A device is described for use with a dental drill guide and a dental tool or implant, comprising means (2) to generate a signal when the dental tool or implant reaches a desired position and/or orientation with respect to the drill guide. Due to the generated signal a desired position and/or orientation with respect to the drill guide can be indicated so that the correct depth of the device like a drill in a patient's jaw can be better controlled.
DEVICE FOR POSITION AND/OR ORIENTATION CONTROL OF DENTAL TOOLS OR IMPLANTS USING DENTAL DRILL GUIDES

FIELD OF THE INVENTION

The current invention is related to computer guided dental implantology and dental drill guides, and is intended to provide position and/or orientation control during implant drilling or implant placement. The current invention is a device that will generate a signal (audible, perceptible, tangible or visible) to inform the user when the dental tool (implant holder/driver, drill...) reaches a predetermined position and/or orientation planned for dental implant planning software, e.g. in CT-based dental implant planning software.

BACKGROUND TO THE INVENTION

In dental treatment drive apparatuses for rotary tools, known as handpieces, are well known. Dental handpieces come in several shapes and most commonly are either straight or have a swan neck. Figure 1 shows a typical swan-necked dental handpiece, which comprises a handle A, a neck B and a head C in which a rotary tool (e.g. drill, bur, implant driver) is fixed. The handpiece is typically driven by a drive shaft or belt, which extends between the head of the handpiece and a remotely located drive motor. The drive shaft transmits the rotational movement of the motor to the handpiece. Handpieces can alternatively be driven by electric or pneumatic drive motors. Handpieces are used to drive tools during various dentistry operations, such as filling cavities, cleaning and the fitting of dental implants.

The use of implant planning software in combination with surgical drill guides is known technology in dental implantology. For example, a CT scan is made of the patient's jaw to visualize the bone in which implants will be placed. In general a scan prosthesis is worn during scanning to visualize the desired tooth setup. Based on these CT images and by means of dental planning software (e.g. SimPlant, Materialise Dental N.V.) dental implants can be planned taken into account aesthetics (i.e. desired tooth setup) and anatomical information (i.e. bone quantity and quality). To transfer the planning to the patient's mouth typically a drill guide (e.g. SurgiGuide, Materialise Dental N.V.) is manufactured. This drill guide fits in the patient's mouth and contains cylindrical tubes which guide the drilling actions in accordance to the treatment plan. More advanced drill guides (e.g. SAFE system, Materialise Dental N.V.) provide
additional functionality, guiding the implant placement itself and guaranteeing the axial position (i.e. depth) of the implants relative to the gums. Such *depth control* is commonly provided by means of a physical stop or by a mark on the dental tool which acts as a visual cue.

There are several shortcomings to the available systems for depth control though. These limit the accuracy of the axial position (i.e. the depth) of the implant. When a physical stop is used, the surgeon still needs to pay attention in order to detect the contact between the guide and the tool e.g. drill, implant driver as soon as it occurs. Otherwise there is a risk that the surgeon forces the tool deeper than planned for example due to compression of the soft tissue underneath the drill guide. In case of depth control by marks on the tool, the visibility of the marks can be poor due to for instance water cooling applied during drilling, limited opening of the mouth by the patient, etc. Moreover, detecting the alignment of the mark on the device with the top surface of the guiding tube in the dental drill guide is a subjective action, which can be influenced by the viewing direction of the surgeon.

**SUMMARY OF THE INVENTION**

An object of the present invention is to provide an alternative device and a method, particularly alternative systems and methods for computer guided dental implantology and dental drill guides. An advantage of the present invention for some embodiments can be that a better depth control is possible and especially that a better position and/or orientation control during implant drilling or implant placement is possible.

The object is achieved by a device according to claim 1 as well as by a method according to claim 9, wherein preferred embodiments of the invention are given by the dependent claims.

The present invention is particularly directed to a device to be used in combination with a dental drill guide, and is intended to generate a signal (audible, perceptible, tangible or visible) to inform the user when the dental tool (e.g. drill) or implant reaches the desired position and/or orientation, i.e. corresponding with the implant position and/or orientation as planned in a dental implant planning software.

The device is particularly characterized in that it has a circuit having two electrical states connected to a signal generator. In a first state, e.g. an open electrical circuit state, no signal is audible, perceptible, tangible or visible that is generated by
the signal generator. The circuit enters a second state, e.g. an electrical switch closes, when the desired position and/or orientation of the dental tool or implant (i.e. the one of the planning) is achieved, causing a signal to be produced.

In an embodiment of the present invention a device is provided for use with a dental drill guide and a dental tool or implant, comprising:
a signal generator that generates a signal when the dental tool or implant reaches a desired position and/or orientation with respect to the drill guide.

