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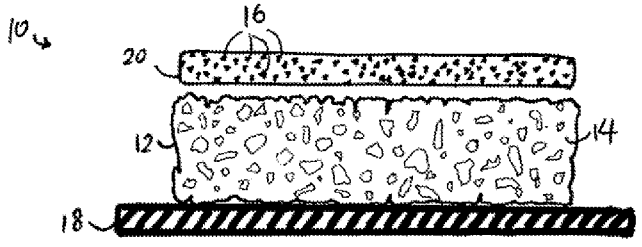

FIG. 1B

(57) Abstract: A periodontal procedure is disclosed herein that uses a dental graft embedded with bone fragments and containing an autogenous platelet-rich plasma gel. The procedure provides a novel method that reverses facia! signs of aging or periodontal conditions such as severe gingivitis, periodontitis and thin biotypes.

DENTAL GRAFT FOR TREATING PERIODONTAL CONDITIONS AND THIN BIOTYPES

Cross-reference to Related Applications

[0001] The present application claims priority to and the benefit of U.S. provisional patent application Serial No. 61/245,884, filed September 25, 2009, which application is incorporated herein by reference in its entirety to the full extent allowed by applicable laws.

Field of the Invention

[0002] The present invention relates generally to materials, kits, and methods related to dental grafts and matrixes designed to facilitate bone and tissue growth in the periodontium. The invention also relates to a novel approach to cosmetic enhancement through surgical alteration of a patient's oral biotype.

Background of the Invention

[0003] As people grow older, their faces start to show signs of aging that include wrinkles, folds, lines, sagging, scaring, unevenness and depressions. These could occur anywhere on the face, but tend to appear around the mouth, nose, eyes, jaw, and in the cheeks. For example, deep age lines tend to develop overlying the orbicularis oris muscle surrounding the lips, and run from near the nostril to the corner of the mouth. These undesirable effects may also result from various health issues such as facial paralysis and rapid weight loss.

[0004] For those seeking a more youthful, healthy, or otherwise aesthetically pleasing look, existing methods for reversing these effects include facial muscle exercise, topically applied lotions, skin stretching appliances and denture modifications. However, results from these existing methods are often uncertain or temporary. And with plastic surgeries such as facelifts, laser resurfacing and cheek implants, fears for visible scarring and nerve damage have prevented many patients from undergoing such procedures.

Brief Summary of the Invention

[0005] In one aspect of the present invention, a dental graft for surgical application to a patient's periodontium is provided. The graft includes a biocompatible carrier, a growth factor or a biological material capable of providing such a growth factor, said growth factor

or biological material contained in said carrier, and hard spacers providing interstitial space and/or structural scaffolding in said dental graft in order to encourage bone and tissue growth and repair in the periodontium. The graft may further include a barrier layer, e.g., a bioabsorbable membrane such as a collagen membrane, on the outside. The dental graft may be adapted for application to both tooth-supporting bones and tooth-roots. The graft may also be adapted for application to the gum and/or connective tissue surrounding at least one tooth. The graft, in one feature, is capable of thickening a patient's oral biotype by permanently thickening an area of said patient's periodontium by at least 0.5 mm, e.g., by providing a filler or protuberance around the cheekbones, upper or lower jaws or otherwise underneath the cheeks or lips.

[0006] In one feature, the biocompatible carrier of the dental graft of the invention comprises collagen. In various embodiments, the biological material of the dental graft of the invention is selected from a platelet concentrate (PC), a platelet-rich plasma (PRP), plasma rich in growth factors, and bone morphogenetic proteins (BMPs). The growth factor or the biological material for providing the growth factor may be isolated from the patient's own blood. The growth factor may be a recombinant growth factor. In an embodiment, the dental graft of the invention further includes a protein that promotes periodontal growth, such as enamel matrix derivatives (EMD) protein.

[0007] In one feature, the spacers of the dental graft have a durometer compatible to that of a tooth-supporting bone. In other words, the spacers can be selected of materials hard and durable enough that they provide more or less a permanent or at least long-lasting structures around the site of grafting. These permanent structures provide interstitial space and/or scaffolding for tissue growth. The spacers, in various embodiments, are bone or bone-like fragments selected from a xenograft, an allograft, an alloplast, an autograft, and a mixture of any of the above.

[0008] In one aspect, the present invention also provides a kit for altering the cosmetic appearance of a patient where the kit includes the dental graft of the invention adapted to surgically thicken a patient's existing oral biotype such that the appearance of at least an area of the patient's face is altered, and instructions for effecting such alteration in the appearance of patient's face. In one embodiment, the kit includes multiple packages separately sealed for application at multiple sites. The instructions may direct a surgeon to ascertain that a candidate patient suffers from a thin or scalloped oral biotype prior to application.

[0009] In one feature, the optional barrier layer is affixed to a side of the biocompatible carrier in the graft. In one feature, the kit instructions state that the graft is adapted to alter the appearance of facial features such as a cheek line, wrinkle, fold, pouch, bag, sagging skin and depression. The kit instructions may state effectiveness against signs of aging, or periodontal conditions such as gingivitis and periodontitis. The periodontal conditions may have been caused by orthodontic procedures. The kit instruction may direct a dental surgeon to apply said dental graft to permanently fill one or more depressions or provide one or more protuberances underneath the patient's cheeks or lips. The instructions may further instruct applying the dental graft at sites substantially symmetrical about the vertical axis defined by the patient's nose bridge.

[00010] In a further aspect, the present invention provides a method or procedure of altering the cosmetic appearance of a patient, the method comprising surgically thickening a patient's oral biotype, e.g., by surgically applying a graft, in particular, a dental graft of the present invention, inside said patient's mouth where the graft comprises a growth factor or a biological material capable of providing such a growth factor. In one feature, the thickening of the oral biotype is carried out in a substantially symmetrical fashion, i.e., about the vertical axis defined by the patient's nose bridge. Besides applying the dental graft of the invention, the method may also include performing a plastic or reconstructive procedure either before or after the dental procedure. The plastic or reconstructive procedure may be selected from the group consisting of blepharoplasty, face scar revision, forehead lifts, hair replacement, laser surgery, mentoplasty, otoplasty, rhinoplasty, skin resurfacing and face lift surgery.

[00011] In the method of the present invention, as in other applications of the inventive principles, the growth factor or said biological material may be selected from the group consisting of a platelet concentrate (PC), a platelet-rich plasma (PRP), plasma rich in growth factors, proteins, and bone morphogenetic proteins (BMPs). The growth factor or the biological material for providing the growth factor may be isolated from the patient's own blood. The growth factor may be a recombinant growth factor. The graft can further include a biocompatible carrier such as collagen. The graft can also include the hard spacers, such as bone or bone-like fragments, as described herein. Still further, the graft may include a barrier layer.

[00012] The method of the present invention can be applied to at least one tooth-supporting bone, a tooth-root, a gum and/or connective tissue surrounding at least one tooth or even edentulous areas. The patient selected to undergo the inventive procedure typically exhibit signs of a thin or scalloped biotype. The procedure alters the appearance of facial

features such as a cheek line, wrinkle, fold, pouch, bag, sagging skin and depression—such features may have resulted at least partly from aging, dental procedures or periodontal conditions such as gingivitis. In an embodiment, the procedure achieves its goal by providing at least one permanent filler or protuberance around the cheekbones, upper or lower jaws or otherwise underneath the cheeks or lips.

Brief Description of the Drawings

[00013] FIG. 1A is a schematic view of the cross-section of an embodiment of the dental graft according to the present invention.

[00014] FIG. 1B is a schematic view of the cross-section of an alternative embodiment of the dental graft according to the present invention.

[00015] FIG. 1C is a schematic view of the cross-section of another alternative embodiment of the dental graft according to the present invention

[00016] FIG. 2A is a photographic view of a patient's gingival recession on the maxillary first premolar and canine before undergoing a grafting procedure according to the present invention.

[00017] FIG. 2B is a photographic view of the preparation of the recipient site in the patient shown in FIG. 2A.

[00018] FIG. 2C is a photographic view of one way of applying the graft of the invention onto a recipient site. This was applied to a patient different from the one shown in FIG. 2A.

[00019] FIG. 2D is a photographic view of the suturing of the dental graft over the recipient site in the patient shown in FIG. 2A.

[00020] FIG. 2E is a photographic view of the recipient site with a coronally advanced flap sutured over the dental graft in the patient shown in FIG. 2A.

[00021] FIG. 2E is a photographic view of the recipient site in the patient shown in FIG. 2A six months after the procedure.

[00022] FIG. 3A is a photographic view of the front of a female patient's lower half of the face before a procedure.

[00023] FIG. 3B is a photographic view of the right side of the same female patient's face before a procedure.

[00024] FIG. 3C shows four photographic views of the same female patient's periodontium prior to a procedure according to one embodiment of the invention: 3C-1: overview; 3C-2: lower anterior; 3C-3: upper right side; 3C-4: lower right side.

[00025] FIG. 3D shows three photographic views of the same female patient's recipient sites while full thickness flaps were being elevated: 3D-1: lower right anterior; 3D-2: upper right side; 3D-3: lower right side.

[00026] FIG. 3E shows two photographic views of the same female patient's periodontium after some of the recipient sites have been decorticated: 3E-1: upper right side; 3E-2: lower right side.

[00027] FIG. 3F shows three photographic views of the same female patient's recipient sites after dental grafts were applied and sutured: 3F-1: lower right anterior; 3F-2: upper right side; 3F-3: lower right side.

[00028] FIG. 3G shows three photographic views of the same female patient's recipient sites after flaps were advanced coronally and sutured over the grafts: 3G-1: lower right anterior; 3G-2: upper right side; 3G-3: lower right side.

[00029] FIG. 3H shows four photographic views of the same female patient's lower half face one month after the procedure: 3H-1: front view of right side which underwent the grafting; 3H—2: front view of left side which did not undergo grafting; 3H-3: side view of her right side; 3H-4: side view of her left side.

[00030] FIG. 4A-4C show photographic views of one male patient's lower half face after undergoing a procedure according the present invention with 4A being a front view, 4B being a side view of his right side, and 4C being a side view of his left side.

[00031] FIG. 5A-5C show photographic views of another male patient's lower half face after undergoing a procedure according the present invention with 5A being a front view, 5B being a side view of his right side, and 5C being a side view of his left side.

