procedures that can produce acceptable results and the underlying scientific evidence for the predictability of such procedures in individual clinical scenarios. Options for surgical treatment of gingival recession include:

1) Coronally repositioned flap without placement of a graft

This procedure may achieve root coverage in patients with a thick periodontal phenotype, but its utility may be limited at sites with thin overlying gingival tissue. Furthermore, this technique has been shown to be enhanced by the application of enamel matrix derivatives (EMD) and recombinant human platelet derived growth factor (rhPDGF-BB) and has resulted in enhanced patient-centered outcomes in those patients.[38-40]

2) Autogenous free gingival graft (FGG) placement

FGGs were initially proposed as a mechanism to treat gingival recession defects in 1957 by Friedman.[41] While they demonstrate marked increases in width of keratinized and attached gingiva postoperatively, they have demonstrated less predictable complete root coverage when compared to CAF + sCTG.[42] Additionally, they often heal with a color discrepancy with the surrounding gingival tissues, which may not allow for their use in esthetic areas.

3) Coronally advanced flap (CAF) with subepithelial connective tissue graft (sCTG)

sCTG and CAF are generally considered the gold standard for root coverage procedures, but a secondary surgical site and site-specific limitations may reduce patient acceptance of these procedures.[38-40,42] As with any autogenous tissue, there is a limit to the quantity of tissue that may be harvested at one time due to underlying anatomical structures.[4]

As such, multiple recession defects may require multiple surgeries with periods of healing in between. It is also of note that connective tissue density may vary based upon the harvesting technique and where in the palate the tissue is harvested, and this may affect clinical outcomes as well.[43,44]

4) Coronally advanced flap (CAF) with acellular dermal matrix (ADM)

Allogeneic grafts have demonstrated an ability to achieve predictable root coverage, particularly at sites without interproximal bone loss (e.g., Cairo RT1), but these techniques demonstrate significantly less increase in keratinized gingiva than CAF and sCTG.[5] While some publications suggest that CAF + ADM can increase attached tissue, deepen the vestibule, and stabilize sites postoperatively,[45,46] heterogenous data exist about the recurrence of recession at sites treated with CAF and ADM. This tissue may have an advantage of avoiding a secondary surgical site and allowing for the treatment of multiple recession defects at one time.[45] Conversely, patients may present with an objection to use of human donor tissue, which could be a barrier to use of an allograft product.

5) Xenogenic matrices

Porcine and bovine collagen matrices have been used as replacement grafts, and while increases in keratinized tissue have been seen, root coverage appears to be less than seen with CAF + CTG, CAF + ADM, or CAF + EMD.[47-51] Patient-reported outcomes were analyzed compared with control treatment using autogenous grafts demonstrating significant pain reduction, less analgesic drug consumption, and better patient acceptance.[47-51]

6) Living cellular constructs

These grafts represent bioengineered, cell-embedded constructs composed of living allogeneic human fibroblasts and keratinocytes, bovine collagen, and human extracellular proteins. It has been shown to be safe and effective in increasing KT in randomized controlled trials and further research is necessary to identify ideal applications.[52,53]

What techniques are available to alter periodontal phenotype?

The term *periodontal phenotype* refers to the bone and gingival characteristics, including keratinized tissue and bone and gingival thickness.[54] While the bone morphotype can only be assessed via CBCT, the gingival phenotype can be assessed clinically with minimally invasive techniques, such as probe visibility in the sulcus and bone sounding.[19,54] The presence of a thin periodontal phenotype has been associated with a greater risk for developing gingival recession over a patient's lifetime and also as a consequence of specific dental therapies, including restorative and orthodontic therapies.[55,56] Current evidence suggests that at deficient zones of keratinized mucosal width (< 2 mm), the likelihood of patient discomfort and suboptimal plaque control increases along with the probability of developing marginal bone loss and bleeding on probing.[56] Recent meta-analyses have assessed the ability of treatment options to alter the periodontal phenotype around teeth and implants. Many treatment options are currently in use to alter periodontal phenotype with clinical success.[13,57] For example, sCTG used in combination with CAF and/or FGG are generally considered the gold standards in cases where periodontal phenotype needs alterations, but limitations of autogenous tissue use may limit patient acceptance of such care.[13,57] Additional treatments including the use of ADM, CAF + EMD, and xenograft matrices may provide adequate gain in KT and increases in tissue thickness and stability that can alter periodontal phenotype to clinically acceptable levels.[12, 46,57]

How can adjunctive materials improve outcomes?