The desired position and/or orientation with respect to the drill guide can correspond with an implant position and/or orientation as planned in a dental implant planning software.

The dental tool can be a drill for example.

The signal generator can be adapted to generate an audible, perceptible, tangible, or visible signal.

Additionally, a circuit can be provided having a first and a second electrical state, wherein the circuit is connected to the signal generator, whereby in the first state, no audible, perceptible, tangible or visible signal is generated by the signal generator, wherein when the desired position and/or orientation of the dental tool or implant is achieved, the circuit is adapted for entering the second state causing an audible, perceptible, tangible or visible signal to be produced by the signal generator.

The first state can be in one option an open electrical circuit state.

A sensor can be provided to sense when the dental tool or implant reaches the desired position and/or orientation with respect to the drill guide.

This sensor can comprise two conductive parts normally in an electrical open circuit condition, wherein the conductive parts are adapted to close when the dental tool or implant reaches the desired position and/or orientation with respect to the drill guide.
BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 shows a dental handpiece;

Figure 2 shows a preferred embodiment of the invention mounted on the head of a dental handpiece;

Figure 3 shows a preferred embodiment of the invention with a decomposition of the different parts;

Figure 4 shows a sectional view of a preferred embodiment of the invention;

Figure 5 shows the moveable part with the ring shaped metal plate;

Figure 6 shows the fixed part with the two half ring shaped metal plates;

Figure 7 shows the clip including the metal plate;

Figure 8 shows a schematic overview of the electrical circuit used by a device according to the present invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

In the following detailed description of the preferred embodiments, reference is made to the accompanying drawings, which form a part hereof, and within which are shown by way of illustration specific embodiments by which the invention may be practiced. The drawings described are only schematic and are non-limiting. In the drawings, the size of some of the elements may be exaggerated and not drawn on scale for illustrative purposes. Those skilled in the art will recognize that other embodiments may be utilized and structural changes may be made without departing from the scope of the invention.

Furthermore, the terms first, second, third and the like in the description and in the claims, are used for distinguishing between similar elements and not necessarily for describing a sequential or chronological order. It is to be understood that the terms so used are interchangeable under appropriate circumstances and that the embodiments of the invention described herein are capable of operation in other sequences than described or illustrated herein.

Moreover, the terms top, bottom, over, under and the like in the description and the claims are used for descriptive purposes and not necessarily for describing relative positions. It is to be understood that the terms so used are interchangeable under appropriate circumstances and that the embodiments of the invention described herein
are capable of operation in other orientations than described or illustrated herein. It is to be noticed that the term "comprising", used in the claims, should not be interpreted as being restricted to the means listed thereafter; it does not exclude other elements or steps. Thus, the scope of the expression "a device comprising means A and B" should not be limited to devices consisting only of components A and B. It means that with respect to the present invention, the only relevant components of the device are A and B.

In the following reference to "patient", "teeth, or "jawbone" should be construed broadly to include not only humans but also animals, especially mammals in need of surgery.

According to a preferred embodiment of the invention a device is provided that can be used during implant placement in combination with a dental drill guide and a dental handpiece 1. It is intended to provide depth control during said implant placement by providing e.g. an audible signal to inform the user when the planned implant depth is reached.

Referring the drawings, according to the preferred embodiment the device is an assembly of several components: (i) a signal generator 2 (e.g. LED, buzzer, or vibration motor); (ii) an electrical power transferring means such as a wire mount 3; (iii) a sensor component, such as a circuit gap (CG) component 4 and (iv) a switch 5. The device is connected to a power source 6. This can be a separate power source (e.g. a battery) or can be the same source as the dental handpiece 1. Together the components and the power source form an electrical circuit which can be opened or closed via the switch 5. The design of the components is such that the device can easily be mounted on the dental handpiece 1. According to the embodiment, the sensor component is designed to sense when a certain depth has been reached. In one embodiment the sensor component is exemplified by the CG component 4. CG component 4 has a cylindrical part 7 which fits to the bottom plate 8 of the head C of the dental handpiece 1. This cylindrical part 7 has a central cylindrical hole 9 which lines up with the axis 10 of said head C in order not to hinder the rotary tool 11 (drill, implant driver. . .) when inserted in the handpiece 1. Extending from the cylindrical part 7 towards the handle A of the handpiece 1 is a retention brace 12 which snaps onto the neck B of the handpiece 1 from the bottom side, directly behind the head C. This retention brace 12 has two arms 13 engaging the neck B of the handpiece 1 on respectively the right and left hand side. The bulk of the CG component 4 is made of
an electrically non-conductive material. The component is further characterized in that
the bottom 1 of the cylindrical part 7 is equipped with two C-shaped conductive plates
14 (e.g. metallic material), one on either side of the central cylindrical hole 9. Each C-
plate 14 is connected to an electrical wire embedded in the CG-component 4. The two
wires run up respectively along either arm 13 of the retention brace 12 ending in small
metal plates 15 at the outer end of the arms 13. Two similar metal plates 16 are located
at the outer ends of the wire mount 3, which also is shaped like a brace with two arms
17 snapping over the neck of the handpiece 1. The wire mount 3 is positioned
diametrically opposite to the retention brace 12 of the CG-component 4 so that the
respective ends of the arms 13, 17 overlap, forcing the metal plates 15, 16 of both
components in contact with one another. The metal plates 16 of the wire mount 3 are
connected - via electric wiring 18 - to the poles of the power source 6. The electrical
circuit is completed by the signal generator 2 and the switch 5. The former can be
integrated for instance in the design of the wire mount 3 as a small LED or can be a
separate unit placed in the circuit producing e.g. an auditory signal. Alternatively the
signal generator 2 may act as a relay, de-activating the dental handpiece 1 when the
circuit is closed i.e. when the desired depth has been reached.

