

FIXTURE FOR DENTAL IMPLANTS AND DENTAL IMPLANT

FIELD

[0001] The present invention relates to a dental implant fixture and a dental implant
5 including the fixture.

BACKGROUND

[0002] Dental implant surgery, which implants a dental implant fixture (hereafter may be referred to as a fixture) into the alveolar bone of the upper or lower jaw, is performed to
10 improve the occlusion, the vocal function, or the aesthetic appearance (refer to, for example, Patent Literature 1).

[0003] Patent Literature 2 describes a fixture having a thread on its periphery and a groove along the thread. This fixture is designed to allow bone tissue to grow inside the groove that extends along the thread.

15 [0004] The main constituent of bone, apatite, is known to have crystallographic anisotropy (refer to, for example, Patent Literature 3 and Non Patent Literatures 1 and 2). The orientation of apatite crystals in, for example, the lower jaw, varies across different portions of the lower jaw (refer to, for example, Non Patent Literature 2). In detail, the orientation of apatite crystals is dominant in the occlusal load direction in the marginal ridges
20 of the teeth, and is dominant in the mesiodistal direction in the bone body.

[0005] The apatite orientation serves to maintain the inherent mechanical function of bone. Thus, retaining the apatite orientation during bone regeneration seems to accelerate bone formation and to maintain the bone quality over a long period of time. In particular, the apatite orientation is to be retained in a cortical bone portion that regenerates in a basal
25 portion of an implant fixture, which receives a load applied from a structural component attached to the fixture.

[0006] However, fixtures known in the art, including the fixture described in Patent Literature 2, are designed without focusing on such apatite orientation.

CITATION LIST

PATENT LITERATURE

[0007] Patent Literature 1: Japanese Patent No. 4740139

Patent Literature 2: Japanese Patent No. 4603893

5 Patent Literature 3: Japanese Patent No. 5153626

Non Patent Literature

PCT/JP2015/081734

[0008] Non Patent Literature 1: Design and optimization of the oriented groove on the hip implant surface to promote bone microstructure integrity, written by Yoshihiro Noyama,

10 Takayoshi Nakano, Takuya Ishimoto, Takashi Sakai, and Hideki Yoshikawa, Bone, 2013, Vol. 52, pp. 659-667

Non Patent Literature 2: The development of artificial joints: From the history to future prospects, written by Hideki Yoshikawa, Takayoshi Nakano, Atsuko Matsuoka, and Yoshio Nakashima, the first edition, Nihon Igakukan, July 1, 2013, pp. 349-351

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BRIEF SUMMARY

TECHNICAL PROBLEM

[0009] One or more aspects of the present invention are directed to a dental implant fixture and a dental implant that allow regenerated cortical bone to retain the apatite

20 orientation.

SOLUTION TO PROBLEM

[0010] A dental implant fixture according to one aspect of the present invention includes a cylindrical body, a wide groove formed in a portion of a periphery of the body adjacent to a distal end of the body, and at least one narrow groove formed in a portion of the periphery adjacent to a basal end of the body. The at least one narrow groove includes a first bottom, a first side wall connecting to one end of the first bottom and nearer the distal end, and a second side wall connecting to another end of the first bottom and nearer the basal end. The first side wall is spaced more from a first reference plane extending through the first bottom and

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perpendicular to a central axis of the body as the first side wall is more away from the first bottom. The second side wall extends parallel to the first reference plane or is spaced more from the first reference plane as the second side wall is more away from the first bottom. In a section parallel to the central axis, the first side wall and the first reference plane form an angle α that is larger than an angle β formed by the second side wall and the first reference plane.

[0011] A dental implant according to another aspect of the invention includes the dental implant fixture according to the above aspect and a structural component attached to the basal end of the body of the dental implant fixture.

ADVANTAGEOUS EFFECTS

[0012] The dental implant fixture according to one or more embodiments of the present invention allows regenerated cortical bone to retain the apatite orientation.

BRIEF DESCRIPTION OF DRAWINGS

[0013] Fig. 1 is a side view of a dental implant fixture according to a first embodiment of the present invention.

Fig. 2 is an enlarged sectional view of a narrow groove of the dental implant fixture shown in Fig. 1.

Fig. 3 is an enlarged sectional view of a wide groove of the dental implant fixture shown in Fig. 1.

Fig. 4 is an enlarged sectional view of a narrow groove of a dental implant fixture according to a second embodiment of the present invention.

Fig. 5 is an enlarged sectional view of a wide groove of the dental implant fixture shown in Fig. 4.