Various surgical techniques have been used to address gingival recession and to increase width of keratinized tissue and gingival tissue thickness. Free gingival grafts, coronally advanced flaps (CAF), laterally positioned flaps, sCTGs, and acellular dermal matrix (ADM) with CAF have all demonstrated efficacy in improving recession defects and their sequelae. However, most studies have been performed on recession defects where one would expect complete root coverage, e.g., Cairo RT1 recession defects.[3-5] At sites with more complex clinical presentations, such as Cairo RT2 and RT3 defects, and in patients with other complicating factors, such as smoking or diabetes mellitus, the adjunctive addition of growth factors and other biologic mediators, including PCs, has been proposed to improve root coverage, gingival tissue quantity/quality, and postoperative patient comfort.[24,58-60]

For example, the addition of EMD to ADM demonstrated increased mean root coverage (55.4% in the test group and 44.0% in the control group; $p < 0.04$) and increased percentage of complete root coverage (complete root coverage achieved in three test sites and one control site; $p<0.02$) in smokers when compared with ADM alone.[58] Furthermore, the addition of growth factors to periodontal plastic surgery techniques has been shown to improve both mean root coverage and percentage of complete root coverage less complex defects.[5,24,61,62] As the evidence suggests that the addition of adjunctive growth factors may improve wound healing and clinical outcomes,[5,24] a search for an adjunctive material that allows for delivery of growth factors to improve wound healing and a comparison and critical evaluation of currently used growth factors is warranted in future research. Advantages of PCs for this type of application are that they are autologous, readily harvested on the day of surgery, and may contain a combination of growth factors in physiologic ratios that may provide benefits during periodontal plastic surgical procedures. Furthermore, PCs have been shown to increase tissue maturation during post-operative healing when used as adjunctive materials with grafting.[63]

Review of platelet concentrates in soft-tissue grafting

It is well established that platelets play a critical role in hemostasis and healing. They are also a robust source of growth factors. Briefly, platelets' alpha granules contain platelet-derived growth factor (PDGF), vascular endothelial factor (VEGF), insulin-like growth factor

(IGF), and transforming growth factor-beta (TGF- β).[64,65] Due to the presence of these growth factors and the high rate of patient acceptance of autologous materials, PCs have been widely used in dental procedures to aid in postoperative wound healing.[66,67] While we have previously reviewed the role of PCs in hard-tissue reconstruction in dentistry,[9] these biomaterials may have a role in soft-tissue grafting as well (figure 1).

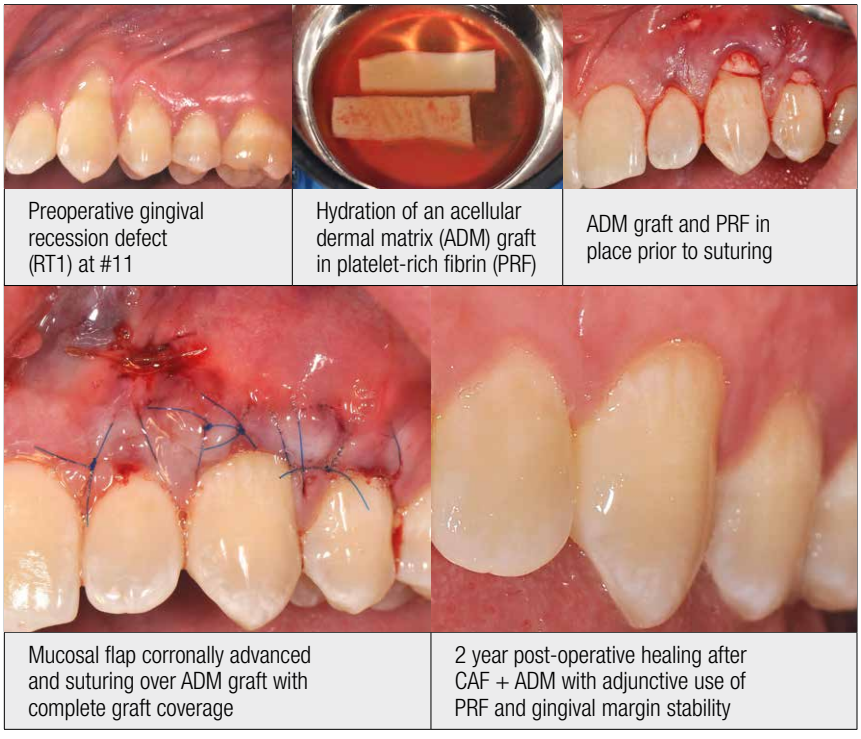

FIGURE 1: Root coverage procedure with CAF + ADM and adjunctive use of PC prior to graft placement

