**(12) STANDARD PATENT** (11) Application No. **AU 2013296108 B2**
**(19) AUSTRALIAN PATENT OFFICE**

(54) Title
**Patient specific instrumentation with mems in surgery**

(51) International Patent Classification(s)
***A61B 5/00*** (2006.01) ***A61B 17/17*** (2006.01)
***A61B 6/00*** (2006.01) ***B81B 7/02*** (2006.01)
***A61B 17/15*** (2006.01)

(21) Application No: **2013296108** (22) Date of Filing: **2013.07.24**

(87) WIPO No: **WO14/015433**

(30) Priority Data

| (31) Number | (32) Date | (33) Country |
|---|---|---|
| **61/675,242** | **2012.07.24** | **US** |

(43) Publication Date: **2014.01.30**
(44) Accepted Journal Date: **2017.08.31**

(71) Applicant(s)
**Zimmer, Inc.;ORTHOsoft Inc.**

(72) Inventor(s)
**McCauley, Jeffrey A.;Amiot, Louis-Philippe**

(74) Agent / Attorney
**Phillips Ormonde Fitzpatrick, L 16 333 Collins St, Melbourne, VIC, 3000, AU**

(56) Related Art
**US 2010/0082035**
**US 2012/0157887**
**US 2010/0076563**

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
30 January 2014 (30.01.2014)

WIPO | PCT

(10) International Publication Number
WO 2014/015433 A1

(51) International Patent Classification:
*A61B 19/00* (2006.01) *A61B 5/00* (2006.01)
*A61B 17/15* (2006.01) *A61B 6/00* (2006.01)
*A61B 17/17* (2006.01) *B81B 7/02* (2006.01)

(21) International Application Number:
PCT/CA2013/050574

(22) International Filing Date:
24 July 2013 (24.07.2013)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/675,242 24 July 2012 (24.07.2012) US

(71) Applicants: **ORTHOSOFT INC.** [CA/CA]; Suite 3300, 75 Queen Street, Montréal, Québec H3C 2N6 (CA). **ZIMMER, INC.** [US/US]; 1800 W. Center Street, Warsaw, Indiana 46580 (US).

(72) Inventors: **MCCAULEY, Jeffrey A.**; c/o Zimmer, Inc., 1800 W. Center Street, Warsaw, Indiana 46580 (US). **AMIOT, Louis-Philippe**; 49 rue Thurlow, Hampstead, Québec H3X 3G8 (CA).

(74) Agent: **NORTON ROSE FULBRIGHT CANADA LLP/S.E.N.C.R.L., S.R.L.**; Suite 2500, 1 place Ville-Marie, Montreal, Québec H3B 1R1 (CA).

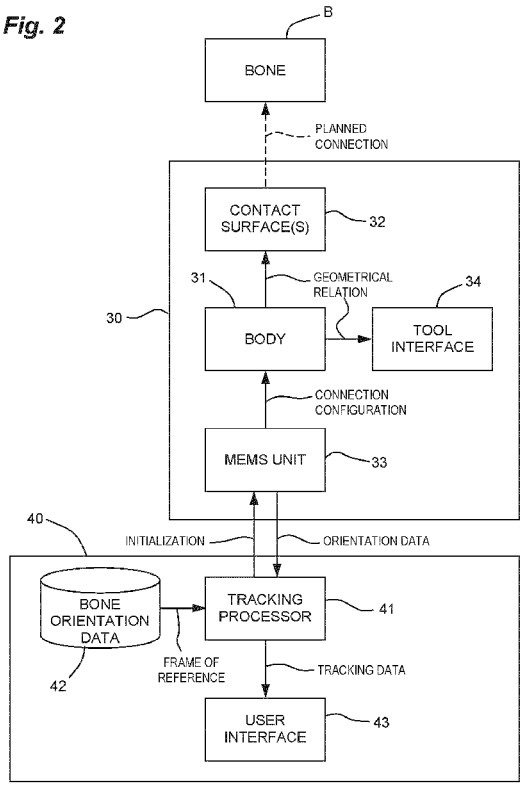
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE,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

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ,

*[Continued on next page]*

(54) Title: PATIENT SPECIFIC INSTRUMENTATION WITH MEMS IN SURGERY

*Fig. 2*




(57) Abstract: An assembly of a patient specific instrument and tracking system comprises a patient specific instrument having a body with a patient specific contact surface negatively shaped relative to a corresponding surface of a bone for complementary contact therewith. An inertial sensor unit with a preset orientation is connected to the body in a planned connection configuration, such that a geometrical relation between the contact surface and the inertial sensor unit is known. A tracking system has a tracking processor connected to the inertial sensor unit, a user interface, and bone orientation data related to the patient specific contact surface, the tracking processor producing orientation tracking data for the bone using the geometrical relation and the bone orientation data when the preset orientation of the inertial sensor unit is initialized, to output the orientation tracking data on the user interface.

