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(54) **TORSIONAL VIBRATION RESONANCE FREQUENCY MEASUREMENT METHOD FOR ESTIMATING STABILITY OF DENTAL IMPLANT AND NOVEL AMPLITUDE TRANSFORMER**

TORSIONSSCHWINGUNGS-RESONANZFREQUENZ-MESSVERFAHREN ZUR SCHÄTZUNG DER STABILITÄT EINES ZAHNIMPLANTATS UND NEUARTIGER AMPLITUDENTRANSFORMATOR

PROCÉDÉ DE MESURE D’UNE FRÉQUENCE DE RÉSONANCE D’UNE VIBRATION DE TORSION PERMETTANT D’ESTIMER LA STABILITÉ D’UN IMPLANT DENTAIRE ET NOUVEAU TRANSFORMATEUR D’AMPLITUDE

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(73) Proprietor: **The Fourth Military Medical University of
Chinese People’s Liberation Army
Xi’an
Shaanxi 710032 (CN)**

(72) Inventors:
- **LI, Dehua
Xi’an, Shaanxi 710032 (CN)**
- **TANG, Yulong
Xi’an, Shaanxi 710032 (CN)**
- **LI, Bing
Xi’an, Shaanxi 710032 (CN)**

(74) Representative: **Wächter, Jochen et al
Kroher-Strobel
Rechts- und Patentanwälte PartmbB
Bavariaring 20
80336 München (DE)**

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Description

Field of the Invention

[0001] The present invention relates to a measuring method for assessing the stability of dental implants in the art of stomatology, and in particular relates to a torsional vibration resonance frequency measuring method for assessing the stability of dental implants and a novel amplitude transformer.

Background Art

[0002] In the 21st century, due to the improvement of technology and the richness and development of the implantation theory, dental implantation has become a mature clinic technology for partial anodontia repairing. It does not only achieve the recovery of the function of missing teeth, but also restores the esthetic appearance of natural teeth. As one of the basic elements for a successful implanting, the osseointegration between the dental implants and the surrounding osseous tissue has been the focus and investigation hotspot for a long time. Only when a dental implant reaches an osseointegration with the surrounding alveolar bone, it can function to support and fix the prosthesis and perform its normal functions. Different designs of dental implants and different surface modifications on dental implants affect the progress and rate of the osseointegration of the implants, and the ultimate objects of seeking better bone healing speed and osseointegration rate is to shorten the treatment period, increase the bonding strength between the dental implants and the osseous tissue and improve its stability and supporting capacity. Therefore, the biomechanic assessing on the dental implant/bone interface has became one of the important topics in the study of osseointegration, and at present a main research target is to find an study means that can harmlessly and precisely reflect the mechanical behavior, i.e., stability, of the bone-implant interface in the dental implant healing progress and make a continuous observation possible, that is, an assessing method that is suitable for the clinical research on dental implant osseointegration, in order to assess the level of the osseointegration of dental implants in an objective fashion. Resonance frequency analysis, as a mature technique for studying structure object and structural mechanics characteristics, has a potential to provide an effective approach for achieving the above target. That idea was seriously proposed by Meredith and Huang in the 1990s, after which, however, many basic and clinical studies proved that the dental implant resonance frequency analysis method they established cannot precisely and objectively reflect the bone healing progress of the dental implants and the interface bonding characteristic, which results in that the result of a single measurement does not possess practical clinic guiding significance. The underlying cause of the above problem is that Meredith and Huang simply chose the bending vibration mode as the study object when studying the resonance frequency of the dental implants. Although the bending vibration mode has advantages such as the easiness of being triggered and being identified and caught by instruments, it cannot directly reflect the mechanical behavior of the dental implant-bone interface, while torsional vibration is the very mode ideal for revealing the structural characteristic of the dental implant-bone interface.

[0003] Taking an overview on the study approach of dental implant osseointegration, besides histologic methods, biomechanic study is one of the important approaches, especially more important in clinical research. Many research techniques have emerged on dental implant osseointegration strength and dental implant stability.

[0004] Dental implant push-out test and spin-out test are commonly used mechanic study approaches for dental implant osseointegration at present, and as they provide the maximum disruptive strength of the dental implant-bone interface, they are destructive test methods, and cannot be used to continuously observe the dental implants over time, and furthermore they are not suitable for clinical research. Dental implant percussion is a qualitatively examining method for clinically deciding the stability of the dental implants and the presence of osseointegration, but it lacks an objective quantitative criteria. The Periotest mobility meter, invented according to the damping principle, overcomes the shortcomings of subjectivity and qualitativeness of simple percussion of dental implants, by outputting the mobility of dental implants as Periotest values (PTVs), which are generally between -5 and +5. However, the method has a poor repeatability, wherein the operation manner greatly affects the results, and investigation proves that the measured numerical values cannot precisely reflect the biomechanic nature of the bone-implant interface of dental implants.

[0005] Objects having masses and structures made up by such objects have their intrinsic frequencies, which are decided by the stiffness of the objects as well as the interfacial stiffness between structures, and when an external energizing frequency overlaps with the intrinsic frequency of an object or a structure interface, resonance occurs. Resonance frequency analysis is already a mature technique for investigating object and structure interface stiffness. It was successfully applied to the investigation on the stiffness of human long bone in the 1990s, and the feasibility that it serves as the method for assessing fracture union and osteoporosis has been preliminarily proven. The direct bonding between the dental implant and the osseous tissue is the foundation of its successful working. In the initial stage after the implanting, assimilation happens between the dental implant and the surrounding osseous tissue due to surgery trauma; and in the process of the bone healing, the stiffness of the interface bone and the osseointegration stiffness increase gradually. Experiments indicate that the binding stiffness of the dental implant-bone interface reflects the extent of bone healing. On the basis of the above principle, Meredith et.al. incorporated the resonance frequency analysis technique into the dental implant stability research, and made the first Osstell dental implant resonance frequency analyzer. Its principle of operation (see the schematic representations) is as follows: to secure a L-shaped amplitude transformer to the dental implant with screws, install two miniature piezoceramics transducers on the inside and outside of the amplitude transformer (wherein one of them is used to emit 5-15KHz continuous sine waves to energize the amplitude transformer-dental implant vibration, and the other one is a receiving transducer for receiving the amplitude and the frequency of the amplitude transformer), record a curve diagram about the frequency and the amplitude by using an analyzer, and obtain the resonance frequency by calculating. What it measures is the resonance frequency of the dental implant at lower order bending vibration mode.