Fig. 6A is a side view of a dental implant fixture according to a third embodiment of the present invention viewed at a different angle from the fixture shown in Fig. 1, and Fig. 6B is a schematic diagram showing a wide groove and a narrow groove of the dental implant fixture.

Fig. 7 is an enlarged side view of a basal end of the body of the dental implant fixture shown in Fig. 6A.

Fig. 8 is an enlarged sectional view of a boundary between the wide groove and the narrow groove of the dental implant fixture shown in Fig. 6A.

5 Fig. 9 is a side view of a dental implant according to one embodiment of the present invention.

Figs. 10A to 10C are schematic diagrams describing a dental implant surgical procedure according to the first embodiment of the present invention.

10 Figs. 11A to 11C are schematic diagrams describing a dental implant surgical procedure according to the second embodiment of the present invention.

DETAILED DESCRIPTION

Dental Implant Fixture

First Embodiment

15 [0014] A dental implant fixture according to a first embodiment of the present invention will now be described in detail with reference to Figs. 1 to 3.

[0015] As shown in Fig. 1, a fixture 1A according to the present embodiment includes a substantially cylindrical body 2. The body 2 includes a distal end 21 and a basal end 22. When the fixture 1A is implanted into a jaw 110 as shown in Figs. 10B and 10C described
20 later, the distal end 21 abuts a spongy bone 113 of an alveolar bone 111, and the basal end 22 abuts a cortical bone 112 of the alveolar bone 111.

[0016] As shown in Fig. 1, the body 2 further includes a periphery 23. The periphery 23 includes a distal portion 231, which is adjacent to the distal end 21, and a basal portion 232, which is adjacent to the basal end 22. When the fixture 1A is implanted into the jaw 110, the
25 distal portion 231 abuts the spongy bone 113, and the basal portion 232 abuts the cortical bone 112. In the present embodiment, the distal portion 231 has a larger area than the basal portion 232. The distal portion 231 tapers to have a smaller diameter from its middle portion toward the distal end 21.

[0017] The fixture 1A according to the present embodiment further includes a wide

groove 3 formed in the distal portion 231 of the periphery 23, and at least one narrow groove 4 formed in the basal portion 232 of the periphery 23. In other words, the fixture 1A according to the present embodiment includes a wide groove 3 formed in a portion of the periphery 23 of the body 2 adjacent to the distal end 21, and at least one narrow groove 4 formed in a portion of the periphery 23 of the body 2 adjacent to the basal end 22.

[0018] The wide groove 3 is a body thread. The wide groove 3 in the present embodiment is helical in the distal portion 231. In other words, the wide groove 3 in the present embodiment extends helically toward the distal end 21. The fixture 1A with this structure can be screwed into the alveolar bone 111 in a self-tapping manner and is implanted in the bone. The wide groove 3 in the present embodiment extends over the entire circumference of the distal portion 231. The wide groove 3 abuts the spongy bone 113 when the fixture 1A is implanted into the alveolar bone 111.

[0019] As shown in Figs. 10B and 10C, the narrow groove 4 is a microthread, which allows the cortical bone 112 to regenerate inside the groove. The narrow groove 4 has a substantially smaller groove width and a substantially smaller groove depth than the wide groove 3 described above. The groove width refers to the length of a straight line connecting the facing edges at an opening of the groove (wide groove 3 or narrow groove 4). The groove depth refers to the dimension of the groove in a direction perpendicular to the central axis S1 of the body 2. As shown in Fig. 1, the central axis S1 of the body 2 extends between and through the distal end 21 and the basal end 22 of the body 2, and functions as a rotation axis about which the fixture 1A rotates.

[0020] The narrow groove 4 in the present embodiment is helical in the basal portion 232. In other words, the narrow groove 4 in the present embodiment extends helically toward the basal end 22. The narrow groove 4 in the present embodiment extends over the entire circumference of the basal portion 232. The narrow groove 4 in the present embodiment is double-threaded, and includes a first narrow groove 4A and a second narrow groove 4B that are spaced from each other as shown in Fig. 2. The fixture may include one to four narrow grooves 4. When the fixture includes a plurality of narrow grooves 4, the narrow grooves 4 may have the same structure or different structures. In the present embodiment, the first

narrow groove 4A and the second narrow groove 4B have substantially the same structure. The first narrow groove 4A will be described. The same then applies to the second narrow groove 4B. The first narrow groove 4A may be described using reference numerals given to the parts of the second narrow groove 4B.

