

(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
10 July 2008 (10.07.2008)

PCT

(10) International Publication Number  
**WO 2008/080235 A1**

(51) International Patent Classification:  
**A61C 7/00** (2006.01)

(74) Agent: **LUSUARDI, Werther**; Dr. Lusuardi AG,  
Kreuzbühlstrasse 8, CH-8008 Zürich (CH).

(21) International Application Number:  
PCT/CH2007/000004

(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(22) International Filing Date: 3 January 2007 (03.01.2007)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicant (*for all designated States except US*): **AO TECHNOLOGY AG** [CH/CH]; Grabenstrasse 15, CH-7002 Chur (CH).

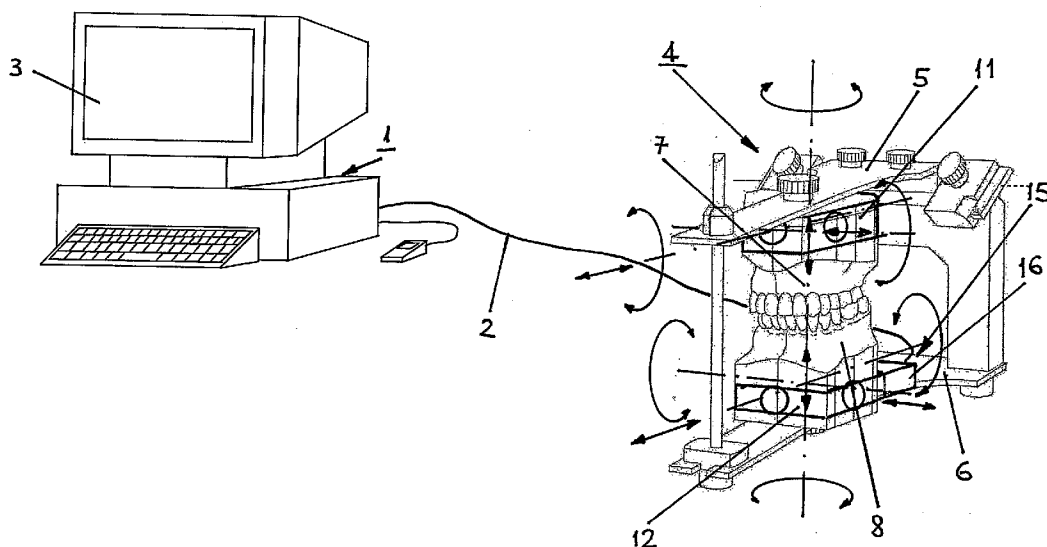
(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

(72) Inventors; and

(75) Inventors/Applicants (*for US only*): **CHAPUIS, Jonas** [CH/CH]; Rue de la Pontaise 14, CH-1018 Lausanne (CH). **ZACHOW, Stefan** [DE/DE]; Hamerlingweg 5, 14167 Berlin (DE). **LANGLOTZ, Frank** [DE/CH]; Weiherstrasse 3, CH-4800 Zofingen (CH). **SCHRAMM, Alexander** [DE/DE]; Im Schwanenring 91, 30627 Hannover (DE).

**Published:**  
— with international search report

(54) Title: DEVICE FOR PLANNING ORTHODONTICS AND/OR ORTHOGNATHIC SURGERY



(57) Abstract: Device for planning orthodontic and/or orthognathic surgery comprising: A) a computer (1) comprising a display (3) and being provided with planning software (I) suitable for planning orthodontic and/or orthognathic surgery; B) a dental articulator (4) comprising a first member (5) for accommodating a first cast (7) of an upper dentition, a second member (6) for accommodating a second cast (8) of a corresponding lower dentition, and at least one powered adjustment drive (11; 12) attached to one of said members (5; 6) allowing to bring said first and second members (5, 6) respectively in a desired position relative to each other; wherein C) transferring means (15) are provided for transferring digital data containing surgical parameters obtained with said planning software and related to position parameters of said first and second members (5; 6) to said at least one powered adjustment drive (11; 12) of said dental articulator (4).

WO 2008/080235 A1

**Device for planning orthodontics and/or orthognathic surgery**

The invention relates to a device for planning orthodontics and/or orthognathic surgery according to the preamble of claim 1 and to a method for planning orthodontics and/or orthognathic surgery according to the preamble of claim 11.