[0006] In the system comprising the dental implant, the surrounding jaw and the transducer, the resonance frequency of the dental implant is decided by multiple factors, which generally include the stiffness and mass of the dental implant, the vibration moment arm, the density and structure of the surrounding bone of the dental implant, the shear stiffness of the dental implant-bone interface and so on, and the vibration mode presents multiple modes including bending vibration, vertical vibration, horizontal vibration and torsional vibration. Therefore, the resonance frequency of the dental implant consists of a plurality of frequencies, rather than a single one, and presents multiple stages. Under different vibration modes, the factors that affect the resonance frequency vary, and the mechanical behaviors of the dental implant-jawbone structural system are reflected with emphasis in different apects. Currently the research on the resonance frequency of dental implant is on the basis of the bending vibration mode of dental implant, and under the mode the resonance frequency is majorly decided by factors such as the structure and mass of the surrounding osseous tissue of the dental implant and the height the dental implant protrudes above the bone surface, and mainly reflects the stability of the dental implant. Due to being influenced by too many factors, the current dental implant resonance frequency analysis method based on the bending vibration mode cannot objectively and precisely reflect the mechanical behavior of the dental implant-bone interface and the osseointegration level, which results in that the result of a single measurement does not possess practical clinic guiding significance; additionally, the connecting location and the arrangement orientation of the transducer largely affects the measurement result, resulting in the doubt on its clinic and scientific application values.

[0007] Relevant prior art is provided by US2002/0143268 and KR20090121808.

[0008] It can be seen that, the afore-said prior art measuring methods of the stability of dental implants still present many defects, and thus urgently need improvement. Given the defects in the prior art stability measuring method of dental implants, the inventor, based on rich practice experience and expertise, made the present invention by positive innovating, unceasing researching and designing, and repeatedly sample trial making and improving.

Brief Sumarry of the Invention

[0009] The invention is as defined in claims 1 and 5.

[0010] The major object of the present invention is to overcome the defects in the prior art measuring method for assessing the stability of dental implants and provide a novel torsional vibration resonance frequency measuring method for assessing the stability of dental implants. The technical problem sought to solve is to make it overcome the defects of the poor repeatability and objectivity of the Periotest method and overcome the defects of the poor relation between the Ostell resonance frequency measuring method and dental implant osseointegration, in order to increase the repeatability of the measurement result and the relation with the dental implant osseointegration progress and improve the practicality.

[0011] Another object of the present invention is to overcome the defects of the prior art amplitude transformers and thus provide a novel amplitude transformer with a new structure. The technical problem sought to solve is to make it measure the resonance frequency under the torsional vibration mode, and by taking advantage of the relation between the resonance frequency and the stiffness of the bone of the bone-implant interface surrounding the dental implant under the mode, increase the objectivity of the measurement result about the dental implant stability determining, avoid the mixed influence from non-osseointegration-related factors, increase its sensibility to dental implant bone healing, and improve its practicality.

[0012] The present invention aims to, beginning from the torsional vibration mode of dental implants, according to the principle that tangential energizing triggers torsional vibration mode, study the amplitude transformer design ideal for energizing torsional vibration mode by using three-dimensional finite element method, establish a resonance frequency analysis method for torsional vibration mode of dental implants by referring to Meredith's flexural resonance frequency measurement technique principle, and reveal the correlativity between the resonance frequency of torsional vibration and dental implant osseointegration by using three-dimensional finite element, in-vitro model experiment and animal experiment study. The present invention will provide an effective novel assessing method for the clinical research on dental implant osseointegration. Not only it will provide an important assessing indicator for studying dental implant osseointegration and optimizing dental implant performance and has an important scientific research value, but also it will provide a clinic assessing approach for judging whether or not the dental implanting is successful and deciding the right time for dental implant repairing and has an important clinical application value.

[0013] The objectives of the present invention can be achieved and the technical problems can be solved by adopting the following technical solutions. A torsional vibration resonance frequency measuring method for assessing the stability of dental implants and a novel amplitude transformer in the present invention comprises the following steps:

step 1: installing a novel amplitude transformer:

installing a novel amplitude transformer having a double-winged, horizontal, symmetrical and vertical structure for measuring resonance frequency onto a dental implant 3, by applying a central bolt 2 of the novel amplitude transformer to tightly fasten the novel amplitude transformer onto the surface of the dental implant 3, with a torque force of 3 to 10 N • cm to fasten the central bolt 2 of the novel amplitude transformer, so as to tighly fasten the two, thus forming a dental implant-amplitude transformer system;

step 2: energizing a torsional vibration mode

in the dental implant-amplitude transformer system, energizing either unilateral side or bilateral sides of the bilateral horizontal wings of the novel amplitude transformer by a contact or non-contact method, and energizing the dental implant in a tangential direction to make torisional vibration as a main vibration mode of the dental implant-amplitude transformer system;

step 3: gathering resonance signals:

recording vibration frequencies and amplitudes of the novel amplitude transformer by applying an electromagnetic signal receiver; and

step 4: analyzing resonance frequencies:

gathering and processing data, plotting an amplitude-frequency curve diagram, and calculating the torsional resonance frequency according to the torsioanl vibraton mode, which is the main vibration peak.

[0014] In the afore-said torsional vibration resonance frequency measuring method for assessing the stability of dental implants, the most preferred torque force of the central bolt for fastening the novel amplitude transformer is 4 to 6 N • cm.

[0015] In the afore-said torsional vibration resonance frequency measuring method for assessing the stability of dental implants, the contact or non-contact method in the dental implant-amplitude transformer system is knock or electromagneticly energizing either the unilateral side or bilateral sides of the bilateral horizontal wings of the novel amplitude transformer, wherein when electromagnetic signal is the energizing source, the frequency ranges from 0-20000 hertz.

[0016] In the afore-said torsional vibration resonance frequency measuring method for assessing the stability of dental implants, the action point of said energizing applied to unilateral side or bilateral sides of the bilateral horizontal wings of the novel amplitude transformer is located at a distal end of the bilateral horizontal wings, perpendicular to the bilateral horizontal wings of the novel amplitude transformer, and tangent to the axial direction of the dental implant.

[0017] The object of the present invention can also be achieved and the technical problems can also be solved by adopting the following technical solutions. The novel amplitude transformer for implementing the torsional vibration resonance frequency measuring method for assessing the stability of dental implants comprise an anti-rotary horizontal double-winged component and a central bolt, wherein the anti-rotary horizontal double-winged component is an integrated horizontal, symmetrical and upright structure with two wings composed by bilateral horizontal wings, a middle pillar and an anti-rotary part, wherein the bilateral horizontal wings have two horizontal wings horizontally stretching outward individually from two sides of the top of the middle pillar along the direction parallel to the end surface of the implant neck, symmetrical with the central axis of the middle pillar and perpendicular to the upper end surface of implant neck as a vertical structure; and the middle pillar is provided with a through hole inside it, and the anti-rotary part is at the bottom which matches the inner structure of the top of the neck of the to-be-measured dental implant so that they can be closely occluded with each other with completely meshing limitation; and the said central bolt goes through the through hole of the middle pillar and closely connects with the inner threads of the dental implant, so as to fasten the novel amplitude transformer closely onto the dental implant, forming a dental implant-amplitude transformer system integrating the novel amplitude transformer with the dental implant, and thus the dental implant-amplitude transformer system which integrates the novel amplitude transformer with the dental implant can vibrate as an integral structure under energizing.

