

The invention relates to a dental implant having the features of the pre-characterising portion of claim 1.

DE-A-35 33 395 discloses such a dental implant, the primary or post part of which has a stepped cylindrical outer contour. The post part is insertable in a correspondingly stepped bore with correspondingly formed bore regions. The stepped outer contour of the post part is said to lead to the most effective transmission of force into the jawbone and inhibits a wedging action which can occur with conical outer contours. The steps of the post part have a smooth outer surface and possess differing heights in the axial direction. Ring grooves with O-rings are provided in a recess in the interior of the post part, to enable movement of an inserted pin of the head part.

A ceramic bone implant is known from DE-A-26 28 443, which has a thread with a cylindrical core, which has a constant outer diameter over the whole length. Circular or radial recesses are provided in the thread region for new infiltrating bone tissue. This dental implant must be screwed into a prepared cylindrical bore in the jawbone over its entire length, and this involves a danger of traumatisation of the cortex. Difficulties can also arise if at the beginning of the insertion of the dental implant its axis does not match with the axis of the prepared cylindrical bore of the jawbone and consequently the wall of the bore and ultimately the jawbone is damaged by the diagonally inserted post part, and in particular its apical end.

A dental implant is known from DE-C-26 19 650, the post part of which is formed with multiple steps in the apical direction. The outer surface of the individual steps are formed essentially cylindrically and contain recesses, into which the bone tissue can penetrate. The post part forms an integral unit with the head part, the head part having a surrounding ring in the region where it emerges from the mucous membrane. After implantation, during the phase of growth into the jawbone, undesirable forces can be exerted on the head part in the region where it emerges from the mucous membrane, whereby the growth of tissue on the post part and the formation of bone and consequently the anchorage of the post part can be adversely affected.

Further, attention is drawn to the earlier, not pre-published European patent application EP-A-424734 (state of the art under Article 54(3) EPC), which relates to a bone screw. With such a bone screw prostheses can be fixed to bones with regions of differing strength. This bone screw contains a middle part, which penetrates the region of the bone marrow and is provided with a conical thread. An apical threaded part is provided with a double thread and is to be screwed into an outer solid bone region. The bore to be formed in the bone is correspondingly conically formed, even for those applications in which bone screws with cylindrical threads are considered unsuitable and disadvantageous. In the intermediate region between the middle thread part and the apical thread part the outer diameter of the tooth points of both threads of the apical thread part is greater than the core diameter of the middle thread part.

Further, a dental implant is known from GB-A-2176709, the post part of which has a conical outer contour with a conical thread. The conical thread extends practically over the whole length of the post part, a cylindrical flange being provided only at the crown end, on which the head part lies after connection by means of a screw. The post part must be screwed into the jawbone over practically its entire length, for which a large number of rotations is required depending on the pitch of the thread and traumatisation of the jawbone tissue can hardly be avoided.

The object of the invention is to develop the dental implant of the kind first mentioned above, so that a functionally secure anchorage of the replacement tooth is enabled using an atraumatic operating technique. The dental implant should also be formed such that it can be implanted in a short time and should reliably meet requirements for high resistance to bacterial penetration. The dental implant should also have a functionally secure construction and assure convenient handling during and after implantation. The phase of growth into the jaw should be able to proceed without being disturbed by external influences and after installation of the replacement tooth the occurrence of undesirable gaps and/or transitions which adversely affect the formation of mucous membrane should be avoided.

This object is achieved through the features set out in the characterising portion of claim 1.

The dental implant of the invention assures a functionally reliable anchoring of the substitute tooth, at least one stepped portion of the post having a screw thread, and the post part being insertable during implantation into the jawbone leaving only one step exposed, so that the post only needs to be screwed into the jawbone to a depth corresponding to the length of one step. In contrast to previously known implants which are screwed in over the entire length of the thread, a comparatively non-traumatic operating technique is thereby provided, since the screwing has to be done over only a fraction of the total length of the thread or post. If four steps are provided, the post is simply inserted into the bore in the bone to $3/4$ of its total length and then is screwed in by only $1/4$ of its length, thereby very elegantly avoiding any traumatising of the cortex by the screw thread. The screw thread provided on at least one step results in better primary stability in comparison with posts that have no thread and whose entire length is inserted into the bore in the bone. The particularly proposed configuration also assures quick implantation, in as much as the simple insertion of the post already achieves a good alignment of the post with the longitudinal axis of the bore, and when the screwing begins the axis of the post is in line with the longitudinal axis. The step at the crown end advantageously may have a cylindrical outer surface to assure intimate contact with the inside wall of the portion of the bore that has the largest diameter. In a particular preferred embodiment, there are no threads or mechanical retaining means in the area of the uppermost step with the greatest diameter, which significantly improves hygiene in the area of an implant.