In orthodontics and orthognathic surgery involving the correction of dental alignment or surgical relocation of the jaw bones conventionally plaster casts of the dentition are used which are mounted on a dental articulator in order to assess the relationship between the upper and lower jaw, i.e. the dental occlusion.

In the following the term dental articulator is used for an apparatus for a simulation of the relation and function of the upper and lower jaw whereby the models, e.g. plaster casts of the upper and lower dentition allow analyzing the static occlusion and the dynamic occlusion (i.e. masticatory movements).

During orthognathic surgery one or both jaws are mobilized (mono-maxillary osteotomy or bi-maxillary osteotomy) and repositioned to more appropriate locations and the corrected situation is stabilized with bone plates and bone screws. In bi-maxillary osteotomy the surgeon starts working on the upper jaw. LE FORT I osteotomy is often performed, cutting the bone with saw and chisel and finishing with down-fracture of the segment to complete the mobilization. This upper jaw segment can then be moved into the planned corrective position. A previously produced intermediary positioning splint is used for guidance while executing the movement. This splint is intraoperatively placed e.g. on the surgically untreated mandible and serves as a mechanical guide when relocating the surgically liberated maxilla into the desired position. After relocation of the maxilla the procedure continues with the mandible. Usually, sagittal split ramus osteotomy (SSRO) is performed on both mandibular rami, separating the body of the mandible. Repositioning is realized then using a final positioning splint also fabricated during surgical planning. This final positioning splint makes the mandible follow the maxillary movement such placing both jaw segments in the planned dental occlusion, i.e. dental bite.

Such dental splints, i.e. removable dental appliances reproducing a certain "bite", particularly the aforementioned intermediary positioning splint and the final positioning splint are produced using a dental articulator together with the plaster casts.

In order to produce these splints, the mandibular and maxillary plaster casts on the dental articulator need to be aligned in the desired relative position each. To achieve the desired relative position of the plaster casts the pre-operatively planned position of each of the two jaw bones has to be transferred to the dental articulator, which is not easy to accomplish due to the six translational and rotational degrees of freedom per mobilized segment. Working with a conventional dental articulator becomes even more difficult in cases where computer assisted planning of relocation procedures is performed in advance. The so planned positions of each segment have to be transferred to the dental articulator manually, which is a tedious task and can often not be performed in a precise manner.

A device using a dental articulator and computer equipment to represent position and function of the jaws and bite of an individual is known from US 6,062,861 ANDERSSON. This known device allows producing a construction or construction alteration based on representations of the jaws on the display of the computer. The construction is then attached to a dental articulator where jaw movements can be simulated such that the respective function of the construction or construction alteration can be observed by a technician. One drawback of this known device can be seen in the fact that the dental articulator is not provided with computer controlled adjustment drives allowing to adjust the construction or e.g. plaster casts of the upper and lower jaw bones mounted on the dental articulator to a relative position being previously planned on the computer.

On this point, the invention intends to provide remedial measures. The invention is based on the objective of providing a device allowing to adjust models, e.g. plaster casts of the upper and lower jaw to a relative position by means of computer controlled driving means whereby the desired relative position of the models has been previously planned using software programmed on the computer.

The invention solves the posed problem with a device that displays the features of claim 1 and with a method for planning orthodontics and/or orthognathic surgery that displays the features of claim 11.

The advantages achieved by the invention are essentially to be seen in the fact that, thanks to the device according to the invention:

- a computer controlled adjustment of the models, e.g. plaster casts on the dental articulator is possible, which is particularly advantageous when an adjustment of two models (upper and lower jaw) has to be performed with respect to six degrees of freedom each. The complex movements of at least one of said first (maxillary) and second (mandibular) plaster casts on the articulator with respect to six degrees of freedom in order to be positioned according to the preoperative plan can be carried out in a precise manner which is currently not possible with known devices; and
- one or more intraoperative positioning splints with improved precision can then be produced in the conventional manner, i.e. using the plaster casts positioned on the dental articulator.

In a preferred embodiment the transferring means are of electrical or electromagnetic nature.

In another embodiment the transferring means are realized by a cable or wireless communication between said computer and said dental articulator.