[0018] In the afore-said novel amplitude transformer, the said anti-rotary part is designed with a conical surface or a concave surface, wherein the concial surface or the concave surface is an anti-rotary structure shaped as a hexagon, octagon or trefoil, the shape of which matches the inner structure of the top of the neck of the to-be-measured dental implant.

[0019] In the novel amplitude transformer, the total length of the bilateral horizontal wings from the distal end of the horizontal wing on one side to the distal end of the horizontal wing on the other side in the horizontal direction is from 10mm to 30mm, the thickness of the bilateral horizontal wings is from 0.5mm to 3mm, and the height of the bilateral horizontal wings is from 3mm to 10mm, wherein the most prefered total length of the bilateral horizontal wings is from 15mm to 20mm, the most preferred thickness of the bilateral horizontal wings is from 1.3mm to 1.6mm, and the most preferred height of the bilateral horizontal wings is from 3mm to 6mm.

[0020] The materials used by the afore-said novel amplitude transformer includes aluminum alloy, pure titanium, titanium alloy and medical stainless steel, among which aluminum alloy is the most preferred material.

[0021] The present invention has at least the following advantages over the prior art:

1. applying a force on dental implants in the tangential direction is one of the effective approaches for energizing its torsional vibration, and the structure design of the novel vertical double-winged amplitude transformer of the present invention facilitates the tangential energizing of dental implants, and by effective energizing, and the torsional vibration mode of dental implants can be transferred into mainly vibration mode, which facilitates signal acquisition;
2. compared with the prior art that uses the flexural resonance frequency of dental implants as the technical principle, by measuring torsional resonance frequency, the present invention can more directly reflect the medium and binding stiffness of the dental implant-bone interface, avoid the influence from non-osseointegration-related factors, and increase the assessing sensibility of dental implant osseointegration and stability;
3. the bone healing of dental implants in terms of mechanical behavior presents in the form that the mechanic stiffness of osseous tissue keeps increasing, and the present invention can more sensitively reflect the extent of dental implant bone healing while monitoring dental implant stability, by which the right time for repairing the dental implants can be guided, and furthermore provide a novel approach for studying dental implant osseointegration.

[0022] The above description is only a brief summary of the technical solution of the present invention. In order to clarify the technical means of the present invention so that they can be implemented according to the content of the description, and in order to make the above and other objects, features and advantages of the present invention easier to understand, the present invention will now be described in detail by referring to preferred examples and accompanying figures.

Brief Description of the Drawings

[0023]

Fig. 1A is a schematic diagram of the main view of the novel applitude transformer of the present invention;

Fig. 1B is a schematic diagram of the top view of the novel amplitude transformer of the present invention;

Fig. 1C is a three-dimensional diagram of the appearance of the novel amplitude transformer of the present invention;

Fig. 2 is a exploded three-dimensional diagram of the novel amplitude transformer of the present invention;

Fig. 3 is an assembly diagram of the novel amplitude transformer and the dental implant of the present invention;

Fig. 4 is a diagram of the torisional vibration of the novel amplitude transformer and the dental implant of the present invention;

wherein:

1: an anti-rotary horizontal bilateral wing component
11: bilateral horizontal wing 12: central standing pillar
13: an anti-rotary part 13
2: central bolt 3: dental implant

DETAILED DESCRIPTION OF SPECIFIC EMBODIMENTS

[0024] The drawings accompanying this specification as listed below as well as the preferred embodiments are to further illustrate the technical methods and functions for achieving the predetermined objects in the present invention. The present invention relates to a torsional vibration resonance frequency measuring method for assessing the stability of dental implants and a novel amplitude transformer, on the basis of the multistage resonance frequency attributes which is the inherent attributes of objects, with a designed structure of the novel amplitude transformer, to realize the energizing of the dental implant-amplitude transformer system in a tangential direction to vibrate the system itself to make torisional vibration as a main vibration mode of the system, measuring the torisional resonance frequency of the dental implant by gathering resonance signals and analyzing resonance frequencies. When directly knocking or applying electromagnetic signal to act on the distal end of the horizontal wings of the transformer, it can realize the tangential energizing of the dental implant-amplitude transformer, in which unilateral or bilateral synchronic energizing can achive the same torisional vibration energizing effect. The specific application methods and steps are as follows.

Embodiment 1

[0025] In figure 4, it shows the preferred embodiment example of the present invention which is the torsional vibration resonance frequency measuring method for assessing the stability of dental implants and a novel amplitude transformer, mainly comprising the following steps:

step 1: installing a novel amplitude transformer:

installing a novel amplitude transformer having a double-winged, horizontal, symmetrical and vertical structure for measuring resonance frequency onto a dental implant 3, by applying a central bolt 2 of the novel amplitude transformer to tightly fasten the novel amplitude transformer onto the surface of the dental implant 3, with a torque force of 3 to 10 N • cm to fasten the central bolt 2 of the novel amplitude transformer, so as to tighly fasten the two, thus forming a dental implant-amplitude transformer system, wherein the most preferred torque force of the central bolt for fastening the novel amplitude transformer is 4 to 6 N • cm. The torque force used in the present embodiment is 5 N • cm;

step 2: energizing a torsional vibration mode:

in the dental implant-amplitude transformer system, energizing unilateral side or bilateral sides of the bilateral horizontal wings 11 of the novel amplitude transformer by a contact or non-contact method, and energizing the dental implant 3 in a tangential direction to make torisional vibration as the main vibration mode of the dental implant-amplitude transformer system;
wherein in the present invention, the contact method is knocking, and the action point of said energizing applied to the unilateral side or bilateral sides of the bilateral horizontal wings 11 of the novel amplitude transformer is located at a distal end of the bilateral horizontal wings 11, perpendicular to the bilateral horizontal wings 11 of the novel amplitude transformer and tangent to the axial direction of the dental implant 3 which is to be measured;

step 3: gathering resonance signals:

recording vibration frequencies and amplitudes of the novel amplitude transformer by applying an electromagnetic signal receiver; and

step 4: analyzing resonance frequencies:

gathering and processing data, plotting an amplitude-frequency curve diagram, and calculating the torsional resonance frequency according to the torsioanl vibraton mode which is the main vibration peak, wherein the torsional vibration resonance frequency value is positively correlated to the stability of the dental implant 3 and the degree of bone healing of the dental implant 3.