At least two, preferably three, steps are threaded, each having essentially the same length. This substantially improves implantation and screwing in of the post. Before any rotational motion and cutting of threads occurs, the post can be inserted into the jawbone, which is bored with matching steps, until virtually all that is lacking is the length of only one more step to reach the final depth of implantation. Then the post needs only to be turned with the self-tapping threads for the length of just one step and anchored in the jawbone. Nonetheless the threads of all the steps carry the load. The result is a substantial reduction in the stress and strain on the tissues in comparison with a thread having a substantially uniform diameter over its entire length. Particularly if three steps are provided, and the threads can be given, for example, four turns on the longitudinal axis to cover the length of the step, then four turns are all that are needed to anchor the post fully. In comparison, a post without steps and with a diameter that is constant over three times the length of one such step, and threaded with the same pitch as in the stepped configuration according to the invention, would require a total of twelve turns to be anchored. Even so, the dental implant of the invention is supported by the entire length of the threads on the steps. Due to the stepped configuration of the post and the fact that the outside diameter of the threads of the step next to the root end is made equal to or less than the outside diameter of the preceding step, the tissues are optimally protected in an especially reliable manner.

In one preferred embodiment, the bottom face of the head lies tightly against the post anchored in the bone, thus reliably preventing the entry of bacteria. The bottom face of the head is axially biased against the upper face of the post. The head is a component that is pre-manufactured and packaged and consists especially of metal. The post is advantageously coated with hydroxyapatite, while the head is provided with a ceramic coating, particular in the area of the face and adjacent surfaces. The face of the head is a planar surface orthogonal to the longitudinal axis. The ceramic coating, which of course is extremely hard, can be worked and ground flat as necessary with comparatively little difficulty. The head advantageously may comprise two parts, namely the actual crown holder and a coupling element which is to be fastened in a bore in the post. The crown holder includes the aforementioned ceramic-coated face which provides the tight, gap-free contact under bias, with the corresponding face of the post. Since the head is joined directly to the post, no spacing sleeve is needed. The crown holder or head and the post contact each other at a single area, namely between the aforementioned face and the bearing face of the post.

The invention will be explained in further detail with reference to an illustrative embodiment shown in the accompanying drawings wherein:

Figure 1 is a side elevation of the dental implant of the invention partially in section along its axial plane;

Figure 2 is an exploded view of the post and coupling element;

Figure 3 is a view similar to Figure 2 but with the coupling element inserted.

Figure 1 shows the dental implant partially in elevation and partially in an axial longitudinal section, with a post 2 which can be anchored in the jawbone, and a head 4 which can be joined to the post. The head 4 is constructed in two pieces, a coupling element 6 and a crown support 8. It is also within the scope of the invention, however, to construct the head 4 in one piece. The important thing in all configurations is that the bottom face 10, which in the illustrated embodiment is the bottom end of the crown support, is in close contact, preferably biased contact, against the bearing surface 12 of the post 2. Otherwise, the relationships and advantages described below in connection with the two-part configuration, as regards the formation of the bottom face 10 of the crown support 8, apply similarly to a one-piece head. The head 4, and in the case of the bipartite configuration shown here, its pot-shaped crown support 8 has an outer surface that tapers toward the post 2. The bottom face 10 is thus smaller than it would be in the case of a cylindrical configuration with an outside diameter corresponding to that of the post 2. Due to this "reduction" of the bottom face 10, it is easier to work, and especially to grind or mill flat the ceramic coating applied to the face 10. The bottom face 10 and likewise at least a portion of the preferably conical outer surface 9 are provided with this ceramic oxide coating which may have a thickness ranging from a few micrometres to a few millimetres. The face 10 coated in this manner forms the one and only surface of the head 4 which must fit with the post 2, and it can be ground flat and/or polished with very great precision.

The ceramic coating 11 on the outer surface 9 advantageously has a comparatively great thickness, as is indicated by the broken lines. The coating thickness is preferably established by making its outside diameter at its bottom face 10 substantially equal to the outside diameter of step 18 of post 2 at the bearing surface 12. Thus a desirably smooth transition is created from the head 4 to the post 2. In the case of such great thicknesses of the coating 11, it is possible within the scope of the invention for the end face of the crown support 8 to be set back a given distance from the bearing surface 12, because then the face 10 will be a part of the ceramic coating 11. Due to the comparatively great thickness of the coating 11, any applied force will be transmitted from the crown support 8 through the coating 11 and its bottom face to the bearing surface 12 of the post 2. The coating 11 is part of the head 4, and the bias is applied through the end face 10 regardless of the thickness of the coating.