5 [0021] The first narrow groove 4A in the present embodiment includes a first bottom 41, a first side wall 42 connecting to a first end 41a of the first bottom 41, and a second side wall 43 connecting to a second end 41b of the first bottom 41. The first bottom 41 is a portion of the first narrow groove 4A including the deepest groove area. The first side wall 42 is nearer the distal end 21 of the body 2. The second side wall 43 is nearer the basal end 22 of the
10 body 2. In the present embodiment, the first side wall 42 and the second side wall 43 are both flat.

[0022] In the present embodiment, the first side wall 42 is spaced more from a first reference plane S2 as being more away from the first bottom 41, or in other words as being outward from the first bottom 41 in the direction of arrow A. The second side wall 43 is
15 spaced more from the first reference plane S2 as being more away from the first bottom 41. In a section parallel to the central axis S1 in Fig. 2, the first side wall 42 and the first reference plane S2 form an angle α that is larger than an angle β formed by the second side wall 43 and the first reference plane S2. In other words, the angle α and the angle β have the relationship written as $\alpha > \beta$. This structure guides the cortical bone 112 into the first narrow groove 4A
20 to regenerate while retaining its apatite orientation. This accelerates bone formation and enables the bone quality to be maintained over a long period of time.

[0023] Experiments described below were conducted to examine the relationship between the angle α and the angle β . In the in vivo experiments, a fixture was implanted in the tibia of a rabbit, and a load was repeatedly applied to the fixture. A histomorphological analysis
25 was then conducted using the bone area ratio and the bone contact ratio. A three-dimensional structure analysis was conducted using parameters such as bone volume fraction (BVF), trabecular number (Tb.N), trabecular thickness (Tb.Th), trabecular separation (Tb.Sp), and bone mineral density (BMD). Further, the number of bone cells generated in the grooves and the apatite orientation were examined. The results show that the groove

satisfying $\alpha > \beta$ allowed a larger amount of new bone and a larger number of bone cells to be generated than the groove satisfying $\alpha < \beta$. In either the groove satisfying $\alpha > \beta$ or $\alpha < \beta$, the orientation of apatite was observed along the side walls of the groove. However, the results indicating the amount of bone and the bone quality were better for the groove satisfying $\alpha > \beta$ than for the groove satisfying $\alpha < \beta$.

[0024] Being outward as described above refers to being toward the outside of the fixture 1A from the first bottom 41, or being in a direction opposite to the inside where the central axis S1 is. The above first reference plane S2 refers to a plane that extends through the first bottom 41 and is perpendicular to the central axis S1 of the body 2.

[0025] The angle α and the angle β are both acute angles. The angle α may preferably be 40 to 65°, and may more preferably be 45 to 60°. The angle β may preferably be 1 to 15°, and may more preferably be 5 to 10°.

[0026] In the present embodiment, the first narrow groove 4A has an opening 46 with edges 46a and 46b facing each other in the sectional view described above. Of the edges 46a and 46b, the edge 46a at the second side wall 43 is curved outward. This structure reduces bone resorption.

[0027] The fixture in the present embodiment has the structure described below to guide the cortical bone 112 into the first narrow groove 4A to regenerate while retaining the apatite orientation. In the sectional view described above, more specifically, a first junction 44 connecting the first bottom 41 and the first side wall 42 is nearer the central axis S1 than a second junction 45 connecting the first bottom 41 and the second side wall 43. In the sectional view described above, the length L42 of the first side wall 42 is larger than the length L43 of the second side wall 43. In the present embodiment, as described above, the edge 46a of the first narrow groove 4A is curved outward. In the present embodiment, the length L43 of the second side wall 43 is determined from a reference position being an end 46a1 of the edge 46a nearer the first bottom 41.

[0028] In the present embodiment, the first bottom 41 is curved inward in the sectional view described above. The first narrow groove 4A with this structure has a larger surface area and a larger volume while retaining its strength. This structure thus allows a large

amount of the cortical bone 112 to be guided into the first narrow groove 4A to regenerate while retaining the apatite orientation. When, for example, the first narrow groove 4A is cleaned with a cleaning tool, such as a titanium brush, the first narrow groove 4A allows smooth movement of the brush end along the groove profile, and thus can be cleaned effectively. Being inward as described above refers to being toward the inside of the fixture 1A from the first side wall 42 and the second side wall 43, or being toward the central axis S1.

[0029] As described above, the first bottom 41 in the present embodiment is curved inward in the sectional view described above. The curve includes a parabola, an ellipse arc, and an arc. The first bottom 41 in the present embodiment has an arc shape that is curved inward in the sectional view described above. More specifically, the first bottom 41 in the present embodiment has an arc shape that is curved inward and has a center O satisfying specific positional relationships described below.