[00032] FIG. 6A and FIG. 6B show photographic views of a portion of a female patient's periodontium before and after, respectively, a procedure according to one embodiment of the invention.

[00033] FIG. 6C is a photographic view of preparing a dental graft of the invention.

[00034] FIG. 6D is a photographic view of applying the graft shown in FIG. 6C, in particular, with a layer of spacers, to a site on the periodontium shown in FIG. 6A.

[00035] FIG. 6E is a photographic view of applying a barrier layer over the layer of spacers shown in FIG. 6D.

[00036] FIG. 6F is a photographic view of a step in the procedure of the invention, specifically, using vertical strips to help fastening the graft to the surgical site.

[00037] FIG. 7 is a table showing clinical data of one patient who underwent the grafting procedure according to the invention, showing changes measured at the10-month point after the procedure.

[00038] FIG. 8 is a table showing clinical data of another patient who underwent the grafting procedure according to the invention, showing changes measured at the15-month point after the procedure.

Detailed Description of the Invention

[00039] The invention is herein described, by way of example only, with reference to the accompanying drawings. With specific reference now to the drawings in detail, it is stressed that the particulars shown are by way of example and for purposes of illustrative discussion of the preferred embodiments of the present invention only, and are presented in the course of providing what is believed to be the most useful and readily understood description of the principles and conceptual aspects of the invention. In this regard, no attempt is made to show structural details of the invention in more detail than is necessary for a fundamental understanding of the invention, the description taken with the drawings making apparent to those skilled in the art how the several forms of the invention may be embodied in practice.

[00040] A key aspect of the present invention is the recognition that surgical alteration of a patient's oral biotype is a novel and viable approach to enhance his or her aesthetic appearance. This approach can erase or at least diminish signs of aging, unhealthy, or generally aesthetically undesirable looks in one's face.

[00041] In one embodiment of such approach, a dental grafting composition or device is provided that thickens the periodontium that underlines one's oral biotype, i.e., changing the biotype from thin to a more normal one. Periodontium, as used herein, typically includes the bone, connective tissue, gum and calcified tissue that surround and support one or more teeth, including but not limited to cementum, periodontal ligaments, gingiva and alveolar bones. In various implementations, the dental graft or matrix of the invention includes a biocompatible carrier and at least one growth factor (or a generator of such growth factor). Preferably, the dental graft also includes spacers, preferably hard spacers, which would encourage and facilitate bone and tissue growth.

[00042] Each individual is genetically predisposed to a certain oral biotype based on his or her heritage. The types of dentitions with respect to the periodontium and gingival structure are broken down into two basic biotypes: thin or scalloped versus thick or flat.

[00043] A person with a thick biotype has relatively thick periodontal bone which often appears flat across the cementoenamel junction (CEJ) and in relationship to the CEJ. The height of the contour of bone tends to be very short with very little curvature.

[00044] A person with a thin biotype tends to have thin gum tissue (by some standard, thinner than 0.8 mm as measured by ultrasound) and thin bones in the mouth in general. That person also tends to have highly scalloped dental bones. This can be quantified by measuring the interproximal height of the bone to the apex point on the mid-root of the tooth. A thin biotype often visualizes as protruding teeth and nearly transparent gingiva where capillaries become visible. The thinner the biotype, the more prominent the roots of the teeth become. People with thin biotypes are prone to suffering foundation losses that lead to diseases such as periodontitis and gingivitis.

[00045] A thin biotype is often genetically inherited but can be acquired too. Acquisition of a thin biotype can happen under various circumstances, often involving some type of bone loss. For example, after an orthodontic treatment, e.g., where the patient puts on dental braces or where teeth are realigned or moved, lots of people start to show signs of thinning biotypes and exhibit gum recession a few years later. Even bad dental habits such as overaggressive tooth-brushing may cause microinflammation and negatively affect normal blood supply in the periodontium, and can result in bleeding in the gum, recession in the gum line and loss of the underlying cementum and bone mass. Other dental, especially periodontal, conditions and diseases may also contribute to undesirable facial features that include cheek lines, wrinkles, folds, pouches, bags, sagging skin and depressions. Some of these periodontal conditions, e.g., gingivitis, are sometimes related to thin biotypes but can occur in people with thicker biotypes as well. Another cause for the potentially undesirable periodontal condition is the aging process, during which both the quality and quantity of bone mass become negatively affected, leading to thinner oral biotypes. As people age, the lower third of their faces become shorter as a result of bone loss. Consequently, wrinkles in the face develop and deepen in the aging population.

[00046] After realizing that thin oral biotypes and certain periodontal conditions can be the cause for cosmetic defects and signs of aging, the present inventors have adopted a novel approach to achieve cosmetic beautification through periodontal treatment. Such treatment uses surgical procedures to permanently, or at least in the long term, alter or enhance a

patient's periodontium to achieve a more aesthetically pleasing result both on the patient's face and periodontium. Specifically, the present invention provides help to (a) grow new tooth-supporting bone mass and improve the bone quantity and quality, (b) grow or reattach connective tissues and gum, i.e., the gingival and periodontal ligaments, that surround and support the teeth, and/or (c) thicken or repair tooth-protecting layers such as the calcified tissue layer of cementum. Therefore, the present invention improves the outward appearance of the patient and reverses certain aspects of the aging process including the bone loss process while providing dental benefits to the patient. In one feature, the present invention achieves cosmetic enhancement while treating various periodontal diseases or conditions such as gingival recession. The inventive procedure not only significantly lessens the pain and suffering otherwise experienced by a patient undergoing conventional grafting procedures such as free soft tissue grafting and subepithelial connective tissue grafting, but also provides postoperative gum line that has much less inflammation and appears much healthier and smoother. In one embodiment, the present invention encompasses a periodontal procedure using a dental graft in combination with a traditionally cosmetic procedure. In another embodiment, the present invention encompasses a periodontal procedure using a dental graft in combination with another dental procedure, e.g., an orthodontic procedure.

[00047] Referring now to FIGS. 1A-1B, a dental graft 10 (or a matrix or scaffold) is provided according to the present invention that can be used to alter the biotype or the underlying tooth-supporting or tooth-protecting structures. In general, the dental graft 10 is provided to increase the mass of the periodontium, e.g., by thickening or lengthening the tooth-supporting or tooth-protecting bone and/or tissue. In one feature, the thickness of the periodontal bone and/or tissue can be increased by about 0.5-1.0 mm or even about 1.0-1.5 mm through application of the dental graft. In another feature, the vertical measurement (i.e., length) of the bone and/or tissue can be increased by about 0.5-1.0 mm, about1.0-1.5 mm, about 1.5-2.0 mm, or even about 2.0-2.5 mm through application of the dental graft. This is particularly extraordinary as vertical bone growth around a living tooth has been long considered impossible—that's why periodontal procedures requiring more bone depth, such as anchoring a dental implant, resorts to further drilling and subsequent filling of the hole thereby drilled. As one can imagine, patients without deep enough tooth-supporting bone had been therefore shut out from procedures like dental implants.

[00048] The present invention offers these and other patients renewed hopes for dental tissue and bone growth at any age, and receiving the resulting cosmetic and health benefits. For instance, healthy gingival coverage normally calls for the gum line to be at or a little

above the CEJ line and in a case of average gingival recession, the gum line is about 2.5 mm below the CEJ line, by growing the gingival, its attachment ligament and/or the underlying bone such that the gum line moves anywhere from 1.0 mm to 2.5 mm towards the CEJ, the present application adds significantly to existing gum coverage, and is capable of regrowing the gum line completely back to health.

[00049] Still referring to FIGS. 1A-1B, exemplary embodiments of the dental graft 10 of the invention typically include several components: a biocompatible carrier 12 that contains a solution or a gel 14 having one or more growth factors or biological materials capable of providing such growth factors; the carrier 12 optionally contains spacers 16, e.g., multiple bone or bone-like fragments, as shown in FIG. 1A. Alternatively, the spacers 16 can be provided in a separate layer 20, e.g., a gelatin layer of coagulated platelet-rich plasma (PRP) or similar blood components. A barrier layer 18 on one side of the dental graft 10 is optionally provided as well. In an embodiment, the barrier layer 18 is affixed to biocompatible carrier 12, e.g., through an adhesive such as glue.

[00050] The biocompatible carrier 12 can be a variety of materials, and preferably is pliable and can hold a significant amount of liquid, semi-liquid, gel or powder. In one embodiment, the biocompatible carrier 12 is a soft, pliable, nonfriable sponge that can be used for wound dressing, such as collagen-based sponges sold under the trademarks CollaCote®, CollaTape® or CollaPlug® and manufactured by Integra LifeSciences Corporation (Plainsboro, NJ). The biocompatible carrier 12 is preferably bioabsorbable or bioresorbable, i.e., the carrier material can be dissolved and assimilated by the body, and therefore, can be removed, replaced or left *in situ*.

[00051] The biocompatible carrier 12 should also exhibit good adherence to moist wounds and to promote hemostasis. A porous structure is advantageous because it absorbs blood and wound exudates and has some three-dimensional space built in for bone and tissue regrowth. Collagen-based carrier is preferred because collagen is known to cause aggregation of platelets, which bind to collagen fibrils in large quantities.

[00052] The solution or gel 14 contained in biocompatible carrier 12 provides one or more growth factors, e.g., platelet-derived growth factor (PDGF), fibroblast growth factor (FGF), epidermal growth factor (EGF), transforming growth factor (TGF)-β, insulin-like growth factor-I, and bone morphogenetic protein (BMP). Platelet concentrate (PC) is known to contain growth factors that stimulate cellular proliferation and differentiation, and is a preferred embodiment of the solution or gel 14 for the present invention. PC is an enhanced concentration of platelets processed from platelet-rich plasma (PRP), which in turn, is the

portion of plasma with a concentrated number of platelets, fibrin, cell adhesion molecules, and white blood cells. PRP is the second component that precipitates off when centrifuging whole blood. *In vitro* studies have demonstrated that PRP affects cell's biologic activities on both genetic and cellular levels. E.g., see Marx R., *Platelet-rich plasma: A source of multiple autologous growth factors for bone grafts,* in: Lynch S. et al., eds. TISSUE ENGINEERING APPLICATIONS IN MAXILLOFACIAL SURGERY AND PERIODONTICS (Quintessence Pub. 1999: 71-82). In addition, the action of growth factors present in PRP is more complex than that of a single recombinant growth factor, i.e., they interact and regulate each other's functions. Hence, in the present invention, the addition of PC to the carrier 12 is preferred over the addition of just a single growth factor. Further, since PC has a higher number of platelets per milliliter, it ought to contain a higher concentration of growth factors in order to accelerate or enhance bone and tissue regeneration. Okuda K. et al., J. PERIODONTOL (2003; 74: 849-57).