The post 2 is formed of metal, particularly of titanium or a titanium alloy, the bearing surface 12 and/or the outer surface 14 being provided with a biologically compatible coating, especially of hydroxyapatite. The post 2 has a stepped profile in which the diameters of successive steps decrease toward the

root end 16 of the post. The top step 18 adjacent the head 4 has a cylindrical outer surface while the three other steps 20 to 22 have self-tapping threads 24 to 26 for turning and cutting into the jawbone. The three steps 20 to 22 provided with the threads are each of substantially the same length 23. It is especially important that the self-tapping thread 26 of step 22 adjacent the root end 16 has an outer diameter 27 that is no greater than the base diameter 29 of the next step 21 toward the head 4; the same applies to threads 25 and 24 with regard to the diameters of the steps 20 and 18 which are successively closer to the head part. As a general rule in accordance with the invention, the thread outer diameter of one step is equal to or smaller than the core diameter of the next-larger step. This assures that the dental implant can be inserted into a similarly stepped bore drilled in the jawbone such that afterwards it needs to be screwed in only one step deeper. Nonetheless, optimal and full seating is assured throughout the length of all, in the present case three, steps. It is to be understood that the bore must first be drilled into the jawbone so that the dental implant can be inserted sufficiently deeply into the prepared bore that it will need to be screwed in only one more step-length. It has furthermore been found to be especially desirable to provide the step 18 adjacent the head 4 with a substantially cylindrical outer surface 14 whose outside or core diameter is at least equal to the outside diameter of step 20 which adjoins it toward the apical end 16.

The threads 24 to 26 of the three steps 20 to 22 are of different diameters but of the same thread pitch. The cores of the threads have a uniform diameter over the entire length of the step and the difficulties encountered with conical threading and/or tapered posts are avoided. Where a plurality of threaded steps are provided, the steps will each have substantially the same axial length. It is considered within the scope of the invention to provide only a single threaded step, for hygienic reasons in the implant area, at least the step which is adjacent the head 4, and has the greatest diameter, having no thread. Basically, the post can thus have a first thread at the root end, which will be adjoined by the second step with a substantially smooth outside surface; each of these steps consequently will account for substantially half of the total length of the post. Embodiments having two threaded steps also lie within the scope of this invention. The illustrated embodiment, with three steps provided with threads, has been found to be especially desirable. In this embodiment, at least approximately three thread flights are provided on each of the threaded steps, so that only three turns are needed to screw it in. Since the post is simply inserted into the stepped bore in the jawbone leaving only the length of one step exposed, and then is screwed in for the length of only one step with three turns, the operating time is minimised without the fear of traumatising the cortex with the screw thread.

A recess 28 provided in the interior of the post 2 comprises a portion 30 in the form of a hexagon with flat surfaces. This portion 30 serves to receive an inserted tool, such as an Imbus

key, to enable a torque to be exerted about the longitudinal axis 32 in order to implant the post 2. Of course, portion 30 can also be configured to receive tools having other configurations in order to insert the post 2 into the jaw and screw it to a depth corresponding to the length of one step into the bore which has been drilled accordingly.

Toward the apical end 16 the cavity 28 contains an internal thread 34 with a smaller diameter than that of portion 30, the internal thread 34 being spaced axially from portion 30. Thus damage to the internal thread 34 by a tool designed for portion 30 is reliably prevented.

The coupling element 6 is fixedly joined to the post 2 by means of a screw 36, the apical end of which engages the internal thread 34 of the post. Immediately after the post is implanted, the cavity 28 is advantageously plugged with a temporary screw or the like (not shown) which, after the post has set in the jaw, and opening of any gum tissue that has grown over the bearing surface 12, is removed again so that the coupling element 6 can be introduced into the cavity 28 in the manner shown and fastened by means of the screw 36. To prevent any unacceptable torque being exerted on the post when inserting the screw 36, the coupling element 6 has at least one planar outside surface 60 which contacts a lateral surface of portion 30 and forms an anti-rotational lock. The coupling element 6 has at its occlusal end a boss 38, preferably one having a hexagonal configuration. By means of an appropriate tool, such as a hexagonal wrench, the post 2 can be secured and held fast by the planar outer surface of the coupling element and portion 30 against unintentional rotation, so that, when screw 36 is screwed in, there is no danger of loosening the post 2.