[0030] More specifically, the first straight line L1 and the second straight line L2 are defined in the above sectional view in the manner described below.

The first straight line L1 connects the facing edges 46a and 46b at the opening 46 of the first narrow groove 4A. In the present embodiment, as described above, the edge 46a of the first narrow groove 4A is curved outward. In the present embodiment, the first straight line L1 is determined from a reference position being an end 46a2 of the edge 46a less near the first bottom 41.

The second straight line L2 extends through a middle point M of the first straight line L1 and is perpendicular to the central axis S1.

[0031] The center O of the first bottom 41 satisfies the positional relationships (i) and (ii) described below with the first straight line L1 and the second straight line L2.

(i) The center O of the first bottom 41 is nearer the central axis S1 than the first straight line L1.

(ii) The center O of the first bottom 41 is nearer the basal end 22 of the body 2 than the second straight line L2.

[0032] The above structure can enhance the advantageous effects produced by increasing the surface area and the volume of the first narrow groove 4A while retaining its strength,

among the advantageous effects described above produced by the first bottom 41 curved inward. This structure also allows capillaries having diameters of a few hundred micrometers to enter the first narrow groove 4A and reach the first bottom 41. This structure is thus expected to increase the amount of new bone and improve the contact ratio between the bone and the fixture 1A.

[0033] In the sectional view described above, the first narrow groove 4A in the present embodiment has a groove width W larger than a groove depth D at the opening 46. This structure allows the cortical bone 112 to be more easily guided into the first narrow groove 4A while retaining the apatite orientation. In the present embodiment, the edge 46a of the first narrow groove 4A is curved outward as described above. In the present embodiment, the groove width W is determined from a reference position being the end 46a1 of the edge 46a adjacent to the first bottom 41.

[0034] In the present embodiment, the wide groove 3 described above has substantially the same structure as the narrow groove 4. More specifically, as shown in Fig. 3, the wide groove 3 in the present embodiment includes a second bottom 31, a third side wall 32, which connects to a first end 31a of the second bottom 31 and is nearer the distal end 21, and a fourth side wall 33, which connects to a second end 31b of the second bottom 31 and is nearer the basal end 22. In the same manner as for the first side wall 42 of the narrow groove 4, the third side wall 32 is spaced more from a second reference plane S3, which extends through the second bottom 31 and is perpendicular to the central axis S1, as being more away from the second bottom 31. As described above, in the present embodiment, the second side wall 43 of the narrow groove 4 is spaced more from the first reference plane S2 as being more away from the first bottom 41. Thus, the fourth side wall 33 of the wide groove 3 is also spaced more from the second reference plane S3 as being more away from the second bottom 31. In the section parallel to the central axis S1 shown in Fig. 3, the third side wall 32 and the second reference plane S3 form an angle γ that is larger than an angle δ formed by the fourth side wall 33 and the second reference plane S3. In other words, the angle γ and the angle δ have the relationship written as $\gamma > \delta$. This structure has less structural changes from the wide groove 3 to the narrow groove 4, and thus allows easy implantation of the fixture 1A

when the fixture 1A is implanted into the alveolar bone 111 by first placing the wide groove 3 and then placing the narrow groove 4. This reduces osteonecrosis. Further, this structure reduces obstructing factors in guiding the cortical bone 112 into the narrow groove 4 to regenerate while retaining the apatite orientation, and can accelerate bone remodeling. The wide groove 3 may not have substantially the same structure as the narrow groove 4, and may have any other structure that achieves its intended functions.

[0035] In the present embodiment, the angle α at the first side wall 42 of the narrow groove 4 is larger than the angle γ at the third side wall 32 of the wide groove 3. Further, the angle β at the second side wall 43 of the narrow groove 4 is the same as the angle δ at the fourth side wall 33 of the wide groove 3. More specifically, in the present embodiment, the angle α and the angle γ have the relationship written as $\alpha > \gamma$, whereas the angle β and the angle δ have the relationship written as $\beta = \delta$. This structure allows easy implantation of the fixture 1A into the alveolar bone 111. Although the angle α is 50° , the angle β is 10° , the angle γ is 45° , and the angle δ is 10° in the present embodiment, the angles may not be these degrees. The angles β and δ being the same refer to the angles β and δ being substantially the same. The same applies to the embodiments described below.

[0036] The fixture 1A according to the above embodiment may preferably be manufactured by additive manufacturing. This method can form the fixture 1A with high processing accuracy. The fixture 1A may be manufactured with methods other than additive manufacturing. For example, the fixture 1A may be manufactured by cutting.