[00053] In one feature of the present invention, the PC/PRP/growth factor (collectively, the "source of growth factor") is prepared from the patient's own blood. In one embodiment, the source of growth factor, e.g., the autogenous PC is collected using the Platelet Concentration Collection System commercially available from 3i, Implant Innovations Inc. (Palm Beach Gardens, Fl). The PC may be applied to the biocompatible carrier 12 in solution or in gel form. One way to make the gel is to activate the PRP by adding calcium with or without thrombin, causing the platelets to release various growth factors from their α granules and also initiating clotting thereby forming the gel. In an alternative embodiment, the growth factor is recombinant or otherwise manmade.

[00054] Optionally, a growth-promoting substance besides the source of growth factor is also added to the dental graft 10 of the invention. In one embodiment, such a substance includes enamel matrix derivatives (EMD) proteins, also known as enamel matrix proteins. EMD proteins have been found to play an important role in development of tooth-supporting tissues. Commercially available from the Straumann Group headquartered in Basel, Switzerland, these proteins have been suggested to promote the secretion of certain growth factors, such as TGF-β1 by periodontal ligament cells.

[00055] In some embodiments of the inventions, spacers are further added to the dental graft. These spacers provide pre-defined space in the dental graft for the underlying bone and tissue to grow and occupy, and are meant to be incorporated into the growing bone and tissue, and therefore, are preferably biocompatible. The spacers are preferably hard and solid in applications aimed at growing tooth roots and other tooth-supporting bones. In one embodiment, the spacers have durometer compatible to a tooth or a tooth-supporting bone.

[00056] In one embodiment, spacers 16 are embedded in the biocompatible carrier 12 as illustrated in FIG. 1A. The spacers 16 may be bone fragments or bone-like fragments, and can be a xenograft, allograft, alloplast, autograft or a mixture of any of the above. Hard, non-compressible spacers, even when small in dimension, add a baseline amount of interstitial space and/or structural scaffolding around them when the dental graft is compressed in order for it to be fastened around a recipient site. In an embodiment, the spacers provide interstitial space that amounts to about at least 0.1%, 0.5%, or 1% of the total volume of the biocompatible carrier when the carrier is compressed under typical wound dressing pressure. Therefore, their addition to the dental graft guarantees small pockets of three-dimensional space for bone and tissue growth. This anchoring or seeding benefit has been observed in our clinical experiments, and is advantageous considering the remainder of the dental graft consists mostly of soft, pliable spongy materials.

[00057] In another embodiment as illustrated in FIG. 1B, the spacers 16 are provided in a layer 20, e.g., a layer of coagulated blood components such as a platelet-rich plasma, that is separate from the carrier 12. In some embodiments (FIG. 1C), carrier 12 is not included in the graft at all, and the surgeon relies on the barrier layer 18 to cover and hold the layer 20 in place after the surgery. The layer 20 preferably include the source of growth factor described herein, and is pliable to ensure the overall pliability and compressibility of the dental graft.

[00058] Referring again to FIGS. 1A-1B, to prevent premature dissolution of the carrier and to prevent relocation of the graft caused by its shrinkage, in some embodiments, the dental graft 10 of the invention further includes an optional barrier layer 18, e.g., a bioabsorbable membrane. A barrier layer is also thought to be useful in inhibiting migration and proliferation of the epithelial cells into the new wound---as a result, no-wall defects, i.e., defects that by themselves lack the structural support to hold any treatment materials, can now be treated using the graft of the present invention. In one embodiment, the barrier layer 18 is a collagen membrane, such as a native collagen membrane sold by Keystone Dental under the trademark DynaMatrix, or a cross-linked membrane made by Colbar under the trademark Ossix® or Ossix Plus®. The barrier layer 18 can be sized to be slightly larger than the rest of the graft, i.e., the carrier 12, so that the barrier layer 18 has an overhanging edge over the carrier sponge 12. Both examples of membranes have been used in guided tissue regeneration and guided bone regeneration procedures. Other membranes that have been used in these and similar procedures, whether cross-linked or not, can be used herein as an outer layer of the dental graft as well.

[00059] The dental graft 10 typically has one or two biocompatible layers 12, with growth-factor-providing solution or gel 14 applied on at least one side and the barrier layer 18 on the other side. In some embodiments, the biocompatible layer 12 is soaked in the solution or gel 14 so that the solution permeates through the biocompatible layer. The dental graft 10, after being trimmed to cover the wound or recipient site, is then fastened to the treatment area, e.g., by being sutured onto the periodontium. A dental flap can be used to further cover and secure the graft.

[00060] In one aspect of the invention, a kit is provided for altering the cosmetic appearance of a patient. The kit includes the dental graft described herein to surgically thicken at least an area of a patient's existing oral biotype such that the appearance of at least an area of the patient's face and periodontium is altered. For example, by providing grafts that aim at permanently filling a depression or providing a protuberance around the cheekbone or otherwise underneath the cheek of the patient, the kit can be used to smoothen a cheek line, wrinkle or fold on the cheek. The kit further includes instructions for effecting such alteration in the appearance of patient's face. In one embodiment, the kit provides the dental graft as one or two layers of a sponge carrier pre-affixed, e.g., through an adhesive such as glue, to a barrier layer. In one feature, the kit further includes reagents needed to make fresh, autologous source of growth factors (e.g., PC or plasma rich in growth factors) to be added to the dental graft, e.g., the Platelet Concentration Collection System commercially available from 3i, Implant Innovations Inc. (Palm Beach Gardens, Fl).

[00061] In one application of the present invention, illustrated in FIGS. 2A-2F, a patient with an inherited or acquired thin oral biotype is treated with the dental graft described herein. One or more recipient sites are selected. Factors that may be considered in site selection include the degree of gingival recession, proximity to the existing age lines, and symmetry of the potential sites. Computer programs and models can be developed to preview expected results from the procedure, both for the periodontist and the patient. In one embodiment, relevant perimeters reflecting the patient's oral biotype, periodontal conditions, facial features and existing signs of aging are first entered into the program. Consequently, the parties can view the likely aesthetic outcomes as they change depending on chosen variables such as the location and size of the grafting sites, and materials and compositions of the grafts. In the particular case illustrated, a recession about 2 mm long was found on the buccal aspects of both the maxillary right canine and first premolar and those two teeth were selected to be the recipient site of the dental graft of the present invention (FIG. 2A). The

clinical probing depth was 2 mm, and the clinical attachment level was 4 mm from the CEJ for both teeth. The width of keratinized tissue was 3 mm.

[00062] In a preferred embodiment, on the day of surgery, blood is drawn from the patient at chairside about 30 minutes before the procedure to prepare an autogenous source of growth factor, such as PRP or PC, which in turn, is used to soak a layer of properly trimmed collagen sponge and a collagen membrane. Spacers, such as bone fragments, may also be soaked in the same source of growth factor—of course, the collagen sponge may be already embedded with bone fragments as described above. Sufficient amount of $CaCl_2$, with or without thrombin, is added to the source of growth factor to initiate the coagulation process, which can take as little as a few seconds to gel. Alternative spacers include alloplast such as Healos® hydroxyapatite bone substitute, FDBA (Freeze-Dried Bone Allograft) and DFDBA (Demineralized Freeze-Dried Bone Allograft). In a preferred embodiment, the spacer material is entirely synthetic or from a human origin.

[00063] After or during the preparation of the dental graft, a surgical procedure is performed on the patient after local anesthesia has been administered where the tooth root underlying the selected site is exposed with adequate flap elevation, and scaled and planed using hand and ultrasonic instruments (FIG. 2B). This step removes any infected soft and hard tissues including degraded cementum and underlying dentine, bacterial buildups and plagues. Optionally, during the preparation of the site, the cortical layer of the alveolar bone between the tooth roots may be decorticated to access the medullary layer of the bone such that autologous blood is supplied to the recipient site in addition to the prepared source of growth factor. One way to do this is to drill 2-5 small holes of about 2 mm deep into the alveolar bone until the medullary layer is reached. The graft is then placed over the denuded root and the supporting alveolar bone. In some cases where space allows, strips of the barrier layer, e.g., a collagen membrane, can be placed in between teeth vertically over the sponge carrier before or after a horizontal layer of the barrier is placed over the same sponge carrier (FIG. 2C). The graft is further stabilized by sutures (FIG. 2D). In the particular case illustrated, the graft consists of PC on collagen sponge with overlying collagen membrane. Subsequently, a flap is coronally positioned to completely cover the graft and secured using suture (FIG. 2E). A periodontal dressing may optionally be placed over the recipient site and the palatal gingiva.

[00064] Post-surgical care includes prescription of antibiotics and mouth-rinse. Patients are instructed to avoid brushing the teeth involved for a period of time, e.g., 2 weeks, after surgery. Plaque control can be carried out during follow-up visits with chlorhexidine.

Complete root coverage can be achieved within 6 months after the procedure, often with good tissue contour and color (FIG. 2F). In the case illustrated in FIG. 2F, 3-mm gains in clinical attachment level for both teeth were achieved with no change in keratinized tissue width.

[00065] In combination with the surgical procedure using the dental graft described herein, a plastic or reconstructive surgery can also be preformed on the same patient. Examples of such plastic or reconstructive procedures are well known to one skilled in those fields and do not need detailed description here. Some examples of such procedures include and are not limited to: blepharoplasty, face scar revision, forehead lifts, hair replacement, laser surgery, mentoplasty, otoplasty, rhinoplasty, skin resurfacing and face lift surgery.

Example I

[00066] An exemplary protocol using the graft of the invention is now described in more technical detail. The protocol can be used to treat *both* marginal gingival recession and signs of aging (e.g., wrinkles and cheek lines) at the same time. Various aspects of the protocol, e.g., (B) and (C), can be conducted sequentially, simultaneously or overlapping in time, unless indicated otherwise.