Clinical indications of platelet concentrates for root coverage

The use of PCs to improve outcomes of soft-tissue procedures is particularly appealing as it allows for use of an autogenous material to enhance wound stability, postoperative healing, and clinical outcomes. Furthermore, it has been proposed that the use of PCs may allow for grafting in some cases without the use of gingival substitute graft materials, thereby reducing treatment time and postoperative morbidity. Application of PCs during soft-tissue grafting results in greater postoperative root coverage with coronally advanced flap (CAF), but not CAF and connective tissue graft (CTF).[62,68] Sites treated with root coverage procedures and adjunctive PC use have also been shown to demonstrate superior gingiva index and an increase in gingival thickness as compared to such procedures without PCs.[69] Additionally, techniques using minimally invasive dental surgery and application of autologous PCs have been proposed as novel root coverage procedures for individuals with RT1 deficiencies.[70,71] In addition to the benefits for clinical outcomes that PCs may provide during soft-tissue grafting, it has also been proposed that PCs may improve postoperative pain control and patient-reported outcomes during the healing phase.[72,73] These improvements have been attributed to the more rapid healing progression attributed to PC application.[72,73]

Clinical indications of platelet concentrates for other soft-tissue grafting procedures

While much attention has been paid to the potential benefits of PCs at soft-tissue graft recipient sites, PCs have shown promise as a method to decrease patient discomfort and encourage blood clot stabilization and healing at autologous graft donor sites. The use of PRF as a biologic bandage at palatal donor sites after harvest of CTG or FGG grafts may provide faster healing at those sites and lead to less morbidity and higher levels of patient acceptance for these therapies.[74] Furthermore, novel therapies including the use of microneedling and injectable PCs have been adapted from dermatologic and plastic surgery applications as methods to increase gingival thickness over time and thus alter periodontal phenotype.[75]

Advances in platelet concentrates for soft-tissue grafting

While first- and second-generation PCs demonstrate different applications and utility for applications in dental surgery,[9] further advances in PC technology have led to the emergence of so-called "third generation PCs," namely, T-PRF, A-PRF, i-PRF, and C-PRF.[76,77] The evolution of PCs for various applications has allowed for more targeted selection of materials based upon the patient's individual needs and the clinical defects that are being treated. Each of these advanced PCs represents an alteration in the preparation process to produce a specialized biomaterial (table 2). These tissues may be utilized for individual procedures that first- and/or second-generation PCs may not be ideally suited for, such as injectable PRF for minimally invasive therapies and targeted gingival enhancements.[75]

Conclusion

Platelet concentrates are emerging as a widely available and highly patient-acceptable biomaterial to aid in hard- and soft-tissue regeneration. The adjunctive use of PCs during soft-tissue grafting procedures may provide distinct benefits during periodontal plastic surgery procedures aimed at increasing root coverage and altering the periodontal phenotype. Additionally, the use of such materials in cases where patient and/or site-specific factors are likely to result in less predictable outcomes may provide increased likelihood of beneficial clinical results. Further, the potent growth factors contained in PCs may allow for decreased healing time and patient-perceived postoperative discomfort, thus increasing patient

TABLE 2: Currently available platelet concentrates and proposed ideal applications in soft-tissue grafting.[68-79]