Second Embodiment

[0037] A fixture according to a second embodiment of the present invention will now be described in detail with reference to Figs. 4 and 5. In Fig. 4 and Fig. 5, the structural parts that are the same as the corresponding parts shown in Figs. 1 to 3 may be given the same reference numerals, and may not be described.

[0038] As shown in Fig. 4, a fixture 1B according to the present embodiment includes a second side wall 43 of a narrow groove 4 extending parallel to a first reference plane S2. In other words, the fixture 1B according to the present embodiment includes the second side wall 43 and the first reference plane S2 forming an angle β of 0° . The angle α and the angle

β have the relationship written as $\alpha > \beta$. This structure allows the cortical bone 112 to be more easily guided into the narrow groove 4 while retaining the apatite orientation. The second side wall 43 may extend substantially parallel to the first reference plane S2.

[0039] In the fixture 1B in the present embodiment, as shown in Fig. 5, the wide groove 3 has substantially the same structure as the narrow groove 4. More specifically, in the present embodiment described above, the second side wall 43 of the narrow groove 4 also extends parallel to the first reference plane S2, and thus the fourth side wall 33 of the wide groove 3 extends parallel to the second reference plane S3. In other words, the fourth side wall 33 and the second reference plane S3 form an angle δ of 0° . Thus, the angle γ and the angle δ have the relationship written as $\gamma > \delta$. As in the first embodiment described above, this structure has less structural changes from the wide groove 3 to the narrow groove 4, and thus allows easy implantation of the fixture 1B when the fixture 1B is implanted into the alveolar bone 11 by first placing the wide groove 3 and then placing the narrow groove 4. This reduces osteonecrosis. This structure reduces obstructing factors in guiding the cortical bone 112 into the narrow groove 4 to regenerate while retaining the apatite orientation, and can accelerate bone remodeling. The fourth side wall 33 may extend substantially parallel to the second reference plane S3.

[0040] In the present embodiment, the angle α at the first side wall 42 of the narrow groove 4 and the angle γ at the third side wall 32 of the wide groove 3 are the same. More specifically, in the present embodiment, the angle α and the angle γ have the relationship written as $\alpha = \gamma$. This structure allows easy implantation of the fixture 1B into the alveolar bone 111. Although the angle α and the angle γ are both 45° in the present embodiment, these angles are not limited to this degree.

The other structural parts are the same as the corresponding parts of the fixture 1A according to the first embodiment, and thus will not be described.

Third Embodiment

[0041] A dental implant fixture according to a third embodiment of the present invention will now be described in detail with reference to Figs. 6A to 8. In Figs. 6A to 8, the structural parts that are the same as those shown in Figs. 1 to 5 may be given the same

reference numerals and may not be described.

[0042] As shown in Figs. 6A and 6B, a fixture 1C according to the present embodiment includes a wide groove 3 formed in a portion of the periphery 23 adjacent to the distal end 21 of the body 2, and at least one narrow groove 4 formed in a portion of the periphery 23 adjacent to the basal end 22 of the body 2.

[0043] In the present embodiment, the portion of the periphery 23 including the wide groove 3 tapers to have a smaller diameter from its middle toward the distal end 21. Further, the portion of the periphery 23 including the wide groove 3 has a larger area than the portion of the periphery 23 including the narrow groove 4.

[0044] The narrow groove 4 in the present embodiment is double-threaded, and includes two grooves, namely a first narrow groove 4A and a second narrow groove 4B that are spaced from each other. In the present embodiment, the first narrow groove 4A and the second narrow groove 4B have substantially the same structure.

[0045] In the present embodiment, the wide groove 3 and the narrow groove 4 both extend helically. This structure reduces the resistance produced against the fixture 1C when it is implanted into the alveolar bone 111.

[0046] In the present embodiment, a boundary 5 between the wide groove 3 and the narrow groove 4 includes a portion 31 of the wide groove 3 adjacent to the basal end 22 and a portion 47 of the narrow groove 4 adjacent to the distal end 21. The portion 31 and the portion 47 extend parallel to each other. The fixture 1C has the boundary 5 allowing gradual structural changes from the wide groove 3 to the narrow groove 4. This structure thus maintains a constant resistance produced against the fixture 1C when the fixture 1C is implanted into the alveolar bone 111 by first placing the wide groove 3 and then placing the narrow groove 4. For the boundary 5 between the wide groove 3 and the narrow groove 4, the area of the periphery 23 of the body 2 excluding the wide groove 3 and the narrow groove 4 is small. This structure reduces the resistance produced against the fixture 1C when it is implanted into the alveolar bone 111. These advantageous effects, in combination with the above advantageous effects produced by the wide groove 3 and the narrow groove 4 that both extend helically, allow easy implantation of the fixture 1C into the alveolar bone 111. This

reduces osteonecrosis. Further, this structure reduces obstructing factors in guiding the cortical bone 112 into the narrow groove 4 to regenerate while retaining the apatite orientation, and can accelerate bone remodeling.