The coupling element 6 furthermore contains a transverse bore 40 having a transverse axis 42 aligned orthogonally to the longitudinal axis 32. As shown, the crown support 8 is pot-shaped with an opening facing toward the apical end 16, and the coupling means 6 engages the inner cavity of the crown support 8. The crown support 8 contains a blind bore 44 which also is disposed orthogonally to the longitudinal axis, the axis 46 of the bore 44 being offset eccentrically from the transverse axis 42. In the illustrated position, the axis 46 is offset from the transverse axis 42 at a short distance 48 toward the crown end. In the transverse bore 40 there is an eccentric pin 50 which has an eccentrically disposed shaft 52 engaging the blind bore 44, and a likewise eccentrically disposed head 54 which lies in a through bore 56 coaxial with the blind bore 44.

By turning the pin, by means of the head 54 which contains a slot or the like for a screwdriver, the eccentric pin 50 is rotated, and the axis 46 shifts from the illustrated position toward the root end 16. This also causes the crown support 8 to shift toward the root end 16 such that the end face 10 of the crown support 8 is biased against the bearing surface 12 of the post 2. Consequently, there is no gap between the ceramic coated end face 10 and the bearing surface 12 of the post 2. Thus a

bacterial-proof joint between the head 4 and the post 2 is assured in a very reliable manner. The eccentricity of the pin 52 and head 54, as well as the diameter of the associated bores 44, are established with great precision, and even the distance between the eccentric axis 46 and the face 10 is definitely established. The same also applies to the axial distance between the transverse bore 40 and the transverse axis 42 from the bearing surface 12 of the post 2. Consequently, in accordance with the invention, by rotating the eccentric pin 50, a precise axial bias between the crown support 8 and the post 2 is established.

Figure 2 is an exploded view of the coupling element 6 and post 2. Here, the planar outside surface 60 of the coupling means can be seen. If the coupling element 6 is inserted into the cavity 28, the cooperation of the outer surface 60 with the lateral surfaces of the hexagonal portion 30 assures that the coupling element 6 is locked against rotation with respect to the post 2. The broken lines indicate the stepped bore 66 in the jawbone, whose upper edge 68 is likewise indicated by broken lines. The post 2 is shown in the position in which it has already been inserted into the jawbone with only one step-length remaining exposed. As can be seen, the bore 66 has four steps 71 to 74 whose respective diameters are each at least equal to the outside diameter of the thread of the step of the post which is screwed into the next following step of the bore. The post is already inserted to 3/4 of its total length into the stepped bore 66, so that a precise alignment with the longitudinal axis 76 of bore 66 is established. The post can then be screwed in by one more step-length, reliably and without special difficulty and without special measures for guiding the post.

In Figure 3, the coupling element 6 is inserted into the blind hole 28 in the post 2, the longitudinal bore 62 for the screw for joining to the post 2 being easily seen. This longitudinal bore 62 has an annular shoulder 64 for engagement by the head of the connecting screw which can be screwed with its external thread into the internal thread 34 of the post 2. The upper edge 68 of the jawbone is indicated by the broken line. The step 18 and thus the upper end of the post 2 extends a distance 78 upwardly beyond the upper edge 68 of bore 66. The bearing surface 12 of the post 2 and the aforescribed head consequently are situated in the region of the mucous membrane.

Reference Numerals

2	Post Part
4	Head Part
6	Coupling Element
8	Crown Support
9	Outer Surface
10	Bottom Face of 4
11	Coating
12	Bearing Surface of 2
16	Apical End
18	Step

20-22 Step
 23 Height
 24-26 Thread
 27 Outer Diameter
 28 Recess
 29 Core Diameter
 30 Extended Region
 32 Longitudinal Axis
 34 Internal Thread
 36 Screw
 38 Boss
 40 Transverse Bore
 42 Transverse Axis
 44 Blind Bore
 46 Axis of 44
 48 Distance
 50 Eccentric Pin
 52 Shaft of 50
 54 Head of 50
 56 Through Bore
 60 Plane Outer Surface
 62 Longitudinal Bore in 6
 64 Annular Shoulder of 62
 66 Bore
 68 Upper Edge
 71-74 Stepped Region
 76 Longitudinal Axis of 66

Claims

1. Dental implant with a post part (2) anchorable in the jawbone, which post part is provided at the crown end with a recess (28) for securing a head part (4) of a replacement tooth and which can be inserted in a stepped bore (71-74) of the jawbone, the outer surface of the post part (2) being stepped towards an apical end (16) and being provided with at least two essentially cylindrical step parts (18, 20-22) of which that nearest the apical end (16) has the smaller outer diameter, characterised in that of two adjacent step parts (21,22), that step part (22) lying closer to the apical end (16) has a thread (26) with an outer diameter (27) which is essentially the same or smaller as the core diameter (29) of the step part (21) lying closer to the head part (4), and in that the step parts (20,21,22) have essentially the same length.