Embodiment 2

[0026] The torque force of the central bolt 2 for fastening the novel amplitude transformer is 5 N • cm. In the novel amplitude transformer system, the non-contact energizing method is applied to electromagneticly energize the unilateral side or bilateral sides of the bilateral horizontal wings 11, wherein when the electromagnetic signal is the energizing source, the frequency ranges from 0-20000 hertz. In the present embodiment, micro piezoelectric ceramic is used as the energizing source to synchronically apply to the bilateral horizontal wings 11 in the same rotation direction. Other steps are the same with those mentioned in embodiment 1.

Embodiment 3

[0027] As shown in figure 1, figure 2, figure 3 and figure 4, the novel amplitude transformer of the preferred embodiment in the present invention mainly includes an anti-rotary horizontal bilateral wing component 1 and a central bolt 2, wherein the anti-rotary horizontal double-winged component 1 is an integrated horizontal, symmetrical and upright structure with two wings composed by bilateral horizontal wing 11, a central standing pillar 12 and an anti-rotary part 13, wherein the bilateral horizontal wing 11 has two horizontal wings which horizontally stretching outward individually from two sides of the top of the central standing pillar 12 along the direction parallel to the end surface of the neck of dental implant 3, symmetrical with the central axis of the central standing pillar 12 and perpendicular to the upper end surface of implant neck as a vertical structure; wherein the central standing pillar 12 is provided with a through hole inside it, and the anti-rotary part 13 is at the bottom which matches the inner structure on top of the neck of the to-be-measured dental implant so that the they can be closely occluded with each other with complete meshing limitation; and the said central bolt 2 goes through the thourgh hole of the central standing pillar 12 and closely connects with the internal threads of the dental implant 3, so as to fasten the novel amplitude transformer closely onto the dental implant 3, forming a dental implant-amplitude transformer system integrating the novel amplitude transformer with the dental implant 3, and thus the dental implant-amplitude transformer system integrats the novel amplitude transformer with the dental implant 3 can vibrate as an integral structure under energizing.

[0028] The said anti-rotary part 13 is designed with a conical surface or a concave surface, wherein the conical surface or the concave surface is an anti-rotary structure shaped as a hexagon, octagon or trefoil, the shape of which matches the inner structure on top of the neck of the to-be-measured dental implant 3 so that they can realize complete meshing limitation.

[0029] The anti-rotary part 13 of the present embodiment is in the shape of an anti-rotary conical surface, which matches the inner structure on top of the neck of the to-be-measured dental implant 3 so that the they can realize complete meshing limitation. In the present embodiment, the anti-rotary conical surface is with a hexagon, octagon or trefoil shaped anti-rotary structure. The said central bolt 2 goes through the thourgh hole of the anti-rotary part 13 and connects with the internal threads of the dental implant 3, so as to fasten the novel amplitude transformer closely onto the dental implant 3, thus forming a detanl implant-amplitude transformer system integrating the novel amplitude transformer with the dental implant 3, and thus the dental implant-amplitude transformer system which integrates the novel amplitude transformer with the dental implant 3 can vibrate as an integral structure under energizing.

[0030] The total length of the bilateral horizontal wing 11 from the distal end of the horizontal wing on one side to the distal end of the horizontal wing on the other side in the the horizontal direction is from 10mm to 30mm, the thickness of the bilateral horizontal wings 11 is from 0.5mm to 3mm, and the height of the bilateral horizontal wing is from 3mm to 10mm, wherein the most preferred total length of the bilateral horizontal wings 11 is from 15mm to 20mm, the most preferred thickness of the bilateral horizontal wings 11 is from 1.3mm to 1.6mm, and the most preferred height of the bilateral horizontal wings 11 is from 3mm to 6mm.

[0031] The materials used by the novel amplitude transformer include aluminum alloy, pure titanium, titanium alloy and medical stainless steel, among which aluminum alloy is the most preferred material. In the present embodiment, the material used is aluminum alloy.

[0032] The said anti-rotary part 13 is designed with an anti-rotary concave surface, wherein the conical surface or the concave surface is an anti-rotary structure shaped as a hexagon, octagon or trefoil shaped anti-rotary structure, the shape of which matches the inner structure on top of the neck of the to-be-measured dental implant 3 so that the they can realize complete meshing limitation.

Claims

1. A torsional vibration resonance frequency measuring method for assessing the stability of dental implants (3), **characterized in** comprising the following steps:

   step 1: installing an amplitude transformer installing an amplitude transformer having a double-winged (11), horizontal, symmetrical and vertical structure for measuring resonance frequencies onto a dental implant, wherein the amplitude transformer is tightly fastented on the dental implant by a central bolt (2) with a torque force of 3 to 10 N • cm, thus the amplitude transformer and the dental implant (3) being closely connected and forming a dental implant-amplitude transformer system;

   step 2: energizing a torsional vibration mode in the dental implant-amplitude transformer system, energizing either unilateral side or bilateral sides of bilateral horizontal wings (11) of the amplitude transformer by a contact or non-contact method, and energizing the dental implant (3) in a tangential direction to make torsional vibration as a main vibration mode of the dental implant-amplitude transformer system;

   step 3: gathering resonance signals recording vibration frequencies and amplitudes of the amplitude transformer by an electromagnetic signal receiver; and

   step 4: analyzing the resonance frequency gathering and processing data using computer, plotting an amplitude-frequency curve diagram, and calculating the torsional resonance frequency according to the torsional vibraton mode, which is the main vibration peak.

2. The torsional vibration resonance frequency measuring method for assessing the stability of dental implants according to claim 1, **characterized in that** the torque force of the central bolt for fastening the amplitude transformer is 4 to 6 N • cm.

3. The torsional vibration resonance frequency measuring method for assessing the stability of dental implants according to any one of claim 1 or 2, **characterized in that** the contact or non-contact method in the dental implant-amplitude transformer system is knock or electromagneticly energizing either the unilateral side or bilateral sides of the bilateral horizontal wings of the amplitude transformer, wherein when electromagnetic signal is the energizing source, the frequency ranges from 0-20000 hertz.

4. The torsional vibration resonance frequency measuring method for assessing the stability of dental implants according to claim 3, **characterized in that** the action point of said energizing applied to unilateral side or bilateral sides of the bilateral horizontal wings of the amplitude transformer is located at a distal end of the the bilateral horizontal wings, perpendicular to the bilateral horizontal wings of the amplitude transformer, and tangent to the axial direction of the dental implant.