A. PPREPARATION OF THE SOURCE OF GRWOTH FACTOR

[00067] About 40-60 mL of blood is drawn from the patient into a 60-mL syringe with an anti-coagulant (e.g., citrate dextrose solution-A).

[00068] Platelet-Rich Plasma (PRP) is collected using a PRP Collection System (currently preferred system is the Plasma Rich in Growth Factors or PRGF-system sold by BTI) according to manufacturer's instruction.

B. PREPARATION OF RECIPIENT SITE

[00069] Local anesthesia is administered to the patient.

[00070] Periodontal surgery is then performed on the patient to expose the root surface and raise a full-thickness flap beyond the mucogingival junction using standard surgical instruments. The incision needs to be far enough to allow adequate relaxation of the flap for later coronal positioning. A periodontal probe may be used to measure the approximate width needed for the graft. The papillae adjacent to the recipient site may be de-epithelialized to enhance blood supply to the coronally advanced flap upon completion of the procedure.

[00071] The root surface is scaled and planed using hand and ultrasonic instruments. Any convexity on root surface is reduced using a curette or a football diamond bur.

[00072] Optionally, the alveolar bone is decorticated using a 0.5-mm round bur.

[00073] An antibacterial solution like tetracycline solution (125 mg tetracycline/cc of sterile water) is prepared and applied to the root surface using cotton pellets. The tetracycline solution is applied to provide antibiotic medicament, inhibit collagenase, remove the smear layer form the root surface, and to enhance tissue attachment by opening the dentinal tubules to expose collagen fibers. The solution is preferably prepared fresh for each procedure and tetracycline can be dissolved in saline solution as well. Alternatively, citric acid and EDTA can be applied instead of tetracycline solution.

[00074] The approximate width necessary for the graft is measured using a periodontal probe (typically, about 8-10 mm for each tooth).

C. PREPARATION OF GRAFT

[00075] In a Petri dish, concurrently immerse the following components of the graft in PRP prepared in (A) for at least 3 min:

- Collagen sponge (one or two layers);
- Collagen membrane;
- Bone fragments (about 0.1 g for each recipient tooth).

[00076] After at least three minutes, coagulants are added to the above immersion for about 7-12 minutes. Coagulants can be: (i) 10% calcium chloride (3 mL) and (ii) either heat (about 38°C) or several drops of bovine thrombin (1,000 units). Calcium chloride is provided in the PRGF system.

D. GRAFT STABILIZATION

[00077] The coagulated layer of bone fragments and PRP mixture from (C) is first applied to the recipient site (denuded root surface); the width of the layer can be estimated empirically (typically 1.5-2.0 mm).

[00078] The collagen sponge prepared according to (C) is placed onto recipient site over the layer of bone fragments.

[00079] The collagen membrane also prepared according to (C) is placed over collagen sponge.

[00080] The membrane is sized to be larger than the collagen sponge so that sponge is entirely enveloped.

[00081] Graft is sutured, e.g., in a continuous crisscross pattern, to the site using 5-O plain gut suture with a P-3 needle. Suture type is selected to biodegrade relatively quickly.

E. FLAP SUTURING

[00082] A flap is coronally positioned to completely cover the graft. The flap is secured by continuous vertical mattress and sling sutures into the mesial and distal papillae using 5-O bioabsorbable polyglactin material and a P-3 needle. Suture type is selected to biodegrade more slowly.

[00083] Non-eugenol periodontal dressings are optionally placed over the site.

Example 2:

[00084] A female patient 35 years of age is shown in FIGS. 3A and 3B with deep lines extending bilaterally from both sides of her nose to just below her lower lip. Age lines this deep are abnormal for her age. Referring to FIGS. 3C-1 to 3C-4, upon further examination, she had a thin oral biotype with early to moderate gingival recession particularly in lower incisors and all four premolar regions. While the reason for her thin biotype was not ascertained, it was noted that a potential contributing factor might be the FGG (Free Gingival Graft) in area 20-22 performed by previous periodontist(s).

[00085] A treatment plan was devised where the right side of the patient would receive dental grafts in three sites while the left side would remain untreated. Full thickness flaps were elevated in lower right anterior (FIG. 3D-1), upper right side (FIG. 3D-2) and lower right side (FIG. 3D-3) to expose teeth roots and prepare the recipient sites. The alveolar bones on the upper right side (FIG. 3E-1) and lower right side (FIG. 3E-2) were decorticated using 0.5 mm round bur.

[00086] Grafts consisting of autogenous PRP (source of growth factor) on collagen sponge (carrier) and DFDBA (spacer) were placed over the recipient sites in lower right anterior (FIG. 3F-1), upper right side (FIG. 3F-2) and lower right side (FIG. 3F-3), each with overlying collagen membrane (barrier layer). The grafts were stabilized and secured with 5-O plain gut sutures. Flaps were advanced coronally and sutured with 5-O Vicryl in lower right anterior (FIG. 3G-1), upper right side (FIG. 3G-2) and lower right side (FIG. 3G-3).

[00087] In one month, patient exhibited remarkable lessening of facial lines and wrinkles on the right side of her face. Her friends and even her nine-year old son all noticed and commented on changes in her face on separate occasions. The contrasts between her right side which received the dental graft and her left side which did not can be seen by

comparing FIGS. 3H-1 and 3H 3 (right side of the face) wtih FIGS. 3H-2 and 3H-4 (left side of the face). On the right side, not only did multiple facial lines and wrinkles diminish, but also some lines completely disappeared, making that side appear much more youthful. Because this resulted from the improvement of the oral biotype from thin to more moderate, the effects should be permanent or at least long lasting.

Example 3

[00088] A first middle-aged male patient with symptoms of a thin biotype underwent a procedure according to present invention, similar to the one described in Example 1, and the resulting changes in his facial appearance are shown in FIGS. 4A-C. A dental graft was surgically applied to the right side of his mouth underneath his cheek (FIG. 4B) and his left side (FIG. 4C) was not treated. As a result, the right side of his cheek was much more fuller and the cheek line was much less visible compared to the left side.

Example 4

[00089] A second middle-aged male patient also underwent a periodontal procedure according to present invention, similar to the one described in Example 1, and the resulting changes in his facial appearance are shown in FIGS. 5A-C. A dental graft was surgically applied to the right side of his mouth underneath his cheek (FIG. 5B) and his left side (FIG. 5C) was not treated. As a result of permanent bone growth underneath, the right side of his cheek became better supported by a more protruding periodontium, and fewer lines were visible than the left side.

Example 5

[00090] A female patient with severe loss of bone mass underneath some of her teeth (FIG. 6A) underwent a periodontal procedure according to present invention. Prior to the procedure, as shown in FIG. 6A, the bone supporting her lower right front tooth "a" is no higher than the bone supporting her lower left tooth "b." The result of the surgical site four months after the procedure is shown in FIG. 6B. Same alphabets correspond to the same teeth in the two figures, noting that FIG. 6A is a photograph of images captured in a mirror placed next to the site. Note the remarkable vertical bone mass growth under lower right front tooth "a" as it is now much higher than the bone supporting tooth "b" (FIG. 6B), which was not part of the grafting site (*see* FIG. 6E, for instance).

[00091] Briefly, the procedure is now described with reference to FIGS. 6C-6F. As shown in FIG. 6C, about 0.5 cc of bone fragments, as hard spacers, were immersed in PRP to form the layer 16 of the graft. Collagen membranes 18 as well as a collagen sponge were also immersed in the same PRP mixture.

[00092] Referring specifically to FIG. 6D, the graft with the layer 16 of bone fragments coagulated in PRP was applied to a cleaned site around three teeth. The collagen sponge, now carrying PRP, and the barrier layer 18 were then sequentially placed over the bone fragment layer 16 (FIG. 6E). Vertical strips of collagen membrane were used in between teeth to help fasten the graft (FIG. 6F) before suturing.

Example 6:

[00093] Two patients underwent grafting procedure as described in Example 1 including the provision of spacers in the graft and the use of vertical strips of collagen membrane in between the teeth (FIG. 2C). Results of their hard and soft tissue changes measured at the 10-month (Patient 1) and 15-month (Patient 2) periods are shown in FIGS. 4 and 5, respectively. In FIG. 4, data regarding each of Patient 1's six teeth that underwent the procedure are shown in respective columns ("D" for "distal," "F" for "facial" and "Px" for "interproximal.") In FIG. 5, data regarding each of Patient 2's six teeth that underwent the procedure are shown in respective columns. In the far left column which includes legend information for the clinical data in each row, the subscript "i" stands for "initial"; the subscript "f" stands for "final"; "CPD" stands for "Clinical Probing Depth"; "KT" stands for "Keratinized Tissue"; "MGJ" stands for "Mucogingival Junction"; "VGR" stands for "Vertical Gingival Recession"; "Stent" stands for "Measured by Stent-probe"; "BG" stands for "Buccal-gingiva" and "BP" stands for "Buccal-papilla." Vertical Gingival Recession (VGR) measures the distance from the CEJ to the free gingival margin. Clinical Probing Depth (CPD) measures the distance between the free gingival margin and the base of the gingival crevice. Width of Keratinized Tissue (WKT) measures the distance from the free gingival margin to the mucogingival junction.

[00094] Further, in FIGS. 4 and 5, "rec." stands for "recession," "red." stands for "reduction" and "cor pos" stands for "coronally positioned." So, as an example, "+: rec. red." stands for "a positive value indicates recession reduction." And the numbers "3" and "5" in FIG.5's far left column stands for "3 mm apical to the gingival margin" and "5 mm apical to the gingival margin," respectively.

[00095] Referring to data presented in FIG. 4, Patient 1 had relatively thick gum to start with, but suffered significant underlying bone loss in the periodontium, therefore making the patient a suitable candidate for undergoing grafting procedure of the present invention. After the procedure, significant improvements in both tissue and bone growth were found. For example, the patient showed reduction in vertical gingival recession by an average of 0.73 mm and as much as 2.0 mm in two teeth measurements (6F and 7F). Stent-measured bone growth was also significant: as much as 3 mm vertical gain as measured interproximal teeth 7 and 8 (Px 7-8) and 0.96 mm on average. It is noted that the patient did show some loss in the width of keratinized tissue, but the patient had exceptionally large width to start with and the recorded loss might just be a short-term effect after the procedure—after all, the post-surgery width of keratinized tissue was still well over the acceptable value of 3 mm. The horizontal gains in both the gingival and bone were also encouraging.