In a further embodiment the transferring means comprise a controller that enables the transformation of said digital data into electrical signals for activating said at least one powered adjustment drive. This embodiment offers the advantage that a customary external controller, e.g. control device or equipment including a digital to analog converter with a digital input and electrically connectable to the powered adjustment drives can be used.

In still a further embodiment the computer is provided with control software suitable for controlling adjusting movements of said at least one powered adjustment drive.

Herewith the advantage can be achieved that rotating electrical motors, e.g. electrical stepper motors which are used as powered adjustment drives can directly be controlled by means of the computer. Such electrical stepper motors allow a direct digital to analog conversion of the transferred digital data.

In yet another embodiment the computer is suitably programmed for linking said planning software and said controlling software in order to have the surgical parameters obtained with said planning software automatically converted into said digital data related to position parameters of at least one of said first and second members. This embodiment offers the advantage that the position of the models, e.g. plaster casts planned on the computer has not to be transferred from the planning software to the controlling software by the operator. The current positions as well as relative translational and rotational parameters are automatically retrieved and set via the computer. The operator must only use the planning software and must not transfer data from one software application to another.

In a further embodiment at least one of said first and second powered adjustment drives is realized by a rotational electrical stepper motor.

In still a further embodiment at least one of said first and second powered adjustment drives is realized by a linear electrical stepper motor.

In another embodiment at least one of said first and second powered adjustment drives is realized by an electrical hybrid drive.

In its preferred application the device according to the invention is used for a correction of dental alignment and/or surgical relocation of the jaw bones of a patient.

The invention and additional configurations of the invention are explained in even more detail with reference to the partially schematic illustration of several embodiments.

In the figures:

Fig. 1 illustrates a schematic representation of one embodiment of the device according to the invention.

The embodiment shown in fig. 1 essentially comprises a computer 1 and a dental articulator 4 to allow a planning of an orthognathic surgery including the production of intraoperatively used positioning splints. The computer 1 comprises a display 3 and is provided with planning software (I) suitable for planning orthodontic and/or orthognathic surgery. Further, said computer 1 is provided with control software (II) suitable for controlling movements of the first and second powered adjustment drives 11;12 mounted on the dental articulator 4. The dental articulator 4 comprises a first member 5 for accommodating a first cast 7 of an upper dentition and a second member 6 for accommodating a second cast 8 of a corresponding lower dentition. By means of said first and second powered adjustment drives 11;12 said first respectively second member 5;6 can be positioned in such manner that said first and second cast 7;8 are adjusted in a surgeon desired position relative to each other. The first and second powered adjustment drives 11;12 include customary rotational and linear electrical stepper motors. Such electrical stepper motors are provided with a controlling unit including an digital to analog converter and can therefore be connected to the computer 1 using customary interface means, e.g. a RS-232 interface or a CAN Bus. Such the necessary positioning of said first (maxillary) and second (mandibular) casts 7;8 on the dental articulator 4 each with respect to six degrees of freedom can be precisely carried out according to the surgical parameters obtained with said planning software. In order to actuate said first and second powered adjustment drives 11;12 transferring means 15 are provided. In the embodiment illustrated in fig. 1 these transferring means 15 include a cable 2 for electrically connecting the computer 1 with the dental articulator 4 and each a controller 16 attached to the first and second member 5;6 allowing to control said first and second powered adjustment drive 11;12. Such said transferring means 15 allow to electrically transfer digital data containing the surgical parameters obtained with said planning software and related to position parameters of said first and second members 5;6 to said first and second powered adjustment drive 11;12 of said dental articulator 4, whereby a digital to analog conversion of the digital data into electrical signal is also performed.

Additionally, said computer 1 is suitably programmed for linking said planning software (I) and said controlling software (II) in order to have the surgical parameters obtained with said planning software (I) automatically converted into said digital data related to position parameters of said first and second members 5;6.

In the following paragraphs the inventive method for surgical planning and preparation of an orthognathic surgery using the inventive dental articulator is described:

A) Preoperative data acquisition:

by performing the steps of:

- a) producing models (e.g. plaster casts) of the upper and lower jaws, in particular a first cast 7 of the upper dentition and a second cast 8 of the lower dentition;
- b) acquiring medical images of the upper and lower jaws of a patient using Computed Tomography or any other imaging means resulting in a three-dimensional dataset of the patient's jaws.