5. Amplitude transformer for implementing the measuring method according to claim 1, **characterised in that** it comprises an anti-rotary horizontal double-winged component and a central bolt, wherein the anti-rotary horizontal double-winged component is an integrated horizontal, symmetrical and upright structure with two wings composed by bilateral horizontal wings, a middle pillar and an anti-rotary part,

wherein the bilateral horizontal wings 11 have two horizontal wings horizontally stretching outward individually from two sides of the top of the middle pillar along the direction parallel to the end surface of the implant neck, symmetrical with the central axis of the middle pillar and perpendicular to the upper end surface of implant neck as a vertical structure; and the middle pillar is provided with a through hole inside it, and the anti-rotary part is at the bottom of the middle pillar and matches the inner structure of the top of the neck of the to-be-measured dental implant so that they can be closely occluded with each other with completely meshing limitation; and the said central bolt goes through the through hole of the middle pillar and is closely connectable with the inner threads of the dental implant, so as to fasten the amplitude transformer closely onto the dental implant, forming a dental implant-amplitude transformer system integrating the amplitude transformer with the dental implant, and thus the dental implant-amplitude transformer system which integrates the amplitude transformer with the dental implant can vibrate as an integral structure under energizing.

6. The amplitude transformer according to claim 5, **characterized in that** said anti-rotary part is designed with a conical surface or a concave surface, wherein the conical surface or the concave surface is an anti-rotary structure shaped as a hexagon, octagon or trefoil, the shape of which matches the inner structure of the top of the neck of the to-be-measured dental implant.

7. The amplitude transformer according to any one of claim 5 or 6, **characterized in that** the total length of the bilateral horizontal wings 11 from the distal end of the horizontal wing on one side to the distal end of the horizontal wing on the other side in the horizontal direction is from 10mm to 30mm, the thickness of the bilateral horizontal wings 11 is from 0.5mm to 3mm, and the height of the bilateral horizontal wings 11 is from 3mm to 10mm, wherein the most preferred total length of the bilateral horizontal wings 11 is from 15mm to 20mm, the most preferred thickness of the bilateral horizontal wings 11 is from 1.3mm to 1.6mm, and the most preferred height of the bilateral horizontal wings 11 is from 3mm to 6mm.

8. The amplitude transformer according to claim 5, **characterized in that** the materials used includes aluminum alloy, pure titanium, titanium alloy and medical stainless steel, among which aluminum alloy is the most preferred material.

Patentansprüche

1. Torsionsschwingungs-Resonanzfrequenzmessverfahren zur Schätzung der Stabilität eines Zahnimplantats (3), **gekennzeichnet durch** die folgenden Schritte:

Schritt 1: Montieren eines Amplitudentransformators
Montieren eines Amplitudentransformators mit einer doppelflügeligen (11), horizontalen, symmetrischen und vertikalen Struktur zum Messen der Resonanzfrequenzen an einem Zahnimplantat, wobei der Amplitudentransformator an dem Zahnimplantat durch einen zentralen Stift (2) mit einem Drehmoment von 3 bis 10 N•cm fest befestigt ist, sodass der Amplitudentransformator und das Zahnimplantat (3) eng anliegend verbunden sind und ein Zahnimplantat-Amplitudentransformator-System bilden;
Schritt 2: Anregen einer Torsionsschwingungsmode
Anregen entweder einer Seite oder beider Seiten der bilateralen horizontalen Flügel (11) des Amplitudentransformators durch ein kontaktgebendes oder ein kontaktloses Verfahren in dem Zahnimplantat-Amplitudentransformator-System, und Anregen des Zahnimplantats (3) in einer tangentialen Richtung, um die Torsionsschwingung zur Hauptschwingungsmode des Zahnimplantat-Amplitudentransformator-Systems zu machen;
Schritt 3: Erfassen der Resonanzsignale
Aufzeichnen von Schwingungsfrequenzen und -amplituden des Amplitudentransformators mit einem elektromagnetischen Signalempfänger; und
Schritt 4: Analysieren der Resonanzfrequenz
Erfassen und Verarbeiten von Daten unter Verwendung eines Computers, Plotten eines Amplituden-Frequenzgang-Diagramms, und Berechnen der Torsionsresonanzfrequenz gemäß der Torsionsschwingungsmode, die dem Hauptschwingungsscheitelwert entspricht.

2. Torsionsschwingungs-Resonanzfrequenzmessverfahren zur Schätzung der Stabilität eines Zahnimplantats nach Anspruch 1, **dadurch gekennzeichnet, dass** das Drehmoment des zentralen Stifts zum Befestigen des Amplitudentransformators 4 bis 6 N•cm beträgt.

3. Torsionsschwingungs-Resonanzfrequenzmessverfahren zur Schätzung der Stabilität eines Zahnimplantats nach einem der Ansprüche 1 oder 2, **dadurch gekennzeichnet, dass** das kontaktgebende oder kontaktlose Verfahren in dem Zahnimplantat-Amplitudentransformator-System eine klopfende oder elektromagnetische Anregung entweder auf einer Seite oder auf beiden Seiten des bilateralen horizontalen Flügels des Amplitudentransformators ist, wobei die Frequenz zwischen 0 und 20.000 Hertz beträgt, wenn das elektromagnetische Signal die Anregungsquelle ist.

4. Torsionsschwingungs-Resonanzfrequenzmessverfahren zur Schätzung der Stabilität eines Zahnimplantats nach Anspruch 3, **dadurch gekennzeichnet, dass** sich die Angriffsstelle der Anregung, die auf einer Seite oder auf beiden Seiten des bilateralen horizontalen Flügels des Amplitudentransformators aufgebracht wird, an einem distalen Ende der bilateralen horizontalen Flügel, senkrecht zu den bilateralen Flügeln des Amplitudentransformators und tangential zur Axialrichtung des Zahnimplantats, befindet.

5. Amplitudentransformator zur Durchführung des Messverfahrens gemäß Anspruch 1, **dadurch gekennzeichnet, dass** er ein horizontales zweiflügeliges Gegendrehelement und einen zentralen Stift aufweist, wobei das horizontale zweiflügelige Gegendrehelement eine integrierte horizontale, symmetrische und aufrechtstehende Struktur mit zwei Flügeln ist, die aus bilateralen horizontalen Flügeln, einer mittleren Säule und einem Gegendrehteil besteht, wobei die bilateralen horizontalen Flügel (11) zwei horizontale Flügel aufweisen, die sich jeweils horizontal von zwei Seiten des oberen Teils der mittleren Säule in Richtung parallel zur Endfläche des Implantathalses, symmetrisch zur Mittelachse der mittleren Säule und senkrecht zur oberen Endfläche des Implantathalses als eine vertikale Struktur nach außen erstrecken; wobei die mittlere Säule eine Durchgangsöffnung aufweist, und das Gegendrehteil an dem unteren Ende der mittleren Säule angeordnet ist und passend zur inneren Struktur des oberen Teils des Halses des zu messenden Zahnimplantats gebildet ist, sodass sie mit genau passenden Begrenzungen eng anliegend miteinander verbunden werden können; und wobei der zentrale Stift durch die Durchgangsöffnung der mittleren Säule verläuft und eng anliegend mit dem Innengewinde des Zahnimplantats verbindbar ist, um den Amplitudentransformator eng anliegend an dem Zahnimplantat zu befestigen, sodass ein Zahnimplantat-Amplitudentransformator-System gebildet wird, das den Amplitudentransformator mit dem Zahnimplantat integriert, wodurch das Zahnimplantat-Amplitudentransformator-System, das den Amplitudentransformator mit dem Zahnimplantat integriert, bei Anregung als eine ganzheitliche Struktur schwingen kann.