Platelet concentrate type	Preparation	Growth factor release	Intra-operative handling	Clinical applications
Platelet-rich plasma (PRP)	Increased preparation time (>30 minutes) with multiple centrifugation steps Requires the use of bovine thrombin/calcium chloride	Rapid release of growth factors over shorter period of time	PRP should be used within 4 hours after preparation for optimum results. End product is a liquid or weak gel and cannot be formed into a clot or membrane.	PRP has shown enhanced root coverage when used in combination with CAF compared to CAF alone. Liquid PRP may be used to hydrate acellular dermal matrices or xenograft matrices or can be applied after suturing to wound surfaces to aid in soft tissue.
Leukocyte-rich platelet-rich fibrin (L-PRF)	Rapid preparation process (<15 minutes) with single-step centrifugation No requirement for additional external additives	Gradual release of growth factors for up to 7-14 days Enhanced protocols, including heat treatment of the clot, may extend growth factor release and structural integrity.	Fibrin clot enables better handling properties. Handling, blood collection, transfer time to centrifuge are critical for ultimate results. PRF volume is dependent upon the volume of blood drawn and natural polymerization process.	L-PRF has been shown to enhance root coverage outcomes when used with CAF compared to CAF alone. May be used as a biologic bandage to reduce patient discomfort during early wound healing.
Titanium prepared platelet-rich fibrin (T-PRF)	After blood is collected, it is prepared and centrifuged using titanium vials (rather than glass) and a single-step centrifugation process.	May demonstrate more polymerized and therefore thicker fibrin network than other L-PRF prepared in glass vials	Increased structural integrity could lead to longer stability in vivo and improved handling capabilities, but further study is needed.	No current data are available.
Advanced platelet-rich fibrin (A-PRF)	After blood draw, A-PRF is prepared using a lower centrifugation speed for a longer period of time than L-PRF (i.e., 1500 rpm, 14 mins).	Microscopy studies demonstrate increased presence of neutrophilic granulocytes in the distal portion of the clot. These neutrophilic granulocytes are critical in the induction of differentiation of macrophages within the clot and surrounding tissues.	Increased macrophage differentiation could lead to increased regenerative cell recruitment, but further study is needed.	No current data are available.
Injectable platelet-rich fibrin (i-PRF)	i-PRF is prepared using lower centrifugation speeds for a relatively short time period (i.e., 700 rpm for 3 mins).	i-PRF has been shown to release growth factors for up to 10 days and demonstrated increased expression of TGF-b, PDGF, and collagen type 1 when compared to other PCs.	i-PRF is liquid and has been proposed as an injectable material with both surgical interventions and microneedling procedures for soft-tissue augmentation. The liquid nature of the material may make it more desirable for minimally invasive procedures, but can limit applications that require more structural integrity.	While case reports and case series report success using i-PRF for both root coverage and periodontal phenotype alterations, long-term RCTs are necessary to determine the comparative effectiveness.
Concentrated platelet-rich fibrin (C-PRF)	The liquid PRF directly collected from the buffy-coat layer after L-PRF preparation protocols is considered concentrated PRF (C-PRF).	C-PRF demonstrates up to a 10-fold increase in platelet and leukocyte yields over whole blood samples and a 3-5-fold increase in platelet numbers are seen in other PRF preparations.	This material is a liquid and is limited in volume that may be harvested (0.3-0.5 mL), thus potentially limiting its handling and applications.	No data are currently available.

satisfaction and treatment acceptance. Lastly, the emergence of third-generation PCs for more specific clinical indications may allow for enhanced personalized care with regard to soft-tissue grafting and postoperative wound healing. It is important to note that future randomized controlled trials comparing standard soft-tissue grafting procedures with and without the adjunctive use of PCs and comparing adjunctive PC use with other growth factors as well as standardization of harvest and preparation protocols are needed to allow practitioners to identify the ideal treatment options for individual patient needs.

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QUESTIONS

1. Gingival recession and subsequent root surface exposure is associated with all of the following except:
   A. Esthetic compromise
   B. Increased rate of radicular caries
   C. Increased rate of edentulism
   D. Dentinal hypersensitivity

2. Established soft tissue grafting techniques used in periodontal defects include:
   A. Free gingival graft (FGG)
   B. Coronally advanced flap with subepithelial connective tissue graft (CAF + sCTG)
   C. Coronally advanced flap with acellular dermal matrix (CAF + ADM)
   D. All of the above

3. Current platelet concentrates (PCs) used in dentistry for augmentation of soft tissue grafting techniques include(s):
   A. Platelet-rich plasma (PRP)
   B. Leukocyte-rich platelet-rich fibrin (L-PRF)
   C. Injectable platelet-rich fibrin (i-PRF)
   D. All of the above

4. All of the following are true about platelet concentrates (PCs), except:
   A. PCs are autogenous materials derived from whole blood.
   B. PCs contain increased concentrations of growth factors and cytokines involved in wound healing and repair.
   C. All PCs require the use of exogenous thrombin.
   D. All PC preparation requires centrifugation.