According to the preferred embodiment, the switch 5 snaps onto the head C of
the dental handpiece 1, covering the cylindrical part 7 of the CG-component 4.
Orientated in the same manner as said cylindrical part 4 and facing the two metal C-
shaped plates 14 is the moveable portion 19 of the switch 5. It is thereby also aligned
with the axis 10 of the head C of the handpiece 1, necessitating a central opening 20
through which the rotary tool 11 can operate freely. Relative to the portion 21 of the
switch 5 attached to the head C of the handpiece 1, the moveable portion 19 can be
temporary displaced along the axis of the rotary tool in the direction of the handpiece 1
when loaded (in that direction). A spring or spring-like element/feature 22 (e.g. an
annular element or wedge shape) forces the moveable portion 19 back into its original
position once the load has been removed. The moveable portion 19 is fitted with a
circular metal plate 23 facing the C-shaped plates 14 of the CG-component 4. In use,
the moveable portion 19 is loaded when it abuts against the drilling template. As a
result, the metal plate 23 of the moveable portion 19 contacts the C-shaped plates 14,
which closes the electrical circuit and activates the signal generator 2.

According to a preferred embodiment of the invention the moveable portion 19
of the switch 5 has at the bottom part a means to connect an additional ring shaped part
with a certain height in order to adapt the depth position of the tool or implant relative to the dental drill guide.

According to another preferred embodiment of the invention the switch 5 to be mounted on the head C of the dental handpiece 1 can use a screw fitting.

Alternatively a bayonet fitting or any other suitable form can be used to mount the switch 5 on the head C of the dental handpiece 1.

According to another preferred embodiment of the invention any connection can be used for the moveable portion 19 of the switch 5 that ensures non-contact with the C-shaped plates of the CG-component 4 except when the moveable portion 19 of the switch 5 is in contact with the dental drill guide, i.e. at the moment the position and/or orientation of the dental tool as planned in dental implant planning software is reached.

According to another preferred embodiment of the invention the device can be incorporated within or mounted on a manual screw driver that is used in combination with a dental drill guide and is intended to provide depth control during implant placement by providing a signal to inform the user when the implant has reached the planned depth.

According to another preferred embodiment of the invention the device can be designed to provide a signal when the planned rotational position is reached for the implant.

According to yet another preferred embodiment of the invention the device can be designed to provide two particularly different perceptible signals: a first perceptible signal is generated at the moment the planned depth position of the implant is reached and after that a second perceptible signal is generated at the moment the planned rotational position of the implant is reached.

According to another preferred embodiment of the invention the device is used during implant drilling through a dental drill guide by means of a dental handpiece 1 and is intended to provide depth control during said implant drilling action by providing a signal (audible, perceptible, tangible or visible) to inform the user when the drill depth that corresponds with the planned implant depth is reached.

The invention is further directed to a method for indicating the position and/or orientation of a device during the use of said device with a dental drill guide and a dental tool or implant, wherein a signal is generated when the dental tool or implant reaches a desired position and/or orientation with respect to the drill guide. The used
device can be designed as previously described. The method can be further designed as previously described with respect to the device according to the invention.