6. Amplitudentransformator nach Anspruch 5, **dadurch gekennzeichnet, dass** das Gegendrehteil mit einer konischen Oberfläche oder einer konkaven Oberfläche gebildet ist, wobei die konische Oberfläche oder die konkave Oberfläche eine Gegendrehstruktur ist, die in Form eines Hexagons, eines Oktagons oder eines Kleeblattes gebildet ist, wobei deren Form zur inneren Struktur des oberen Teils des Haies des zu messenden Zahnimplantats passt.

7. Amplitudentransformator nach einem der Ansprüche 5 oder 6, **dadurch gekennzeichnet, dass** die Gesamtlänge der bilateralen horizontalen Flügel (11) von dem distalen Ende des horizontalen Flügels auf einer Seite zu dem distalen Ende des horizontalen Flügels auf der anderen Seite in der horizontalen Richtung zwischen 10 mm und 30 mm beträgt, die Dicke der bilateralen horizontalen Flügel (11) zwischen 0,5 mm und 3 mm beträgt, und die Höhe der bilateralen horizontalen Flügel (11) zwischen 3 mm und 10 mm beträgt, wobei die Gesamtlänge der bilateralen horizontalen Flügel (11) vorzugsweise zwischen 15 mm und 20 mm beträgt, die Dicke der bilateralen horizontalen Flügel (11) vorzugsweise zwischen 1,3 mm und 1,6 mm beträgt, und die Höhe der bilateralen horizontalen Flügel (11) vorzugsweise zwischen 3 mm und 6 mm beträgt.

8. Amplitudentransformator nach Anspruch 5, **dadurch gekennzeichnet, dass** die verwendeten Materialien eine Aluminiumlegierung, reines Titan, eine Titanlegierung und medizinischen, rostfreien Stahl umfassen, von denen die Aluminiumlegierung das bevorzugte Material ist.

Revendications

1. Procédé de mesure d'une fréquence de résonance d'une vibration de torsion permettant d'estimer la stabilité d'implants dentaires (3), **caractérisé en ce qu'**il comprend les étapes suivantes :

Etape 1 : installation d'un transformateur d'amplitude
Installation d'un transformateur d'amplitude possédant une structure horizontale, symétrique et verticale à ailes doubles (11) permettant de mesurer des fréquences de résonance sur un implant dentaire, dans lequel le transformateur d'amplitude est fixé rigidement sur l'implant dentaire par l'intermédiaire d'un boulon central (2) avec un couple de serrage compris entre 3 et 10 N*cm, de sorte que le transformateur d'amplitude et l'implant dentaire (3) sont étroitement connectés et forment un système transformateur d'amplitude/implant dentaire ;
Etape 2 : excitation d'un mode de vibration de torsion dans le système transformateur d'amplitude/implant dentaire, excitation soit d'un seul côté, soit des deux côtés des ailes horizontales bilatérales (11) du transformateur d'amplitude grâce à un procédé avec contact ou sans con-

tact, et excitation de l'implant dentaire (3) dans une direction tangentielle afin que la vibration de torsion soit le mode de vibration principal du système transformateur d'amplitude/implant dentaire ;
Etape 3 : collecte de signaux de résonance ;
Enregistrement des fréquences de vibration et des amplitudes du transformateur d'amplitude à l'aide d'un récepteur de signal électromagnétique ; et
Etape 4 : analyse de la fréquence de résonance
Rassemblement et traitement de données en utilisant un ordinateur, traçage d'un diagramme d'une courbe amplitude-fréquence, et
Calcul de la fréquence de la résonance de torsion en fonction du mode de vibration de torsion, qui est le pic de vibration principal.

2. Procédé de mesure d'une fréquence de résonance d'une vibration de torsion permettant d'estimer la stabilité d'implants dentaires selon la revendication 1, **caractérisé en ce que** le couple de serrage du boulon central destiné à fixer le transformateur d'amplitude est compris entre 4 et 6 N*cm.

3. Procédé de mesure d'une fréquence de résonance d'une vibration de torsion permettant d'estimer la stabilité d'implants dentaires selon l'une quelconque des revendications 1 ou 2, **caractérisé en ce que** le procédé avec contact ou sans contact dans le système transformateur d'amplitude/implant dentaire consiste à appuyer sur ou à exciter électromagnétiquement soit un seul côté soit les deux côtés des ailes horizontales bilatérales du transformateur d'amplitude, dans lequel lorsque le signal électromagnétique est la source de l'excitation, la fréquence se trouve dans une fourchette comprise entre 0 et 20000 hertz.

4. Procédé de mesure d'une fréquence de résonance d'une vibration de torsion permettant d'estimer la stabilité d'implants dentaires selon la revendication 3, **caractérisé en ce que** le point d'action de ladite excitation appliquée sur un seul côté ou sur les deux côtés des ailes horizontales bilatérales du transformateur d'amplitude se situe au niveau d'une extrémité distale des ailes horizontales bilatérales, perpendiculairement aux ailes horizontales bilatérales du transformateur d'amplitude et de manière tangentielle à la direction axiale de l'implant dentaire.

5. Transformateur d'amplitude selon la revendication 1, **caractérisé en ce qu'**il comprend un composant à ailes doubles horizontal anti rotation et un boulon central,
dans lequel le composant à ailes doubles horizontal anti rotation est une structure en une seule pièce horizontale, symétrique et verticale, munie de deux ailes composées d'ailes horizontales bilatérales, un fût médian et une partie anti rotation, dans lequel les ailes horizontales bilatérales (11) possèdent deux ailes horizontales qui s'étendent horizontalement vers l'extérieur séparément à partir des deux côtés de la partie supérieure du fût médian dans la direction parallèle à la surface d'extrémité du col de l'implant, symétrique avec l'axe central du fût médian et perpendiculaire à la surface d'extrémité supérieure du col de l'implant sous la forme d'une structure verticale ; et le fût médian est muni d'un trou traversant, et la partie anti rotation se trouve dans la partie inférieure du fût médian et correspond à la structure interne de la partie supérieure du col de l'implant dentaire qui doit être mesuré de telle sorte qu'elles peuvent se refermer l'une sur l'autre, avec une limite d'engagement total ; et ledit boulon central traverse le trou traversant du fût médian et peut s'engager étroitement sur les filetages internes de l'implant dentaire, de manière à fixer le transformateur d'amplitude étroitement sur l'implant dentaire, en formant un système transformateur d'amplitude/implant dentaire qui intègre le transformateur d'amplitude avec l'implant dentaire, et ainsi le système transformateur d'amplitude/implant dentaire qui intègre le transformateur d'amplitude avec l'implant dentaire peut vibrer en tant que structure intégrale, sous l'effet de l'excitation.