[00096] Referring to data presented in FIG. 5, Patient 2 had very thin biotype prior to the procedure. Significant improvement in bone growth was recorded 15 months after the grafting procedure. Stent-measured vertical bone growth reached 1.5 mm in two places and 1.0 mm on average. The patient did exhibit an increase in the vertical gingival recession, but all occurring in the papilla. The horizontal gains in both the gingiva and bone were remarkable: the buccogingival gain was as much as 1.5 mm in several measurements.

[00097] While the present invention has been particularly shown and described with reference to the structures and methods disclosed herein and as illustrated in the drawings, it is not confined to the details set forth and this invention is intended to cover any modifications and changes as may come within the scope and spirit of the following claims. All publications and patent literature described herein are incorporated by reference in entirety to the extent permitted by applicable laws and regulations.

[00098] We claim:

Claims

1. A dental graft for surgical application to a patient's periodontium, said graft comprising:
    a. a biocompatible carrier;
    b. a growth factor or a biological material capable of providing such a growth factor, said growth factor or biological material contained in said carrier; and
    c. hard spacers providing interstitial space in said dental graft in order to encourage bone and tissue growth in the periodontium.

2. The dental graft of claim 1 further comprising a barrier layer on the outside.

3. The dental graft of claim 2 wherein said barrier layer comprises a bioabsorbable membrane.

4. The dental graft of claim 2 wherein said barrier layer comprises a collagen membrane.

5. The dental graft of claim 1 adapted for application to both tooth-supporting bones and tooth-roots.

6. The dental graft of claim 1 adapted for application to gum and/or connective tissue surrounding at least one tooth.

7. The dental graft of claim 1 wherein said biocompatible carrier comprises collagen.

8. The dental graft of claim 1, wherein said growth factor or said biological material is selected from the group consisting of a platelet concentrate (PC), a platelet-rich plasma (PRP), plasma rich in growth factors, and bone morphogenetic proteins (BMPs).

9. The dental graft of claim 1, wherein said growth factor or said biological material is isolated from patient's own blood.

10. The dental graft of claim 1, further comprising a protein that promotes periodontal growth.

11. The dental graft of claim 10 wherein said protein comprises enamel matrix derivatives (EMD) protein.

12. The dental graft of claim 1, wherein said spacers have a durometer compatible to that of a tooth-supporting bone.

13. The dental graft of claim 1 wherein said spacers comprise bone or bone-like fragments.

14. The dental graft of claim 11, wherein said bone or bone-like fragments are selected from the group consisting of a xenograft, an allograft, an alloplast, an autograft, and a mixture of any of the above.

15. The dental graft of claim 1, wherein said growth factor comprises a recombinant growth factor.

16. The dental graft of claim 1 capable of permanently thickening an area of said patient's periodontium by at least 0.5 mm.

17. The dental graft of claim 1 wherein said hard spacers are embedded in said biocompatible carrier.

18. The dental graft of claim 1 wherein said hard spacers are embedded in a layer of coagulated blood components separate from said biocompatible carrier.

19. A kit for altering the cosmetic appearance of a patient, said kit comprising:

a dental graft adapted to surgically thicken a patient's existing oral biotype such that the appearance of at least an area of the patient's face is altered, said graft comprising:

a. a biocompatible carrier;

b. a growth factor or a biological material capable of providing such a growth factor, said growth factor or biological material contained in said carrier; and

c. hard spacers providing interstitial space in said dental graft in order to encourage bone and tissue growth in a periodontal site; and

instructions for effecting such alteration in the appearance of patient's face.

20. The kit of claim 19, wherein the dental graft further comprises a barrier layer.

21. The kit of claim 20 wherein said barrier layer is affixed to a side of the biocompatible carrier.

22. The kit of claim 19, adapted for application to both tooth-supporting bones and tooth-roots.

23. The kit of claim 19, adapted for application to gum and/or connective tissue surrounding at least one tooth.

24. The kit of claim 19, wherein said biocompatible carrier comprises collagen.

25. The kit of claim 19, wherein said growth factor or said biological material is selected from the group consisting of a platelet concentrate (PC), a platelet-rich plasma (PRP), plasma rich in growth factors, and bone morphogenetic proteins (BMPs).

26. The kit of claim 25, further comprising a reagent for coagulating said biological material.

27. The kit of claim 19, further comprising reagents needed to obtain platelet growth factor or said biological material from patient's own blood.

28. The kit of claim 19, wherein said hard spacers comprise bone or bone-like fragments.

29. The kit of claim 28, wherein said bone or bone-like fragments are selected from the group consisting of a xenograft, an allograft, an alloplast, an autograft, and a mixture of any of the above.

30. The kit of claim 19, wherein said growth factor is a recombinant growth factor.

31. The kit of claim 19, wherein said growth factor is endogenous to the patient.

32. The kit of claim 19 wherein said hard spacers are embedded in said biocompatible carrier.

33. The kit of claim 19 wherein said hard spacers are embedded in a layer of coagulated blood components separate from said biocompatible carrier.

34. The kit of claim 19, wherein said instructions direct a surgeon to ascertain that a candidate patient suffers from a thin or scalloped oral biotype prior to application.

35. The kit of claim 19, wherein said instructions state that said graft is adapted to alter the appearance of at least one facial feature selected from the group consisting of a cheek line, wrinkle, fold, pouch, bag, sagging skin and depression.

36. The kit of claim 19, wherein said instructions state effectiveness against signs of aging, or a periodontal condition.

37. The kit of claim 19, wherein said instructions direct applying said dental graft to permanently fill one or more depressions or provide one or more protuberances underneath the patient's cheeks or lips.

38. The kit of claim 19, further comprising multiple packages separately sealed for application at multiple sites.

39. The kit of claim 19 wherein said instructions direct a surgeon to apply said dental graft at sites substantially symmetrical in the patient's face.