[0047] As shown in Fig. 6B, the boundary 5 between the wide groove 3 and the narrow groove 4 is a portion including an end 48 of the narrow groove 4 adjacent to the distal end 21 and an end 32 of the wide groove 3 adjacent to the basal end 22. In Fig. 6B, the lines indicating the wide groove 3 are drawn along the second bottom 31 of the wide groove 3 (refer to Figs. 3 and 5). The same applies to the narrow groove 4. In Fig. 6B, the lines indicating the narrow groove 4 are drawn along the first bottom 41 of the narrow groove 4 (refer to Figs. 2 and 4).

[0048] The portion 31 of the wide groove 3 and the portion 47 of the narrow groove 4 extending parallel to each other refer to the portions 31 and 47 extending side by side. The portions 31 and 47 extending parallel to each other may be spaced from each other, or may partially merge with each other. The portions 31 and 47 partially merging with each other refer to the portions 31 and 47 having their parts merging with each other within the range that enables the individual intended functions of the portions 31 and 47. In the present embodiment, the portions 31 and 47 extend parallel to each other with their parts merging each other as shown in Figs. 7 and 8. This structure allows smooth structural changes from the wide groove 3 to the narrow groove 4.

[0049] In the present embodiment, as shown in Fig. 6A, the boundary 5 between the wide groove 3 and the narrow groove 4 includes the portion 31 of the wide groove 3 and the portion 47 of the narrow groove 4 extending parallel to each other in the state described below. In the present embodiment, the portions 31 and 47 extend parallel to each other to have a point 47a with the largest groove depth D4 in the portion 47 of the narrow groove 4 substantially in the middle of the boundary 5 between the wide groove 3 and the narrow groove 4.

[0050] In the present embodiment, the portions 31 and 47 extend parallel to each other to have an angle $\theta 1$ formed by a reference line S4 parallel to the central axis S1 and the portion 31 of the wide groove 3 larger than an angle $\theta 2$ formed by the reference line S4 and the

portion 47 of the narrow groove 4. In the present embodiment, the angle θ_1 is larger than the angle θ_2 . In other words, the angle θ_1 and the angle θ_2 have the relationship written as $\theta_1 > \theta_2$ in the present embodiment.

[0051] The angle θ_1 and the angle θ_2 may preferably be both acute angles. In the boundary 5 between the wide groove 3 and the narrow groove 4, the portion 31 of the wide groove 3 smoothly continues to the end 32 of the wide groove 3 adjacent to the basal end 22, and the portion 47 of the narrow groove 4 smoothly continues to the point 47a at the largest groove depth D4. This allows smooth structural changes from the wide groove 3 to the narrow groove 4. The angle θ_1 may preferably be 15 to 25°, and the angle θ_2 may preferably be 10 to 20°. The angles may not be these degrees.

[0052] In the present embodiment, the portion 31 of the wide groove 3 has a smaller groove depth D3 toward the basal end 22, whereas the portion 47 of the narrow groove 4 has a larger groove depth D4 toward the basal end 22. In this structure as well, the portion 31 of the wide groove 3 smoothly continues to the end 32, and the portion 47 of the narrow groove 4 smoothly continues to the point 47a at the largest groove depth D4 in the boundary 5 between the wide groove 3 and the narrow groove 4. This allows smooth structural changes from the wide groove 3 to the narrow groove 4.

[0053] The body 2 in the present embodiment further includes a bevel 6 at the basal end 22. When the fixture 1C is viewed in the direction perpendicular to the central axis S1, the bevel 6 in the present embodiment has a substantially trapezoidal shape having its long side 61 nearer the distal end 21. As shown in Fig. 11C described below, the bevel 6 protrudes from the cortical bone 112 when the fixture 1C is implanted into the alveolar bone 111. The long side 61 of the bevel 6 is at the boundary between the cortical bone 112 and a gingiva 101, and thus defines a bone edge line L.

[0054] In the present embodiment, as shown in Fig. 7, an end 49 of the narrow groove 4 adjacent to the basal end 22 is nearer the distal end 21 than the bone edge line L adjacent to the basal end 22 of the periphery 23. This structure has tighter seal, and increases the strength of the fixture 1C. In the present embodiment, the end 49 of the narrow groove 4 is near the bone edge line L. This structure increases the area occupied by the narrow groove 4.