6. Transformateur d'amplitude selon la revendication 5, **caractérisé en ce que** ladite partie anti rotation est conçue avec une surface conique ou une surface concave, dans lequel la surface conique ou la surface concave est une structure anti rotation ayant la forme d'un hexagone, d'un octogone ou d'un trèfle, dont la forme épouse la structure interne de la partie supérieure du col de l'implant dentaire qui doit être mesuré.

7. Transformateur d'amplitude selon l'une quelconque des revendications 5 ou 6, **caractérisé en ce que** la longueur totale des ailes horizontales bilatérales (11) à partir de l'extrémité distale de l'aile horizontale d'un côté jusqu'à l'extrémité distale de l'aile horizontale de l'autre côté dans la direction horizontale est comprise entre 10 mm et 30 mm, l'épaisseur des ailes horizontales bilatérales (11) est comprise entre 0,5 mm et 3 mm, et la hauteur des ailes horizontales bilatérales (11) est comprise entre 3 mm et 10 mm, la longueur totale vraiment préférée des ailes bilatérales (11) est comprise entre 15 mm et 20 00, l'épaisseur vraiment préférée des ailes horizontales bilatérales (11) est comprise entre 1,3 mm et 1,6 mm, et la hauteur vraiment préférée des ailes horizontales bilatérales (11) est comprise entre 3 mm et 6 mm.

8. Transformateur d'amplitude selon la revendication

5, **caractérisé en ce que** les matériaux utilisés comprennent un alliage d'aluminium, le titane pur, un alliage de titane et l'acier inoxydable médical, parmi lesquels l'alliage d'aluminium est le matériau préféré.