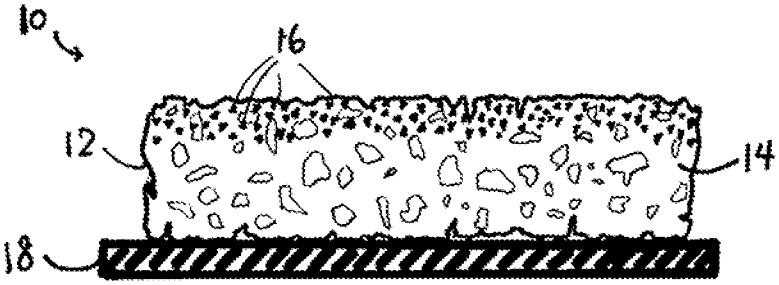

FIG. 1A

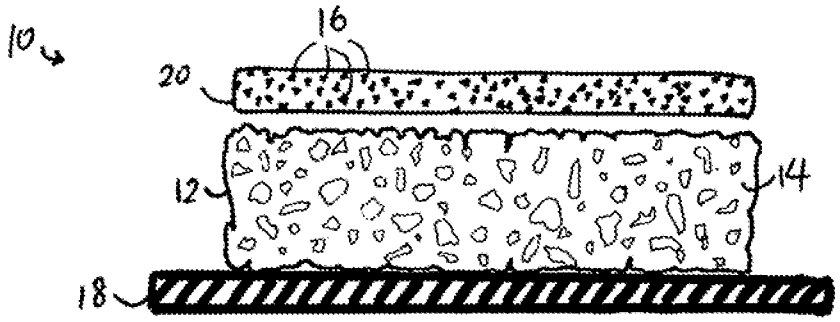

FIG. 1B

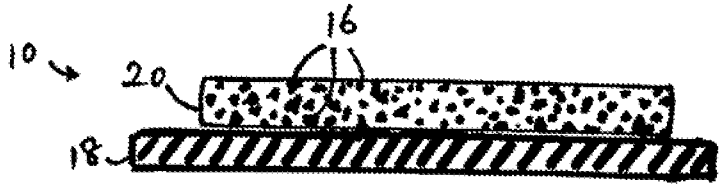

FIG. 1C

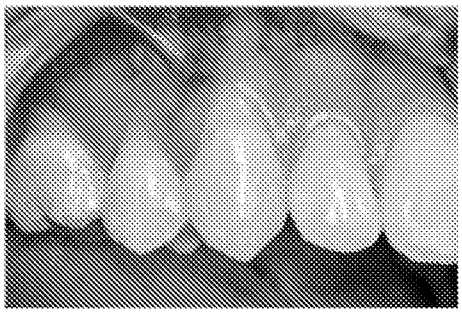

FIG. 2A

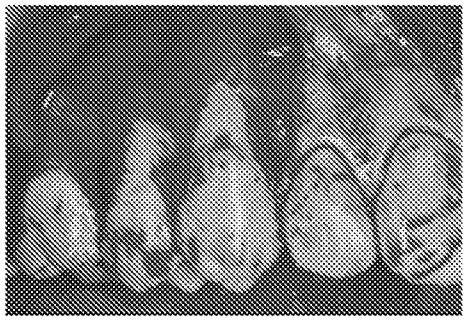

FIG. 2B

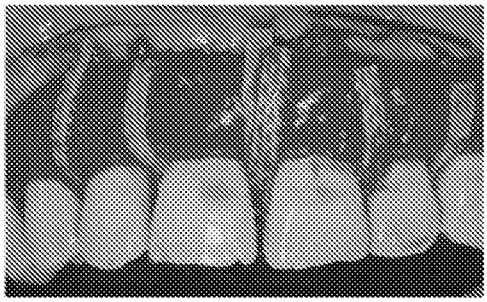

FIG. 2C

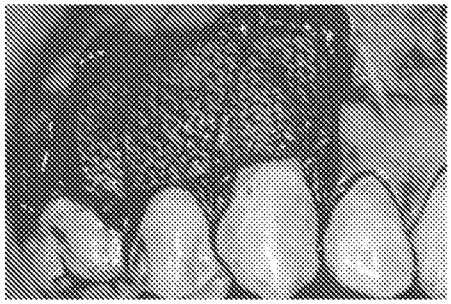

FIG. 2D

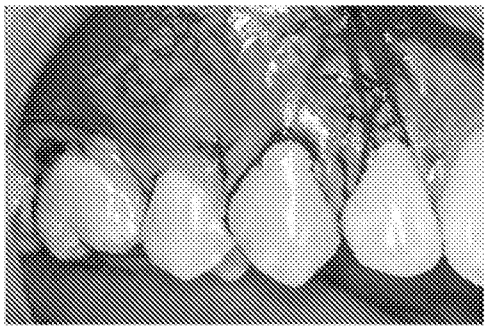

FIG. 2E

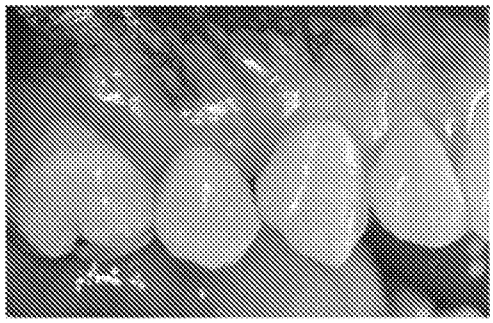

FIG. 2F

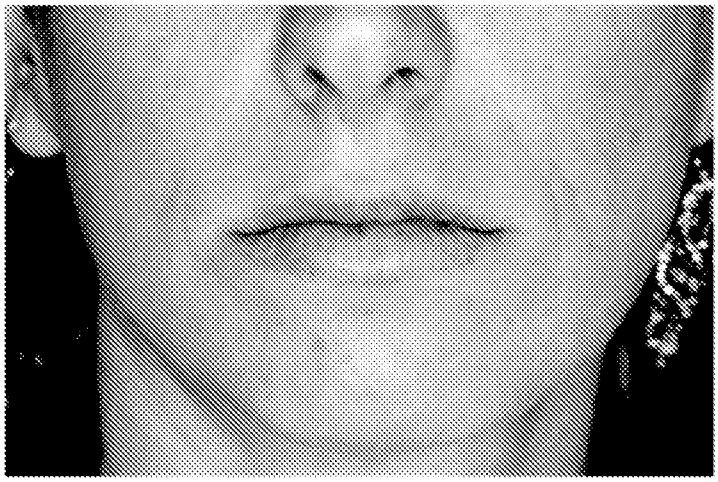

FIG. 3A

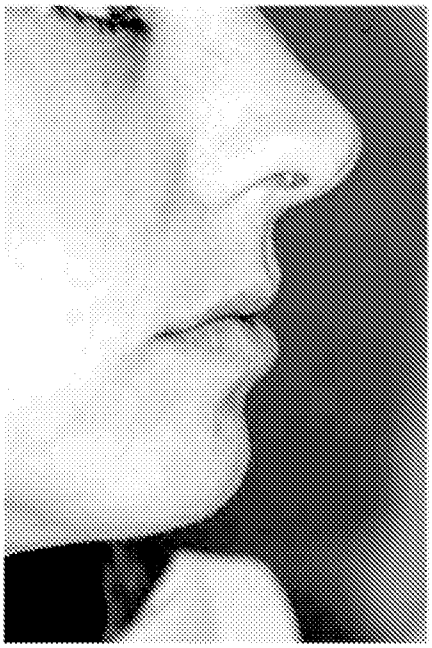

FIG. 3B

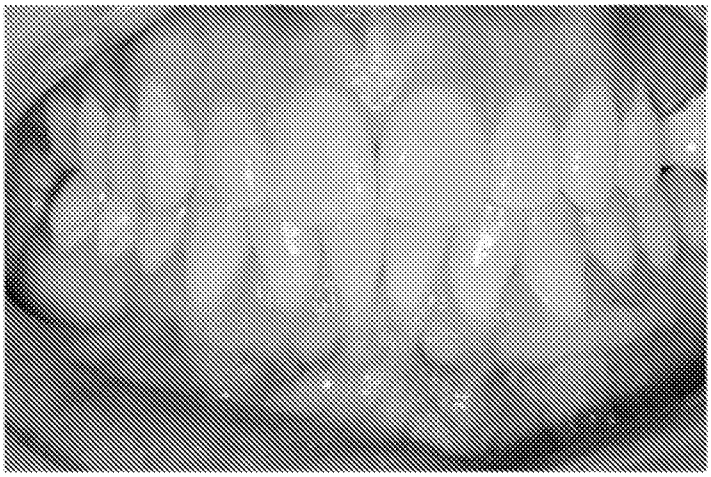

FIG. 3C-1

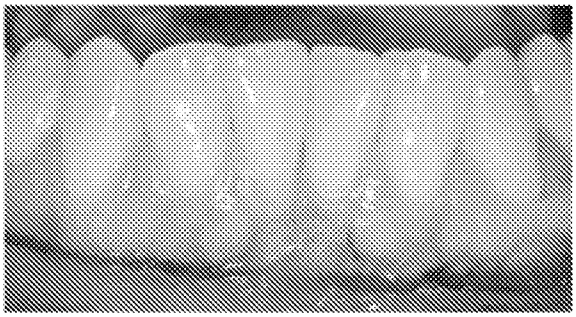

FIG. 3C-2

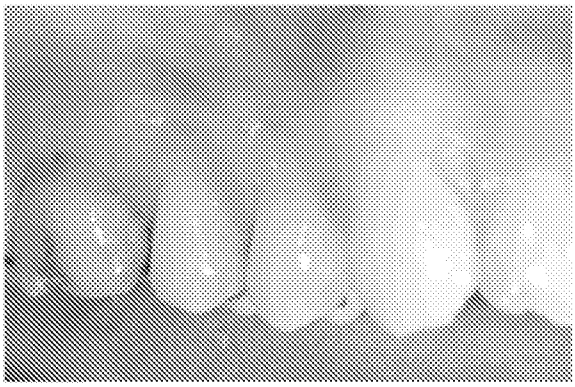

FIG. 3C-3

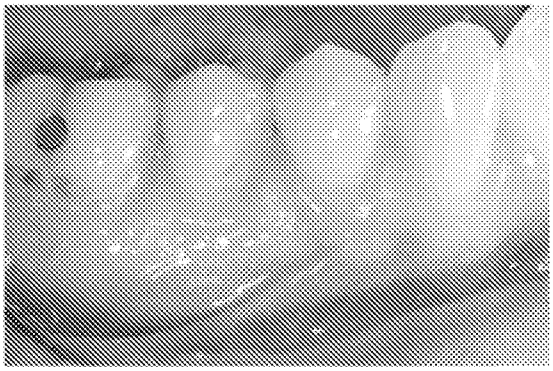

FIG. 3C-4

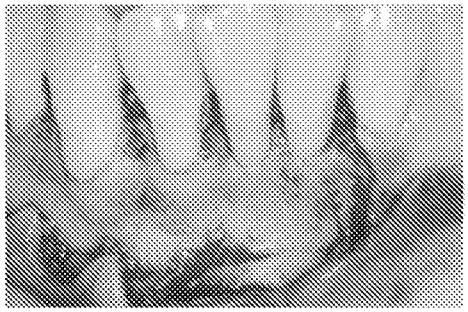

FIG. 3D-1

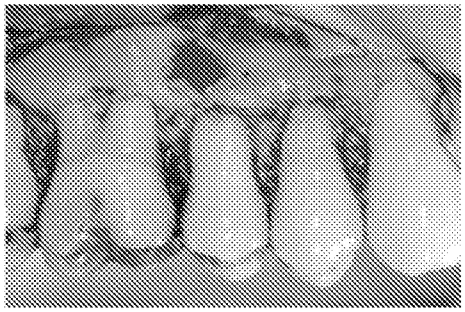

FIG. 3D-2

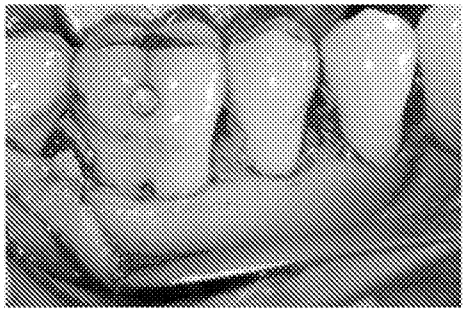

FIG. 3D-3

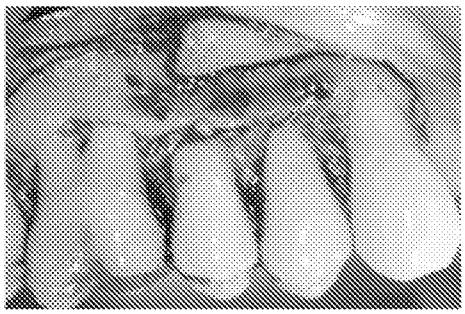

FIG. 3E-1

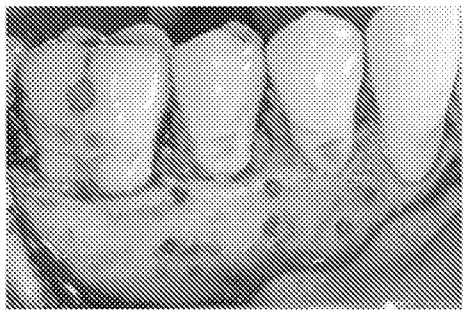

FIG. 3E-2

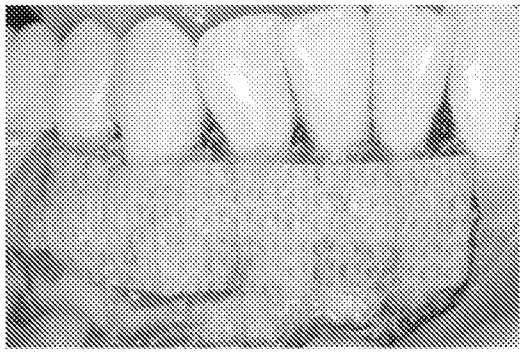

FIG. 3F-1

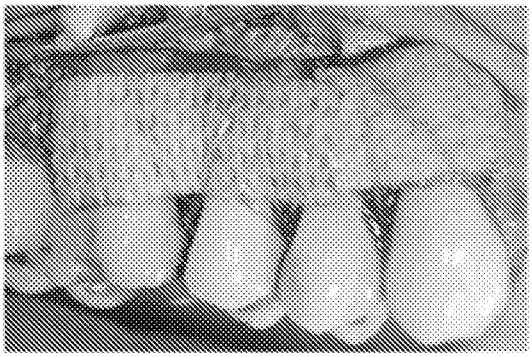

FIG. 3F-2

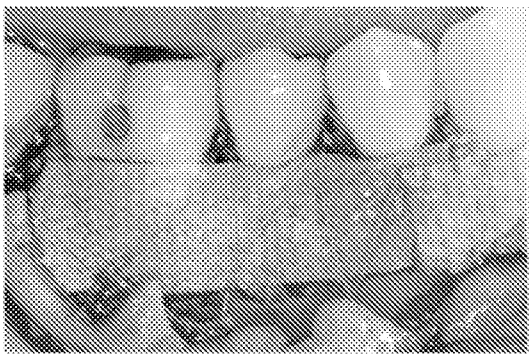

FIG. 3F-3

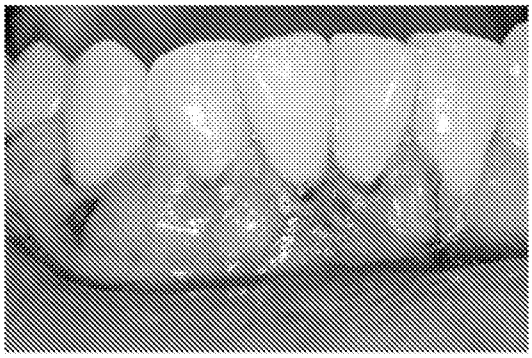

FIG. 3G-1

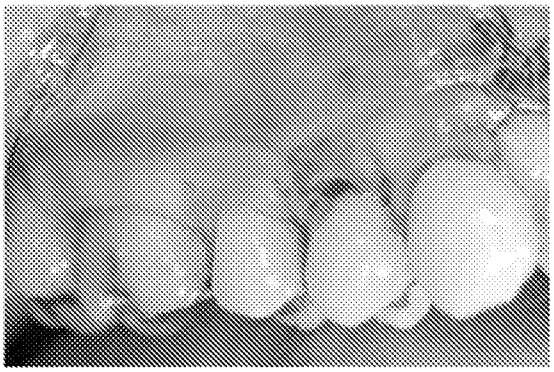

FIG. 3G-2

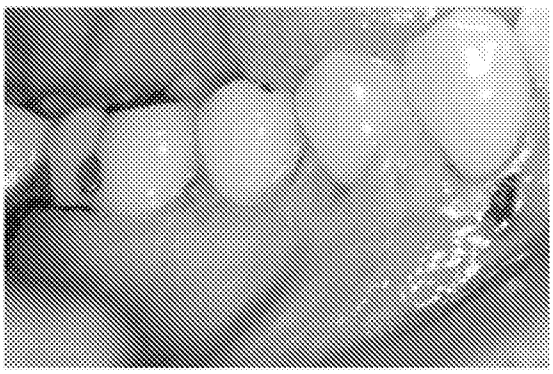

FIG. 3G-3

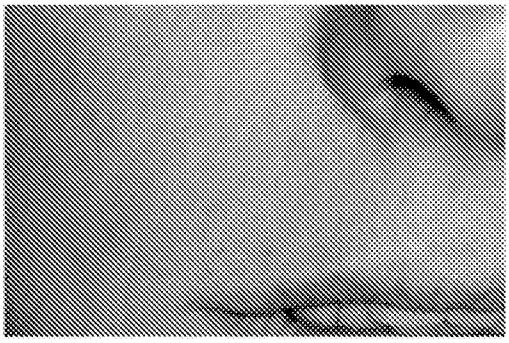

FIG. 3H-1

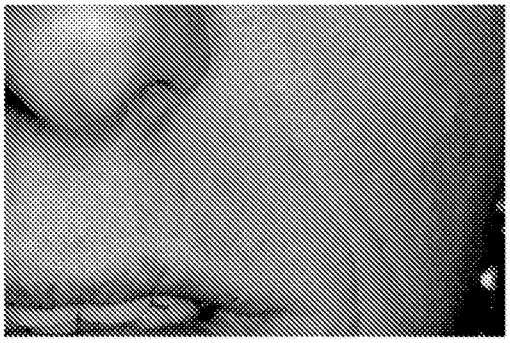

FIG. 3H-2

FIG. 3H-3

FIG. 3H-4

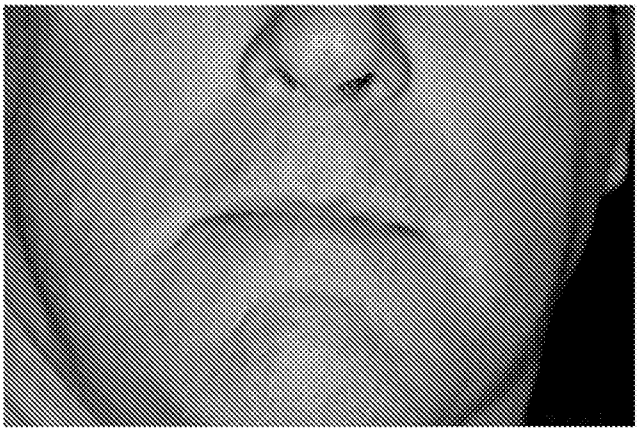

FIG. 4A

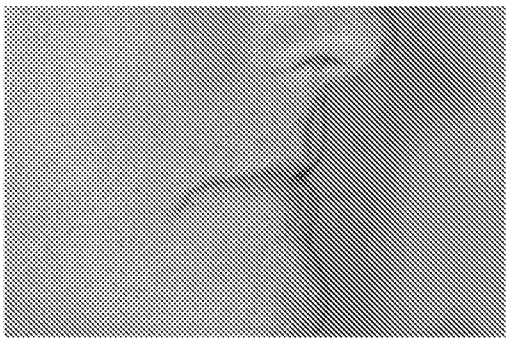

FIG. 4B

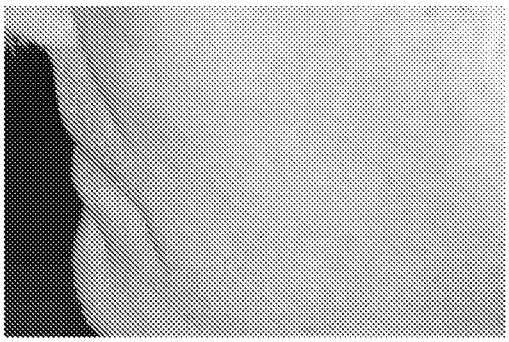

FIG. 4C

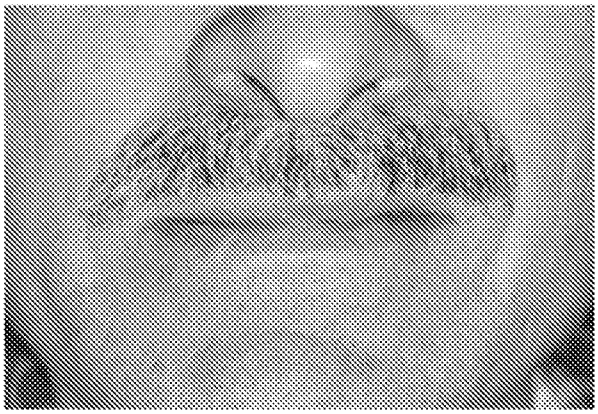