As shown in Fig. 6B, the narrow groove 4 in the present embodiment has a smaller groove depth D4 toward the end 49.

The other structural parts are the same as the corresponding parts of the fixtures 1A and 1B according to the first and second embodiments, and will not be described.

5 Dental Implant

[0055] A dental implant according to one embodiment of the present invention including the fixture 1A according to the first embodiment described above will now be described in detail with reference to Fig. 9.

[0056] As shown in Fig. 9, a dental implant 10 according to the present embodiment
10 includes the fixture 1A and an artificial tooth 11. The artificial tooth 11 is a structural component attached to the basal end 22 of the body 2 of the fixture 1A.

[0057] The artificial tooth 11 is formed artificially from, for example, a metal, ceramics, or a rigid resin. The artificial tooth 11 is usually custom-made, and is attached to the basal end 22 of the fixture 1A with an abutment 12. The artificial tooth 11 may be a single tooth
15 or a bridge. The artificial tooth 11 may be replaced by another artificial tooth as a structural component. Examples of such other artificial teeth include dental prostheses. Examples of dental prostheses include dentures, such as partial dentures and full dentures. A denture is removably attached to the basal end 22 of the fixture 1A with an attachment.

[0058] The fixture 1A described in the present embodiment may be replaced by the
20 fixture 1B or the fixture 1C to form a dental implant that has the same advantageous effects as described above.

Dental Implant Surgical Procedure

First Embodiment

[0059] A dental implant surgical procedure according to the first embodiment of the
25 present invention using the fixture 1A according to the first embodiment will now be described in detail with reference to Figs. 10A to 10C.

[0060] As shown in Fig. 10A, an implant hole 100 is first bored into the gingiva 101 and the alveolar bone 111 of the jaw 110 with a drill or another tool. The implant hole 100 in the present embodiment is slightly smaller than the fixture 1A.

[0061] As shown in Fig. 10B, the fixture 1A is implanted into the implant hole 100. After the healing period of several weeks to several months, the cortical bone 112 regenerates inside the narrow groove 4. In the present embodiment, as described above, the angle α at the first side wall 42 of the narrow groove 4 and the angle β at the second side wall 43 of the narrow groove 4 have the relationship written as $\alpha > \beta$. The cortical bone 112 is guided into the narrow groove 4 to regenerate while retaining its apatite orientation. The procedure in the present embodiment is expected to accelerate bone formation and maintain the bone quality over a long period of time.

[0062] During the healing period, a healing cap 13 may be attached to the basal end 22 to protect the gingiva 101 as shown in Fig. 10B. After the fixture 1A is anchored to the jaw 110, the healing cap 13 is removed from the basal end 22 as shown in Fig. 10C. A structural component, such as the artificial tooth 11, is then attached to the basal end 22 to complete a dental implant. This completes the procedure.

Second Embodiment

[0063] A dental implant surgical procedure according to a second embodiment of the present invention using the fixture 1C according to the third embodiment will now be described in detail with reference to Figs. 11A to 11C. In Figs. 11A to 11C, the structural parts that are the same as the parts shown in Figs. 10A to 10C may be given the same reference numerals, and may not be described.

[0064] As shown in Fig. 11A, an implant hole 100 is first bored into the gingiva 101 and the alveolar bone 111 in the same manner as in the first embodiment.

[0065] As shown in Fig. 11B, the fixture 1C is then implanted into the bored implant hole 100. In the present embodiment, as described above, the wide groove 3 and the narrow groove 4 both extend helically, and the portion 31 of the wide groove 3 adjacent to the basal end 22 and the portion 47 of the narrow groove 4 adjacent to the distal end 21 extend parallel to each other in the boundary 5 between the wide groove 3 and the narrow groove 4. The fixture 1C with this structure can be smoothly implanted into the implant hole 100 (alveolar bone 111). This reduces osteonecrosis. Further, this structure reduces obstructing factors in guiding the cortical bone 112 into the narrow groove 4 to regenerate while retaining the

apatite orientation, and can accelerate bone remodeling.

[0066] After the fixture 1C is implanted into the implant hole 100, the fixture 1C is anchored to the jaw 110 as shown in Fig. 11C in the same manner as in the first embodiment. A structural component is then attached to the basal end 22 to complete a dental implant.

5 This completes the procedure.

[0067] The fixtures 1A and 1C described in the first and second embodiments may be replaced by the fixture 1B to produce the same advantageous effects as described above.