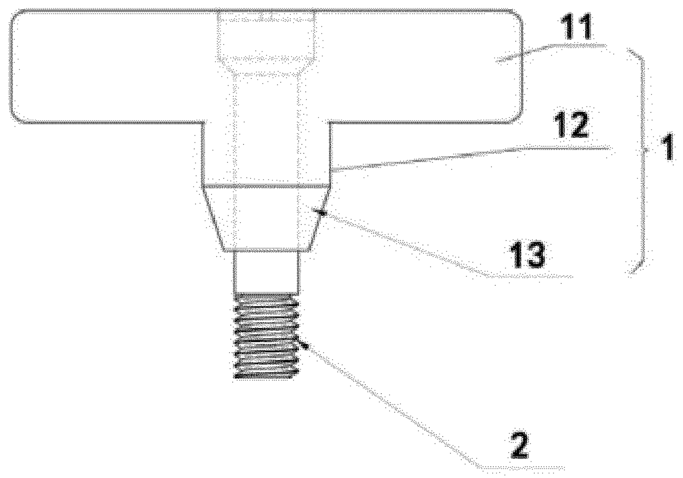

Fig. 1A

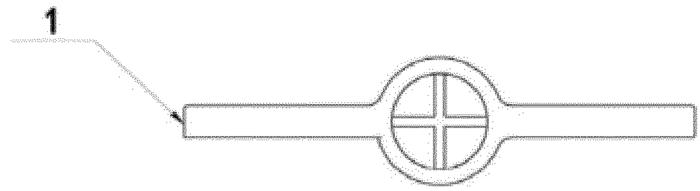

Fig. 1B

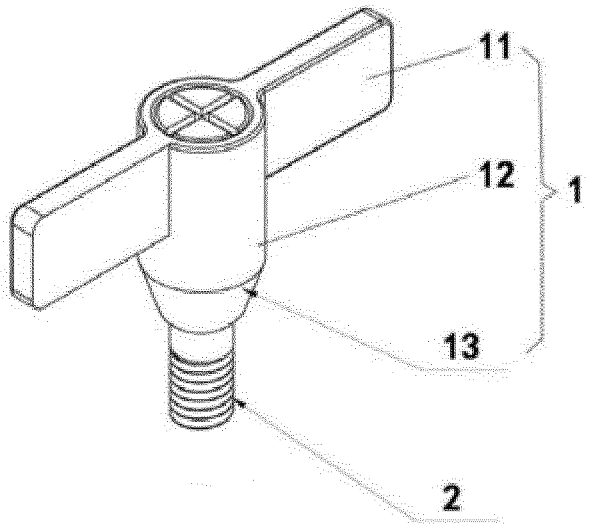

Fig. 1C

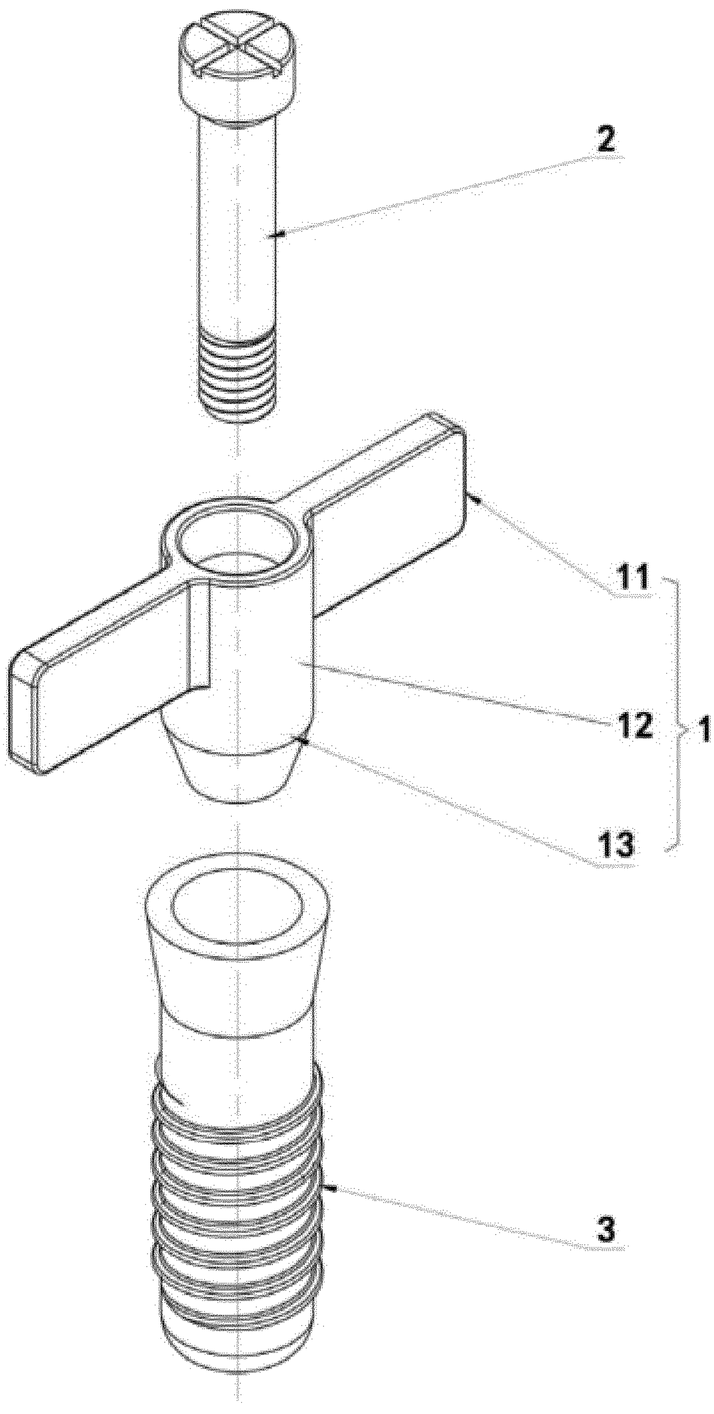

Fig. 2

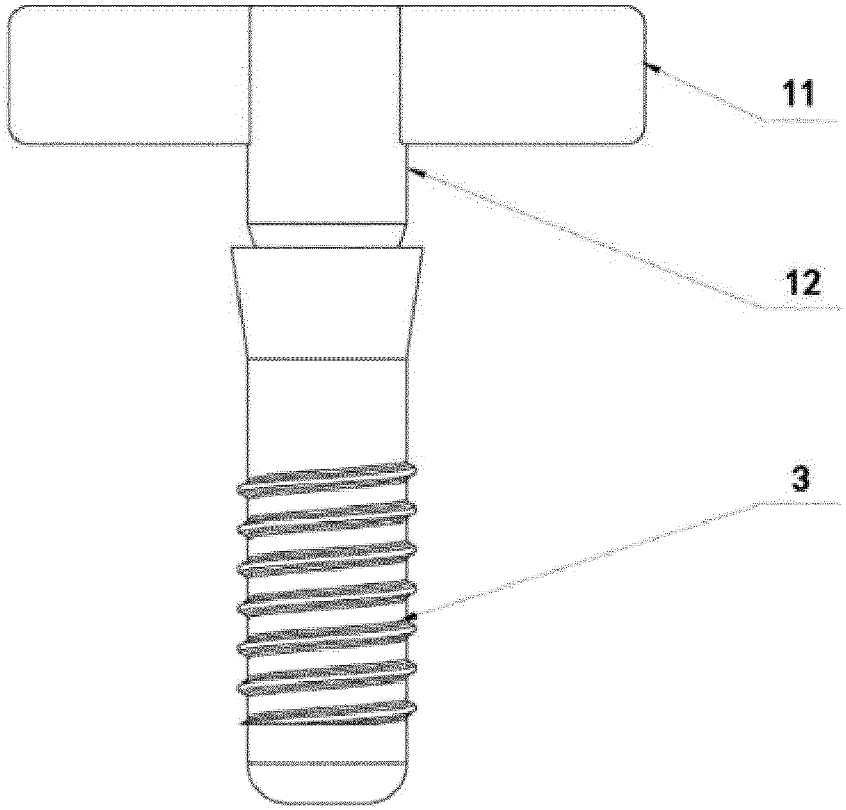

Fig. 3

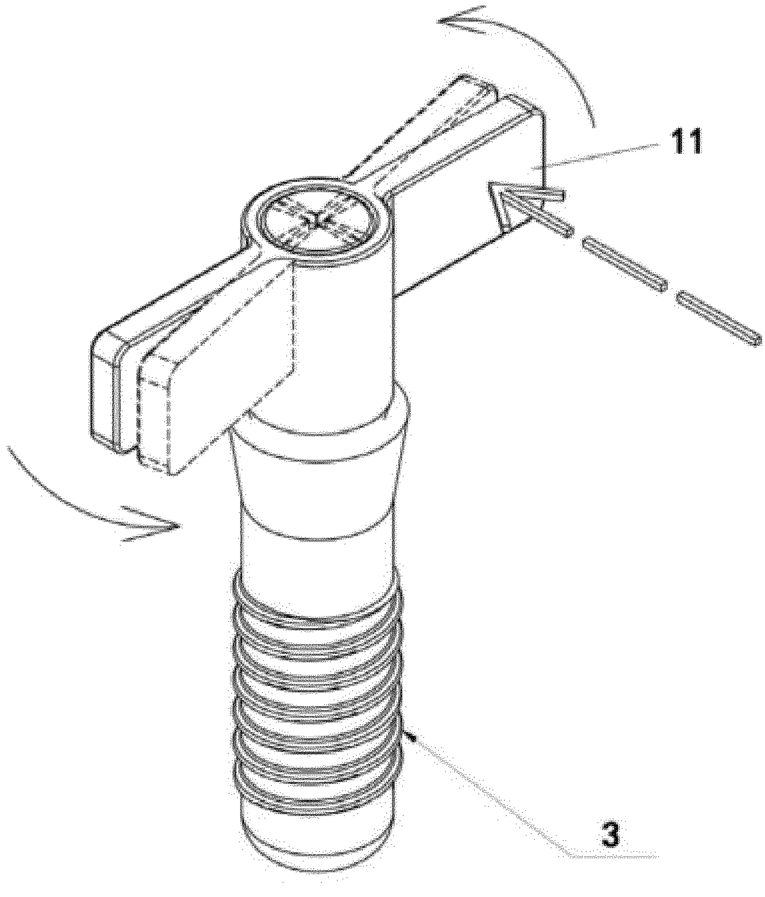

Fig. 4

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 20020143268 A **[0007]**
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[标]发明人	LI DEHUA TANG YULONG LI BING		
发明人	LI, DEHUA TANG, YULONG LI, BING		
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摘要(译)

本发明涉及一种用于评估牙种植体稳定性的扭转振动共振频率测量方法和一种新型振幅变换器，其中用于评估牙种植体稳定性的切割振动共振频率的测量方法包括安装新型振幅变换器，激励振幅变换器系统的环形振动模式，收集共振信号并分析共振频率，能够检测牙种植体的稳定性，连续监测临床治疗中的骨整合并指导确定修复植入物的机会，其中小说振幅变换器包括一个防旋转水平双翼组件和一个中心螺栓，有利于激活牙种植体的扭转振动，从而检测牙种植体在扭转振动模式下的共振频率，从而增加牙种植体骨界面区域骨骼刚度的敏感性，避免了非相关因素的混合影响，检测牙种植体的稳定性，为连续骨整合检测提供科学有效的方法和研究。