5. Which of the following are growth factors that are released by PCs?
   A. Platelet-derived growth factor (PDGF)
   B. Transforming growth factor-β (TGF-β)
   C. Vascular endothelial growth factor (VEGF)
   D. All of the above

6. The American Academy of Periodontology's glossary of terms defines a mucogingival deformity as "a departure from the normal dimension and morphology of, and/or interrelationship between gingiva and alveolar mucosa; the abnormality may be associated with a deformity of the underlying ___."
   A. Tooth structure
   B. Alveolar bone
   C. Connective tissue
   D. Periosteum

7. Mucogingival deformities include all of the following except:
   A. Periodontitis
   B. Gingival recession
   C. Lack of keratinized and/or attached gingiva
   D. Aberrant frenum/muscle position

8. The success of treatments for gingival recession is influenced by:
   A. Individual recession depths
   B. Gingival thickness
   C. Interdental clinical attachment level (CAL)
   D. All of the above

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QUESTIONS

9. Gingival thickness of less than ___ is associated with reduced root coverage in procedures that utilize coronally advanced flaps without additional soft tissue graft materials.
   A. 0.5 mm
   B. 1.0 mm
   C. 2.0 mm
   D. 5.0 mm

10. All of the following are true about gingival recession defects classified as Cairo recession type 1 (RT1) except:
   A. Interproximal CEJ is not clinically detectable on the buccal aspect of the tooth.
   B. No loss of interdental bone is noted.
   C. Complete root coverage can be anticipated.
   D. Interproximal CEJ is not clinically detectable at both mesial and distal aspects of the tooth.

11. All of the following cells generally characterize normal soft tissue healing after grafting procedures except:
   A. Fibroblasts
   B. Odontoblasts
   C. Epithelial cells
   D. Endothelial cells

12. Healing at sites where soft tissue procedures were used generally involve:
   A. Formation of immature fibrovascular tissue (i.e., granulation tissue) containing fibroblasts, collagen, and blood vessels that precedes mature angiogenesis
   B. Keratinization based upon the phenotype of the original source of materials
   C. Resorption of graft materials over time
   D. A and B

13. Autogenous grafts generally survive initially through ___ prior to angiogenesis and anastomosis of existing capillaries to allow for reestablishment of blood supply to the graft.
   A. Salivary nutrients
   B. Plasmatic circulation
   C. Gingival crevicular fluid nutrients
   D. None of the above

14. PCs, specifically PRF, have demonstrated an upregulation of proliferation of various cell types, including:
   A. Periodontal ligament fibroblasts (PDL-F)
   B. Gingival fibroblasts (GF)
   C. Osteoblasts
   D. All of the above

15. Autogenous free gingival grafts (FGG) have been used to treat gingival recession defects since 1957. All of the following are true about FGGs except:
   A. Sites treated with FGGs demonstrate marked increases in the width of keratinized and attached gingiva postoperatively.
   B. FGGs are considered the gold standard for root coverage procedures.
   C. FGGs demonstrate less predictable root coverage when compared to CAF + sCTG.
   D. FGGs often heal with color discrepancies with the surrounding gingival tissues.

16. Allogeneic grafts have demonstrated an ability to achieve predictable root coverage, particularly at sites without interproximal bone loss (e.g., Cairo RT1). These techniques demonstrate significantly less increase in keratinized gingiva than CAF + sCTG.
   A. Both statements are true.
   B. The first statement is true; the second statement is false.
   C. The first statement is false; the second statement is true.
   D. Both statements are false.