2. Dental implant as claimed in 1, characterised in that the crown step part (18) adjacent the head part (4) has an essentially cylindrical outer surface (14) with an outer diameter which is essentially the same or greater than the thread outer diameter of the next step part (20) in the direction of the apical end (16).

3. Dental implant as claimed in claim 1 or 2, characterised in that the head part (4) provided to receive the replacement tooth has a bottom face (10) which lies tightly on the bearing surface (12) of the post part (2), and in that the head part (4) has an



20-22 Step
23 Height
24-26 Thread
27 Outer Diameter
28 Recess
29 Core Diameter
30 Extended Region
32 Longitudinal Axis
34 Internal Thread
36 Screw
38 Boss
40 Transverse Bore
42 Transverse Axis
44 Blind Bore
46 Axis of 44
48 Distance
50 Eccentric Pin
52 Shaft of 50
54 Head of 50
56 Through Bore
60 Plane Outer Surface
62 Longitudinal Bore in 6
64 Annular Shoulder of 62
66 Bore
68 Upper Edge
71-74 Stepped Region
76 Longitudinal Axis of 66

Claims

1. Dental implant with a post part (2) anchorable in the jawbone, which post part is provided at the crown end with a recess (28) for securing a head part (4) of a replacement tooth and which can be inserted in a stepped bore (71-74) of the jawbone, the outer surface of the post part (2) being stepped towards an apical end (16) and being provided with at least two essentially cylindrical step parts (18, 20-22) of which that nearest the apical end (16) has the smaller outer diameter, characterised in that of two adjacent step parts (21,22), that step part (22) lying closer to the apical end (16) has a thread (26) with an outer diameter (27) which is essentially the same or smaller as the core diameter (29) of the step part (21) lying closer to the head part (4), and in that the step parts (20,21,22) have essentially the same length.

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3. Dental implant as claimed in claim 1 or 2, characterised in that the head part (4) provided to receive the replacement tooth has a bottom face (10) which lies tightly on the bearing surface (12) of the post part (2), and in that the head part (4) has an



outer surface (9) in the region where it emerges from the mucous membrane.

4. Dental implant as claimed in one of claims 1 to 3, characterised in that the bottom face (10) of the head part (4) is provided with a ceramic coating, which is ground flat and/or polished.

5. Dental implant as claimed in one of claims 1 to 4, characterised in that at least part of the outer surface (9) which contacts the bottom face (10) of the head part (4) is also provided with a ceramic coating (11) which the bottom face (10) preferably has.

6. Dental implant as claimed in one of claims 1 to 5, characterised in that the head part (4) comprises a pot-like crown support (8) and a coupling element (6) for fixing in the recess (28) of the post part (2).

7. Dental implant, in particular as claimed in one of claims 1 to 6, characterised in that the head part (4) and particularly the crown support (8) thereof contacts the bearing surface (12) of the post part (2) through its bottom face (10) under axial bias.

8. Dental implant as claimed in one of claims 1 to 7, characterised in that an eccentric pin (50) is arranged in a transverse bore (40) of the coupling element (6), by means of which the crown support (8) can be axially tensioned relative to the post part (2).

9. Dental implant as claimed in one of claims 1 to 8, characterised in that the step part (18) adjacent to the bearing surface (12) has a cylindrical outer surface and the, in particular three, step parts (20-22) extending towards the apical end (16) have the screw threads (24-26).

10. Dental implant as claimed in one of claims 1 to 9, characterised in that the coupling element (6) is provided in particular with a flat outer surface (60) for rotational locking relative to the post part (2), which surface matches a corresponding surface in the bore (28), in particular in a region (30).

11. Dental implant as claimed in one of claims 1 to 10, characterised in that the coupling element (6) has a through bore (62) for a screw (36), the head of which lies on an annular shoulder (64) of the coupling element (6) and the point of which engages in an internal thread (34) of the post part (2).

12. Dental implant as claimed in one of claims 1 to 11, characterised in that the outer surface (14) of the post part (2), in particular the step parts (18) thereof, have essentially the same outer diameter in the region of the bearing surface (12) as the bottom face (10) with the coating (11).