CLAIMS

1. A dental implant fixture, comprising:

a cylindrical body;

a wide groove formed in a portion of a periphery of the body adjacent to a distal end

5 of the body; and

at least one narrow groove formed in a portion of the periphery adjacent to a basal
end of the body,

the at least one narrow groove including

a first bottom,

10 a first side wall connecting to one end of the first bottom, the first side wall
being nearer the distal end, and

a second side wall connecting to another end of the first bottom, the second
side wall being nearer the basal end,

wherein the first side wall is spaced more from a first reference plane extending
15 through the first bottom and perpendicular to a central axis of the body as the first side wall is
more away from the first bottom,

the second side wall extends parallel to the first reference plane or is spaced more
from the first reference plane as the second side wall is more away from the first bottom, and

in a section parallel to the central axis, the first side wall and the first reference plane
20 form an angle α that is larger than an angle β formed by the second side wall and the first

reference plane,

wherein in the section, an opening of the at least one narrow groove has facing edges one of which is adjacent to the second side wall and is curved outward.

2. The dental implant fixture according to claim 1, wherein

5 the second side wall extends parallel to the first reference plane.

3. The dental implant fixture according to claim 1 or claim 2, wherein in the section, the first side wall is longer than the second side wall.

4. The dental implant fixture according to any one of claims 1 to 3, wherein

10 in the section, a first junction connecting the first bottom and the first side wall is nearer the central axis than a second junction connecting the first bottom and the second side wall.

5. The dental implant fixture according to any one of claims 1 to 4, wherein in the section, the first bottom is curved inward.

6. The dental implant fixture according to any one of claims 1 to 5, wherein

15 in the section, the first bottom has an arc shape that is curved inward and has a center nearer the central axis than a first straight line and is nearer the basal end than a second straight line, where the first straight line connects facing edges at an opening of the at least one narrow groove, and the second straight line extends through a middle point of the first straight line and is perpendicular to the central axis.

7. The dental implant fixture according to any one of claims 1 to 6, wherein
in the section, the at least one narrow groove has a groove width larger than a groove
depth at an opening.

8. The dental implant fixture according to any one of claims 1 to 7, wherein
5 the at least one narrow groove includes a first narrow groove and a second narrow
groove that are spaced from each other.

9. The dental implant fixture according to any one of claims 1 and 3 to 8,
wherein the wide groove includes
a second bottom,
10 a third side wall connecting to one end of the second bottom, the third side
wall being nearer the distal end,
a fourth side wall connecting to another end of the second bottom, the fourth
side wall being nearer the basal end,
wherein the third side wall is spaced more from a second reference plane extending
15 through the second bottom and perpendicular to the central axis as the third side wall is more
away from the second bottom,
the fourth side wall extends parallel to the second reference plane when the second
side wall extends parallel to the first reference plane,
the fourth side wall is spaced more from the second reference plane as the fourth side

wall is more away from the second bottom when the second side wall is spaced more from the first reference plane as the second side wall is more away from the first bottom, and

in a section parallel to the central axis, the third side wall and the second reference plane form an angle γ that is larger than an angle δ formed by the fourth side wall and the second reference plane.

10. The dental implant fixture according to any one of claims 1 to 9, wherein the wide groove and the at least one narrow groove extend helically.

11. The dental implant fixture according to claim 10, wherein

in a boundary between the wide groove and the at least one narrow groove, a portion

of the wide groove adjacent to the basal end and a portion of the at least one narrow groove adjacent to the distal end extend parallel to each other.

12. The dental implant fixture according to claim 11, wherein

the portion of the wide groove and the portion of the at least one narrow groove extend parallel to each other and partially merge with each other.

13. The dental implant fixture according to claim 11 or claim 12, wherein

the portion of the wide groove and a reference line parallel to the central axis form an angle θ_1 that is larger than an angle θ_2 formed by the reference line and the portion of the at least one narrow groove.

14. The dental implant fixture according to claim 13, wherein

the angle θ_1 and the angle θ_2 are acute angles.

15. The dental implant fixture according to any one of claims 11 to 14, wherein
the portion of the wide groove has a groove depth that is smaller toward the basal
end, and

5 the portion of the at least one narrow groove has a groove depth that is larger toward
the basal end.

16. The dental implant fixture according to any one of claims 11 to 15, wherein
an end of the at least one narrow groove adjacent to the basal end is nearer the distal
end than a bone edge line of the periphery adjacent to the basal end.

10 17. The dental implant fixture according to claim 16, wherein
the end of the at least one narrow groove adjacent to the basal end is near the bone
edge line.

18. A dental implant, comprising:

a dental implant fixture according to any one of claims 1 to 17; and

15 a structural component attached to the basal end of the body of the dental implant
fixture.