17. Living cellular constructs used in soft tissue grafting are:
   A. Created using cells harvested from the patient being treated
   B. Bioengineered scaffolds embedded with autogenous cells
   C. Cell-embedded constructs composed of living allogeneic human fibroblasts and keratinocytes, bovine collagen, and human extracellular proteins
   D. Able to deliver better postoperative results for root coverage than CAF + sCTG

18. The term periodontal phenotype refers to the bone and gingival characteristics, including keratinized tissue and bone and gingival thickness. The presence of a thin periodontal phenotype has been associated with a greater risk for developing gingival recession over a patient's lifetime and also as a consequence of specific dental therapies, including restorative and orthodontic therapies.
   A. Both statements are true.
   B. The first statement is true; the second statement is false.
   C. The first statement is false; the second statement is true.
   D. Both statements are false.

19. Sites with keratinized tissue width of less than 2 mm have been associated with:
   A. Increased probability of marginal bone loss
   B. Increased likelihood of patient discomfort at those sites
   C. Increased rates of bleeding on probing (BOP) at those sites
   D. All of the above

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QUESTIONS

20. The use of biologic mediators, including PCs, has been suggested to improve outcomes at sites with more complex clinical presentations and in patients with other complicating factors, including:
    A. Cairo RT2 and RT3 gingival recession defects
    B. Defects in smokers
    C. Defects in patients with poorly controlled diabetes mellitus
    D. All of the above

21. Advantages of PCs for adjunctive use in soft tissue grafting procedures include all of the following except:
    A. Their autologous nature
    B. They are readily harvested on the day of surgery
    C. They require complex and time-consuming preparation prior to surgery
    D. They may contain a combination of growth factors in physiologic ratios

22. PCs are known to contain growth factors from platelets' alpha granules, including:
    A. Platelet-derived growth factor (PDGF)
    B. Vascular endothelial factor (VEGF)
    C. Transforming growth factor-beta (TGF- β)
    D. All of the above

23. Application of PCs during soft tissue grafting results in greater postoperative root coverage with coronally advanced flap (CAF). Application of PCs during soft tissue grafting results in greater postoperative root coverage with coronally advanced flap (CAF) and subepithelial connective tissue graft (CAF + sCTG).
    A. Both statements are true.
    B. The first statement is true; the second statement is false.
    C. The first statement is false; the second statement is true.
    D. Both statements are false.

24. Sites treated with root coverage procedures and adjunctive PC use have been shown to demonstrate ___ gingival index and ___ gingival thickness as compared to such procedures without PCs.
    A. Superior, greater
    B. Equivalent, greater
    C. Superior, less
    D. Equivalent, less

25. PCs may improve postoperative pain control and patient-reported outcomes during the healing phase. These improvements have been attributed to the more rapid healing progression attributed to PC application.
    A. Both statements are true.
    B. The first statement is true; the second statement is false.
    C. The first statement is false; the second statement is true.
    D. Both statements are false.

26. The use of PRF as a biologic bandage at palatal donor sites after harvest of CTG or FGG grafts may provide:
    A. Faster healing at autologous graft donor sites
    B. Decreased postoperative morbidity
    C. Higher levels of patient acceptance for grafting procedures
    D. All of the above

27. The use of microneedling and injectable PCs has been adapted from dermatologic and plastic surgery applications as methods to:
    A. Increase root coverage
    B. Increase hard-tissue thickness
    C. Increase gingival thickness and alter periodontal phenotype
    D. Alter gingival color variations

28. Advanced platelet-rich fibrin (A-PRF) has been associated with:
    A. Increased macrophage differentiation
    B. Improved root coverage after use in soft tissue grafting
    C. Improved histologic fibrin organization
    D. Increased number of fibroblasts within the PRF material

29. Titanium prepared platelet-rich fibrin (T-PRF) is prepared using titanium vials rather than glass and this has been associated with:
    A. Improved root coverage after use in soft tissue grafting
    B. Increased structural integrity of the PRF material after preparation
    C. Increased cellularity of the PRF material
    D. Decreased quantities of growth factors within the PRF materials

30. The adjunctive use of PCs during soft tissue grafting procedures may provide distinct benefits during periodontal plastic surgery procedures aimed at increasing root coverage and altering the periodontal phenotype. The use of such materials in cases where patient and/or site-specific factors are likely to result in less predictable outcomes may provide increased likelihood of beneficial clinical results.
    A. Both statements are true.
    B. The first statement is true; the second statement is false.
    C. The first statement is false; the second statement is true.
    D. Both statements are false.