Any of the functionality of devices or methods according to the present invention may be implemented as hardware, computer software, or combinations of both. The signal generator may be implemented with a general purpose processor, an embedded processor, a digital signal processor (DSP), an application specific integrated circuit (ASIC), a field programmable gate array (FPGA) or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination designed to perform the functions described herein. A general purpose processor may be a microprocessor, controller, microcontroller or state machine. A processor may also be implemented as a combination of computing devices, e.g., a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration.
CLAIMS

1. A device for use with a dental drill guide and a dental tool or implant, comprising:
   means to generate a signal when the dental tool or implant reaches a desired position
   and/or orientation with respect to the drill guide.

2. The device of claim 1 wherein the desired position and/or orientation with respect to
   the drill guide corresponds with an implant position and/or orientation as planned in a
dental implant planning software.

3. The device of claim 1, wherein the dental tool is a drill.

4. The device of any previous claim, wherein the means to generate a signal generates
   an audible, perceptible, tangible, or visible signal.

5. The device of any previous claim, further comprising a circuit having a first and a
   second electrical state, wherein the circuit is connected to the means to generate a
   signal, whereby in the first state, no audible, perceptible, tangible or visible signal is
   generated by the means to generate a signal, wherein when the desired position and/or
   orientation of the dental tool or implant is achieved, the circuit is adapted for entering
   the second state causing an audible, perceptible, tangible or visible signal to be
   produced by the signal generator.

6. The device of claim 5, wherein the first state is an open electrical circuit state.

7. The device of any previous claim further comprising a sensor to sense when the
dental tool or implant reaches the desired position and/or orientation with respect to the
drill guide.

8. The device of claim 7, wherein the sensor comprises two conductive parts normally
   in an electrical open circuit condition, wherein the conductive parts are adapted to
   close when the dental tool or implant reaches the desired position and/or orientation
   with respect to the drill guide.
9. A method for indicating the position and/or orientation of a device, particularly according to anyone of claims 1 to 8, during the use of said device with a dental drill guide and a dental tool or implant, wherein a signal is generated when the dental tool or implant reaches a desired position and/or orientation with respect to the drill guide.

10. The method of claim 9, wherein the signal is an audible, perceptible, tangible or visible signal.
Fig. 8
**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

A61C1/08, H01H1/12

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

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

EPO-Internal

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

<table>
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<th>Category</th>
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<td>US 5 343' 391 A (MUSHABAC DAVID R [US]) 30 August 1994 (1994-08-30) column 5, line 26 - line 33</td>
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**D. Further documents are listed in the continuation of Box C**

- *Special categories of cited documents*
  - "A" document defining the general state of the art which is not considered to be of particular relevance
  - "E" earlier document published on or after the international filing date
  - "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
  - "O" document referring to an oral disclosure, use, exhibition or other means
  - "P" document published prior to the international filing date but later than the priority date claimed

- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance, the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance, the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "A" document member of the same patent family

Date of the actual completion of the international search: 22 December 2009

Date of mailing of the international search report: 07/01/2010

Name and mailing address of the ISA:

European Patent Office, P B 5818 Patentlaan 2
NL - 2280 HV RIJSWIJK
Tel (+31-70) 340-2040, Fax (+31-70) 340-3016

Authorized officer: Kerner, Bodo


**INTERNATIONAL SEARCH REPORT**

**Box No. ii** Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

<table>
<thead>
<tr>
<th>1</th>
<th>Claims Nos 9–10</th>
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<tr>
<td>#</td>
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<tr>
<td></td>
<td>because they are non-searchable matter not required to be searched by this Authority, namely</td>
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<td>because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically</td>
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<tr>
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<td>because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)</td>
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</table>

**Box No. iii** Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

| 1 | As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims |
| 2 | As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of additional fees |
| 3 | As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos |
| 4 | No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims, it is covered by claims Nos |

**Remark on Protest**

- The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (April 2005)
Continuation of Box II.1

Claims Nos.: 9-10

Independent claim 9 and therefore also dependent claim 10 fall under Rule 39.1(iv) PCT as their subject-matter implicitly contains method steps for treatment of the human body by surgery: Claim 9 specifies a method of indicating the position of a dental tool (must be a "dental drill" as the tool is used with a drill guide, see wording of claim 1) or an implant with respect to a drill guide. It is obvious that this device is used during drilling of a hole in a patient's jaw and/or the subsequent step of placing an implant at this place. These steps are clearly part of a surgical method carried out on the human body.

Continuation of Box II.2

Claims Nos.: 1-8(all partially)

Due to the very broad formulation of claim 1 and therefore the high amount of novelty destroying prior art, it was not possible to carry out a complete search. It is not yet clear which subject-matter a final amended claim 1 will define. Consequently, the cited prior art only represents an incomplete picture of the potentially relevant prior art.

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guideline C-VI, 8.2), should the problems which led to the Article 17(2) declaration be overcome.
### Patent document cited in search report
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