Firstly, impressions of the upper and lower dentitions are taken in a solidifying gel and imprints of the bite are acquired using a standard dental wax sheet. The solidified gel allows then to produce said first and second cast 7;8 of the upper respectively lower dentition and the bite imprints are used to mold a sheet of plastic into a registration splint which corresponds to the normal bite of a patient.

A CT Scan (Computed tomography) of a patient's upper and lower jaw is then obtained in order to generate a three dimensional computer representation of said upper and lower jaw. In order to provide a quick and accurate registration means registration markers are attached to the registration splint. The patient then goes through a typical protocol (512 x 512 pixels slice resolution with a slice thickness of 0,6 – 1,0 mm) using a known digital volume Tomography technology, whereby the X-ray source and the oppositely arranged image intensifier rotate through 360° to generate projection data of the targeted upper and lower jaw. During the scanning procedure the patient bites into the registration splint in order to set the upper and lower jaw in a referenced relative position.

B) Generation of the virtual representation:

A virtual representation, e.g. virtual skeletal model of the upper and lower jaw is established as a set of binary data by means of the computer using said CT scan and customary software, e.g. the Visualization Toolkit (VTK, Kitware Inc., New York USA);

C) Planning surgery:

by performing the steps of:

c) planning the correction of dental alignment and/or surgical relocation of the jaw bones of a patient at the display 3 of a computer 1 using said virtual representation and known surgical simulation software, e.g. "cut&move" surgical planners. Osteotomies at the virtual representation of the upper and lower jaw, i.e. the virtual skeletal model are simulated by combinations of planar cuts;

d) attaching said first and second cast 7;8 to the first respectively the second member 5, 6 of a dental articulator 4, whereby each a reference element (not shown) is attached to said first and second cast 7;8 allowing the use of a commercially available tracking system, e.g. Polaris, Northern Digital Inc., Waterloo, Canada for measuring and such registering the spatial position of the first and second cast 7;8. After placing the registration splint onto said first and second cast 7;8 the latter can then be secured in their respective position and registered by means of the tracking system. This reproduces the pathological dental occlusion on the dental articulator 4 and corresponds exactly to the situation imaged in the CT scan. The occlusion planning technique based on said first and second cast 7;8 is then performed by the surgeon by seeking the optimal occlusion by manipulating said first and second cast 7;8 while the motion of the first and second cast 7;8 is measured and is visualized on the display 3 of the computer 1 using said virtual representation.

e) automatically adjusting the first and second cast 7;8 on said dental articulator 4 by transferring the planning parameters obtained by said computer 1 to said first and second powered adjusting drive 11;12 acting on said first and second member 5;6.

f) producing one or more positioning splints. Once, the optimal dental occlusion has been defined a dental positioning splint is commonly produced to be used to ensure intraoperative placement of the patient's jaws in accordance with the surgical plan. By mimicking the desired bite on the dental articulator 4 a final positioning splint can be



produced. This final positioning splint is used to assist in realizing the final intraoperative movement, i.e. relocation of the mandible when the maxilla is already in the desired corrected position. Such positioning splint implements the desired occlusal outcome reliably and helps in holding the mandible steady during placement of the final bone fixation plates. For assistance in the realization of the first surgical movement, i.e. relocation of the upper jaw an intermediary positioning splint is produced in the same manner. Thereto, imprints of the bite simulated on the dental articulator 4 are acquired using a standard dental wax sheet and are used to mold a sheet of plastic into a desired positioning splint.

## Claims

1. Device for planning orthodontic and/or orthognathic surgery comprising:

A) a computer (1) comprising a display (3) and being provided with planning software (I) suitable for planning orthodontic and/or orthognathic surgery;

B) a dental articulator (4) comprising a first member (5) for accommodating a first cast (7) of an upper dentition, a second member (6) for accommodating a second cast (8) of a corresponding lower dentition, and at least one powered adjustment drive (11;12) attached to one of said members (5;6) allowing to bring said first and second members (5, 6) respectively in a desired position relative to each other;

wherein

C) transferring means (15) are provided for transferring digital data containing surgical parameters obtained with said planning software and related to position parameters of said first and second members (5;6) to said at least one powered adjustment drive (11;12) of said dental articulator (4).

2. Device according to claim 1, wherein said transferring means (15) are of electrical or electromagnetical nature.

3. Device according to claim 1 or 2, wherein said transferring means (15) are realized by a cable or wireless communication between said computer (1) and said dental articulator (4).