FIG. 5A

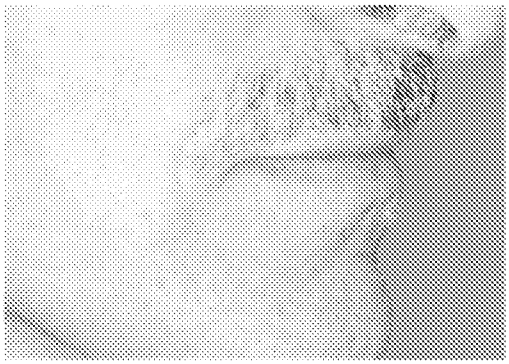

FIG. 5B

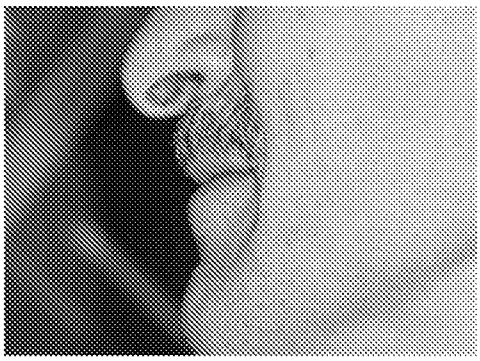

FIG. 5C

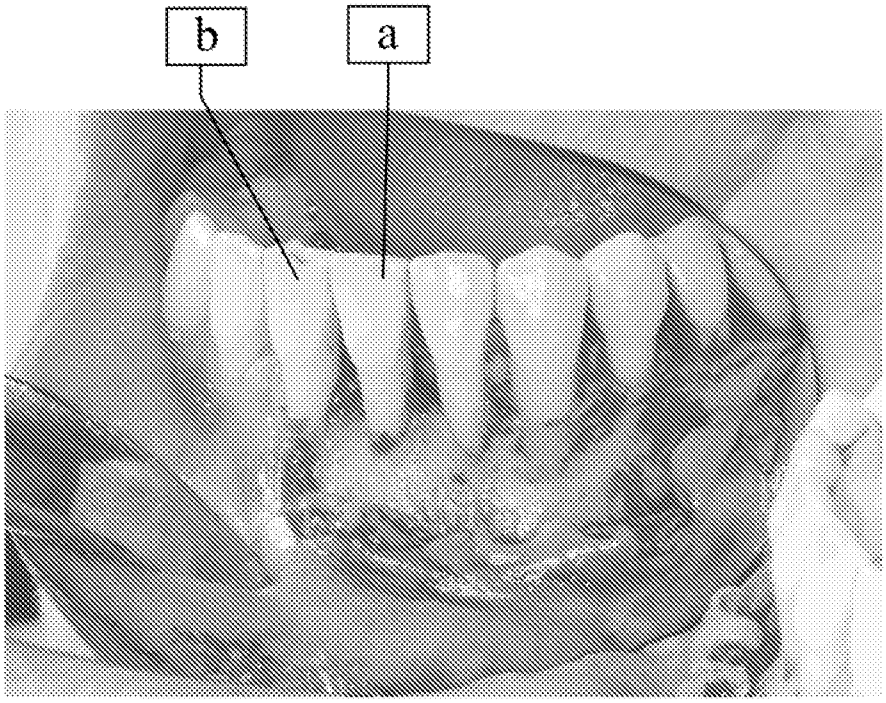

FIG. 6A

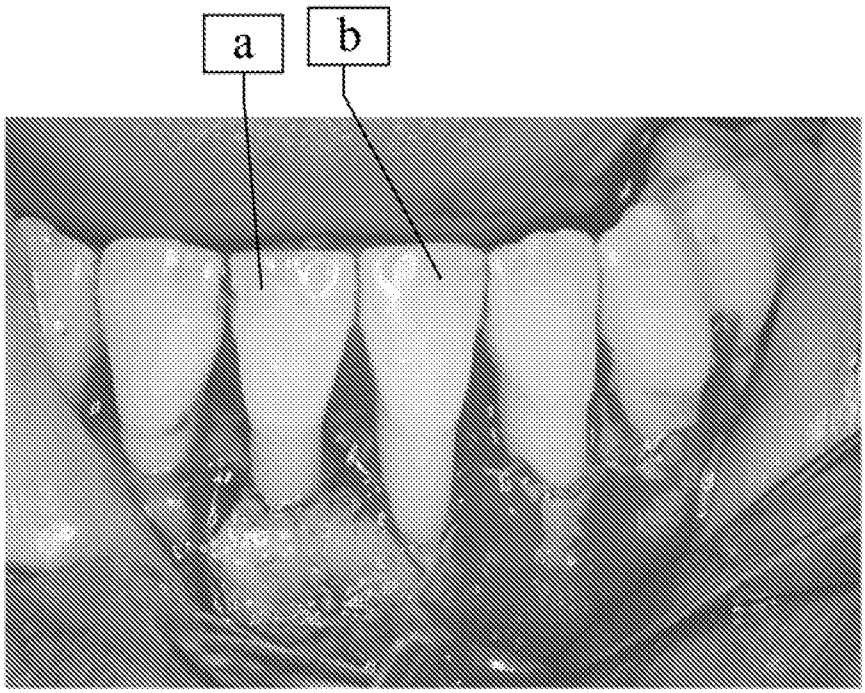

FIG. 6B

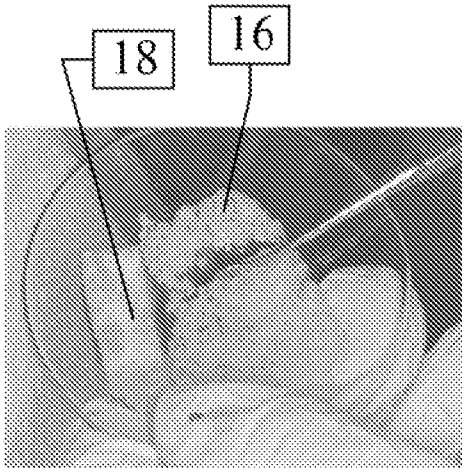

FIG. 6C

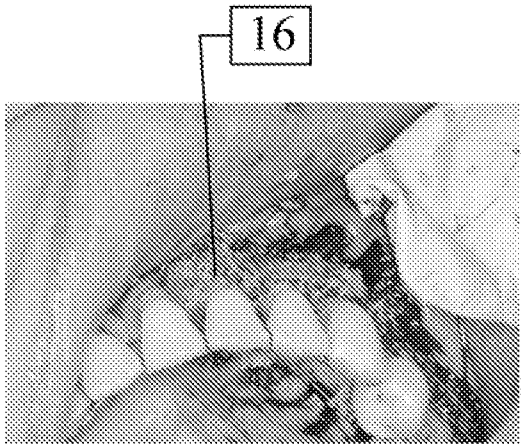

FIG. 6D

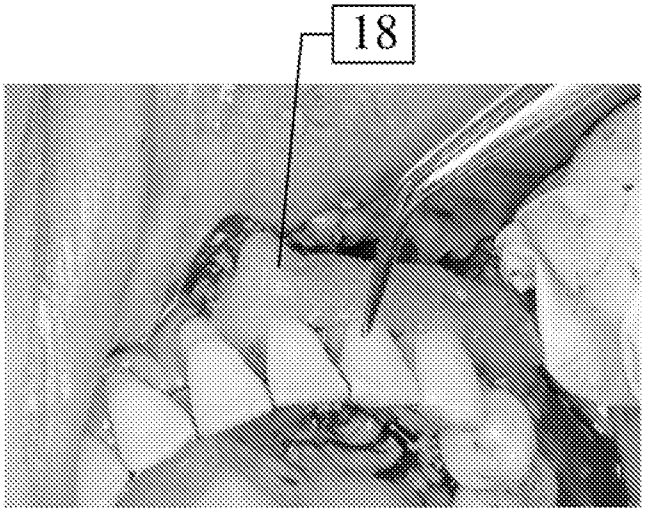

FIG. 6E

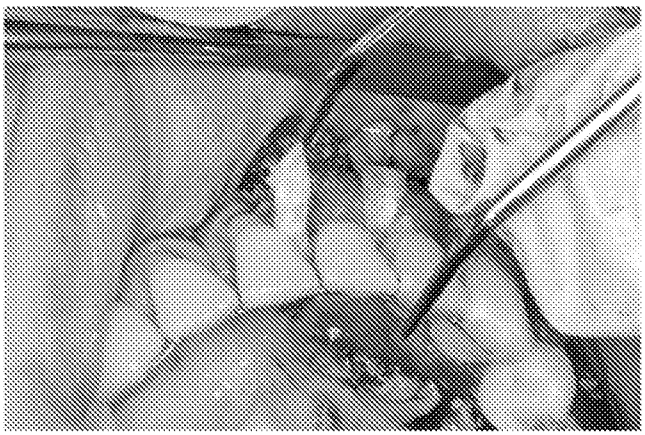

FIG. 6F

Hard & Soft Tissue Changes (mm) in 10 Months - Patient 1

	6D	6F	Px 6-7	7F	Px 7-8	8F	Px 8-9	9F	Px 9-10	10F	Px 10-11	11F	11D	Mean
Vertical Changes														
CPDi	2	1	2.2	2	5.5	2	4.3	2	5.2	2	3.2	2	5	
CPDf	1	2	1.1	2	2.2	2	3.1	2	3.2	1	1.1	1	3	
Δ CPD (+: CPD red.)	1	-1	1.1	0	3.3	0	1.2	0	2.0	1	2.1	1	2	**1.11**
Width of KTi		6		7		5.5		6		7		6.5		
Width of KTf		4.5		5		4.5		4		4.5		3		
Δ Width of KT (+: loss)		1.5		2		1		2		2.5		3.5		**2.08**
Δ Stent tip-MGJ (+: cor pos)		2		1		2		1.5		2.5		3		**2**
VGRi (+: rec.)	-0.5	0	0	0	1.5	0	-0.5	0	0.5	0	0.5	0	0	**0.12**
VGR f (+: rec.)	-0.5	-2	0	-2	0.5	-1.5	0	-0.5	0.5	-1.5	0	-1	0	**-0.62**
Δ VGR (+: rec. red.)	0	2	0	2	1	1.5	-0.5	0.5	0	1.5	0.5	1	0	**0.73**
Δ Stent-bone (+: gain)	0	0.5	0.5	0	3	0	1	1	2	1	1	0.5	2	**0.96**
Horizontal Changes														
Δ Stent-gingiva (+: gain)		1		0.5		0.5		0		0		-0.5		**0.25**
Δ Stent*-bone (+: gain)		0.5		0.5		0.5		0.5		1		0.5		**0.58**

FIG. 7

Hard & Soft Tissue Changes (mm) in 15 Months – Patient 2

	22D	22F	Px22-23	23F	Px 23-24	24F	Px 24-25	25F	Px 25-26	26F	Px 26-27	27F	27D	Mean
Vertical Changes														
CPD i	3	3	3.4	3	2.2	4	3.4	4	3.4	3	4.3	3	3	3.22
CPD_{15M}	2	1	2.2	1	1.1	1	1.1	1	1.1	1	1.1	1	1	1.17
Δ CPD (+: CPD red.)	1	2	1.2	2	1.1	3	2.3	3	2.3	2	3.2	2	2	**2.06**