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ANSWER SHEET

Stick to your gums! Platelet concentrates and soft-tissue grafting

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Educational Objectives

1. Understand the prevalence, etiology, and treatment options for gingival recession.
2. Discuss the applications of platelet concentrates for enhancing the outcomes of soft-tissue grafting procedures.
3. Select the appropriate preparation protocol to achieve good and predictable results utilizing soft-tissue grafting and platelet concentrates.
4. Evaluate the gaps in our current scientific knowledge regarding platelet concentrates and soft-tissue grafting procedures.

Course Evaluation

1. Were the individual course objectives met?

   Objective #1: Yes No Objective #3: Yes No

   Objective #2: Yes No Objective #4: Yes No

Please evaluate this course by responding to the following statements, using a scale of Excellent = 5 to Poor = 0.

2. To what extent were the course objectives accomplished overall?	5	4	3	2	1	0
3. Please rate your personal mastery of the course objectives.	5	4	3	2	1	0
4. How would you rate the objectives and educational methods?	5	4	3	2	1	0
5. How do you rate the author's grasp of the topic?	5	4	3	2	1	0
6. Please rate the author's effectiveness.	5	4	3	2	1	0
7. Was the overall administration of the course effective?	5	4	3	2	1	0
8. Please rate the usefulness and clinical applicability of this course.	5	4	3	2	1	0
9. Please rate the usefulness of the references.	5	4	3	2	1	0
10. Do you feel that the references were adequate?	Yes		No			
11. Would you take a similar course on a different topic?	Yes		No			

12. If any of the continuing education questions were unclear or ambiguous, please list them.

13. Was there any subject matter you found confusing? Please describe.

14. How long did it take you to complete this course?

15. What additional dental continuing education topics would you like to see?

Mail/fax completed answer sheet to:
Endeavor Business Media
Attn: Dental Division
7666 E. 61st St. Suite 230, Tulsa, OK 74133
Fax: (918) 831-9804

☐ Payment of $69 is enclosed (this course can be completed online for $59. Scan the QR code or go to dentalacademyofce.com to take advantage of the lower rate).

Make check payable to Endeavor Business Media

If paying by credit card, please complete the following:

☐ MC ☐ Visa ☐ AmEx ☐ Discover

Acct. number: _____

Exp. date: _____ CVC #: _____

Billing address: _____

_____

Charges on your statement will show up as Endeavor.

1.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	16.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
2.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	17.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
3.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	18.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
4.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	19.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
5.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	20.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
6.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	21.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
7.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	22.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
8.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	23.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
9.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	24.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
10.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	25.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
11.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	26.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
12.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	27.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
13.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	28.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
14.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	29.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
15.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	30.	Ⓐ	Ⓑ	Ⓒ	Ⓓ

EXAM INSTRUCTIONS
All questions have only one answer. If mailed or faxed, grading of this examination is done manually. Participants will receive confirmation of passing by receipt of a Verification of Participation form. The form will be mailed within two weeks after receipt of an examination.

COURSE EVALUATION AND FEEDBACK
We encourage participant feedback. Complete the evaluation above and e-mail additional feedback to Aileen Southerland (asoutherland@endeavorb2b.com) and Laura Winfield (lwinfield@endeavorb2b.com).

COURSE CREDITS AND COST
All participants scoring 70% or higher on the examination will receive a verification form for three (3) continuing education (CE) credits. Participants are urged to contact their state dental boards for CE requirements. The cost for courses ranges from $20 to $110.

PROVIDER INFORMATION
Endeavor Business Media is an ADA CERP–recognized provider. ADA CERP is a service of the American Dental Association to assist dental professionals in identifying quality providers of continuing dental education. ADA CERP neither approves nor endorses individual courses or instructors, nor does it imply acceptance of credit hours by boards of dentistry. Concerns about a CE provider may be directed to the provider or to ADA CERP at ada.org/cerp.

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Dental Board of California: Provider RP5933. Course registration number CA code: 03-5933-21010. Expires 7/31/2022. "This course meets the Dental Board of California's requirements for three (3) units of continuing education."

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RECORD KEEPING
Endeavor Business Media maintains records of your successful completion of any exam for a minimum of six years. Please contact our offices for a copy of your CE credits report. This report, which will list all credits earned to date, will be generated and mailed to you within five business days of receipt.

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Participants who are not 100% satisfied can request a refund by contacting Endeavor Business Media in writing.

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