4. Device according to one of the claims 1 to 3, wherein said transferring means (15) comprise a controller (16) that enables the transformation of said digital data into electrical signals for activating said at least one powered adjustment drive (11;12).

5. Device according to one of the claims 1 to 4, wherein said computer (1) is provided with control software (II) suitable for controlling adjusting movements of said at least one powered adjustment drive (11, 12).

6. Device according to claim 5, wherein said computer (1) is suitably programmed for linking said planning software (I) and said controlling software (II) in order to have the surgical parameters obtained with said planning software (I) automatically converted

into said digital data related to position parameters of at least one of said first and second members (5;6).

7. Device according to one of the claims 1 to 6, wherein at least one of said first and second powered adjustment drives (11;12) is realized by a rotational electrical stepper motor.

8. Device according to one of the claims 1 to 7, wherein at least one of said first and second powered adjustment drives (11;12) is realized by a linear electrical stepper motor.

9. Device according to one of the claims 1 to 8, wherein at least one of said first and second powered adjustment drives (11;12) is realized by an electrical hybrid drive.

10. Use of the device according to one of the claims 1 to 9 for the correction of dental alignment and/or surgical relocation of the jaw bones of a patient.

11. Method for producing a positioning splint in orthognathic surgery for relocating the upper and/or lower jaw using the device according to any one of claims 1 to 9 comprising the steps of:

- a) producing models (e.g. plaster casts) of the upper and lower jaws;
- b) attaching said models to the first and second member (5, 6) of the dental articulator (4);
- c) planning the correction of dental alignment and/or surgical relocation of the jaw bones of a patient at the display (3) of a computer (1);
- d) automatically adjusting the models on said dental articulator (4) by transferring the planning parameters obtained by said computer (1) to at least one powered adjusting drive acting on said first and second member (5, 6); and
- e) producing a positioning splint.