WKT i		0		2		0		0		0		1		0.5
WKT_f		1.5		4		2		2.5		4		2		2
Δ WKT (-: gain)		-1.5		-2		-2		-2.5		-4		-1		**-2.17**
VGR_i	0	1.5	0,0	0	2,0	0	0,0	0	0,0	0	0,0	0	0	0.19
VGR_f	0	0	0,1	0	1,2	0	2,1.5	0	2,2	0	1,1	0	0	0.75
ΔVGR (-: rec. gain)	0	1.5	0,-1	0	1,-2	0	-2,-1.5	0	-2,-2	0	-1,-1	0	0	**-0.56**
ΔStent-papilla (-: loss)			-1.5		-1.5		0		-1		-1.5			**-1.1**
ΔStent-bone (+: gain)			0.5		0.5		1.5		1.5		1			**1**
Horizontal Changes														
ΔStent-BG 3 (+: gain)		0.5		0.5		0.5		1.5		0		0		**0.5**
ΔStent-BP 3 (+: gain)		0		0		-0.5		1		0		0		**0.08**
ΔStent-BG 5 (+: gain)		-1		1		1.5		2		1		1.5		**1**
ΔStent-BP 5 (+: gain)		0.5		1		0.5		1.5		0		0.5		**0.67**

FIG. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2010/050422

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - A61F 2/02 (2010.01)
USPC - 424/423
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - A61F 2/02, 2/28; A61K 6/00; A61L 27/00 (2010.01)
USPC - 424/423, 424, 428, 459; 435/384; 623/17.17, 908

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatBase

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 7,335,508 B2 (YAYON et al) 26 February 2008 (26.02.2008) entire document	1-39
Y	US 2007/0129807 A1 (LYNCH et al) 07 June 2007 (07.06.2007) entire document	1-39
Y	US 2009/0054995 A1 (ODERMATT et al) 26 February 2009 (26.02.2009) entire document	2-4, 20-21
Y	US 2008/0090207 A1 (RUBBERT) 17 April 2008 (17.04.2008) entire document	6, 10-11, 14, 23
A	US 6,911,046 B2 (SCHULTER) 28 June 2005 (28.06.2005) entire document	1-39

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 December 2010	30 DEC 2010
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774