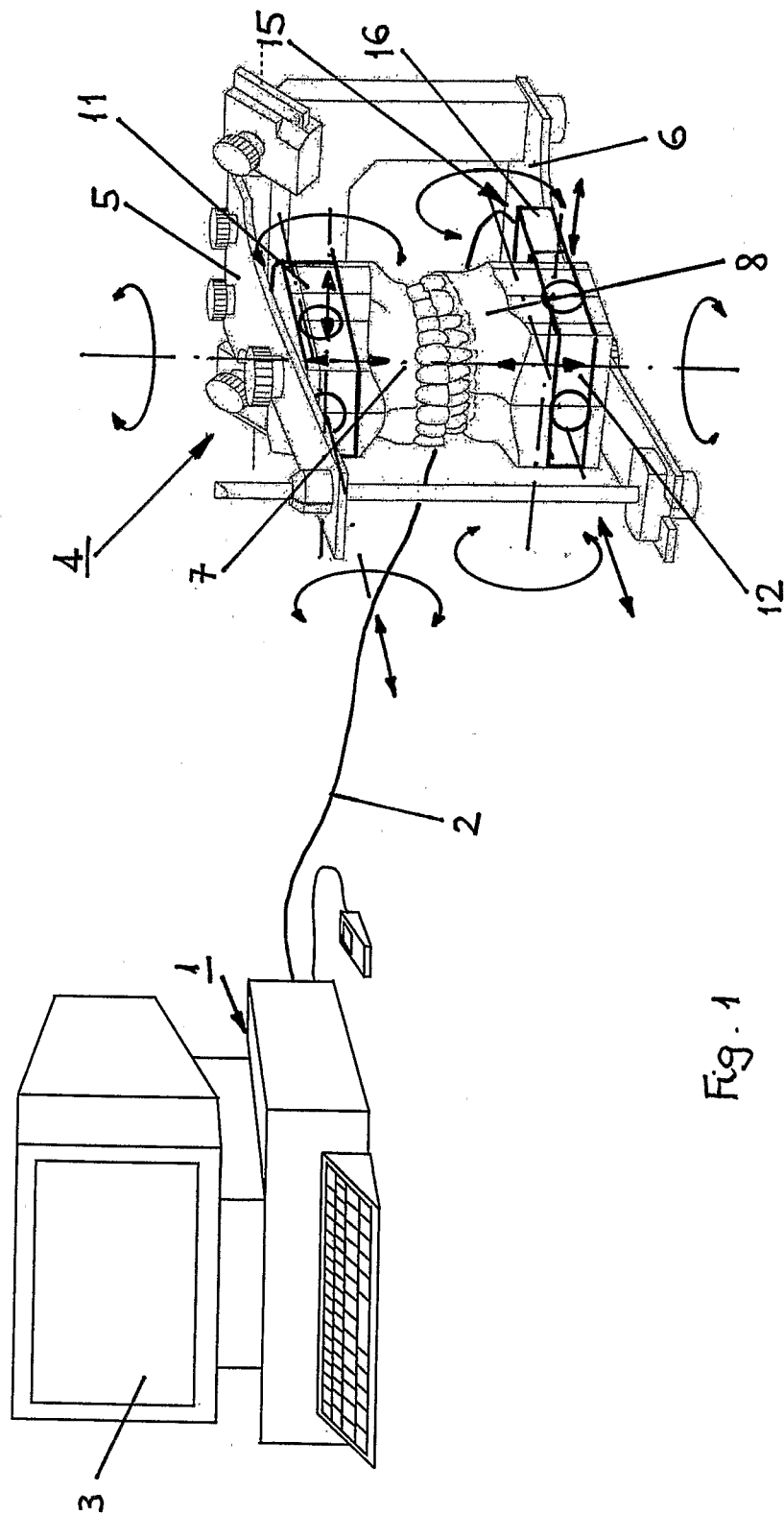


Fig. 1

# INTERNATIONAL SEARCH REPORT

International application No  
PCT/CH2007/000004

## A. CLASSIFICATION OF SUBJECT MATTER

INV. A61C7/00

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
A61C

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

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2006/000063 A (MEDICIM NV [BE]; SCHUTYSER FILIP [BE]) 5 January 2006 (2006-01-05) paragraphs [0053], [0056]	1-11
X	US 5 340 309 A (ROBERTSON JAMES G [US]) 23 August 1994 (1994-08-23) column 3, line 50 - column 4, line 4 column 4, lines 19-26 column 5, lines 32-37, 65-68 column 8, lines 29-36 ----- -/--	1-10

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

☒ See patent family annex.

### \* 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 but published on or after the international filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

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

Date of the actual completion of the international search

12 September 2007

Date of mailing of the international search report

21/09/2007

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3016

Authorized officer

Fortune, Bruce

## INTERNATIONAL SEARCH REPORT

International application No

PCT/CH2007/000004

## C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 35 42 177 A1 (KUBEIN MEESENBURG DIETMAR [DE]; MEYER GEORG [DE]; BUECKING WOLFRAM DR) 4 June 1987 (1987-06-04) column 5, lines 30-33 column 7, lines 55-59 claim 8 figures 1,2	1-5,7-10
A	----- EP 0 910 997 A (ONO SOKKI CO LTD [JP]) 28 April 1999 (1999-04-28) paragraphs [0041], [0104] figures 3,11	6,11
A	----- US 6 213 769 B1 (BETTEGA GEORGES [FR] ET AL) 10 April 2001 (2001-04-10) column 1, lines 7-14 column 6, lines 17-24 column 9, lines 44-50	1-10
A	----- WO 00/33759 A1 (ALIGN TECHNOLOGY INC [US]) 15 June 2000 (2000-06-15) page 6, line 28 - page 7, line 6 page 13, lines 1-15 page 16, lines 8-22 -----	1

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/CH2007/000004

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
WO 2006000063	A	05-01-2006	CN 1998022 A EP 1759353 A1 US 2007197902 A1	11-07-2007 07-03-2007 23-08-2007
US 5340309	A	23-08-1994	NONE	
DE 3542177	A1	04-06-1987	CA 1267551 A1 DK 574486 A EP 0229266 A2 US 4875857 A	10-04-1990 30-05-1987 22-07-1987 24-10-1989
EP 0910997	A	28-04-1999	US 6120290 A	19-09-2000
US 6213769	B1	10-04-2001	DE 69729804 D1 DE 69729804 T2 EP 0954252 A1 FR 2757373 A1 WO 9827892 A1	12-08-2004 14-07-2005 10-11-1999 26-06-1998 02-07-1998
WO 0033759	A1	15-06-2000	AU 2164100 A	26-06-2000