WO 2014/015433 A1

TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

**Published**:

— *with international search report (Art. 21(3))*

2013296108 16 Aug 2017

# PATIENT SPECIFIC INSTRUMENTATION WITH MEMS IN SURGERY

## FIELD OF THE APPLICATION

**[0001]** The present application relates to the patient specific instrumentation and inertial sensors such as micro-electromechanical sensors (MEMS) in orthopedic surgery.

## BACKGROUND OF THE ART

**[0002a]** A reference herein to a patent document or other matter which is given as prior art is not to be taken as an admission that that document or matter was known or that the information it contains was part of the common general knowledge as at the priority date of any of the claims.

**[0002b]** Where the terms "comprise", "comprises", "comprised" or "comprising" are used in this specification (including the claims) they are to be interpreted as specifying the presence of the stated features, integers, steps or components, but not precluding the presence of one or more other features, integers, steps or components, or group thereto.

**[0002]** One of the essential steps in navigating a bone and tools with MEMS sensors is to initially locate the bone relative to the sensors, i.e., creating a frame of reference or coordinate system. Some steps must be performed to create the frame of reference considering specifications of MEMS sensor systems. Specifications of MEMS sensor systems may include orientation tracking along two degrees of freedom only, or the absence of positional tracking. Known steps of calibration comprise various manipulations of a sensor and/or bone, for the orientational setting of the sensor (hereinafter, the reference tracker) with respect to the bone. Once the orientational setting is completed, navigation steps may be performed, with the bone being tracked via the frame of reference using the reference tracker.

2013296108 16 Aug 2017

**[0003]** In some instances, the sensor must be constrained with respect to a bone for subsequent tracking. For femur tracking for example, the orientation of the sensor relative to the lateral axis can be constrained mechanically (e.g., with claws inserted under the posterior condyles) so that the sensor lateral axis is aligned with the lateral axis of the bone.

**[0004]** In other instances, various tools used to perform alterations on a bone must be calibrated with respect to a MEMS reference tracker, to be tracked during navigation. One example is the cutting block (a.k.a., positioning block), which may be mechanically constrained to the MEMS reference tracker for the calibration to be made. In such known cases, specific manipulations must be executed by the operator to ensure that the positioning block is connected to the reference tracker for the calibration of the positioning block, for subsequent tracking and bone alterations.

**[0005]** Patient specific instrumentation (hereinafter "PSI") pertains to the creation of instruments that are made specifically for the patient, and that hence have a contact surface(s) that is a negative of the bone surface to which it will be anchored. Hence, when the contact surface of the PSI is positioned against the bone, there is complementary contact (the contact surface negatively matching the anchor surface). PSI are typically manufactured from data using imagery to model bone geometry and thus be a true negative. The complementary engagement is predictable as such contact surfaces are specifically manufactured to match the surface of a bone. It would therefore be desirable to use PSI technology with MEMS.

## SUMMARY OF THE APPLICATION

**[0006]** It is therefore desirable to provide a novel method and patient specific instrumentation for tracking bones and tools using MEMS in surgery.

2013296108 16 Aug 2017

**[0007]** Therefore, in accordance with a first embodiment of the present disclosure, there is provided a method for creating a patient specific instrument model with an inertial sensor unit, comprising: obtaining a patient specific bone model of at least part of a bone; identifying at least one contact surface of the bone; identifying orientation data related to the bone, a geometrical relation between the at least one contact surface and the orientation data being known; generating a patient specific instrument model having at least one surface negatively corresponding to the at least one contact surface of the bone; defining a connection configuration for an inertial sensor unit in the patient specific instrument model using said geometrical

relation, the connection configuration relating a preset orientation of the inertial sensor unit to the orientation data of the bone; and outputting the patient specific instrument model with the connection configuration for receiving the inertial sensor unit.

**[0008]** Further in accordance with the first embodiment, identifying orientation data related to the bone comprises identifying at least one axis of the bone.

**[0009]** Still further in accordance with the first embodiment, identifying orientation data related to the bone comprises scanning the bone while in a known orientation relating the ground, identifying at least one axis of the bone, generating the patient specific bone model from the scanning, and relating the known orientation to the patient specific bone model.

**[0010]** Still further in accordance with the first embodiment, defining a connection configuration comprises aligning an axis from the preset orientation of the inertial sensor unit with an axis of said orientation data.

**[0011]** Still further in accordance with the first embodiment, wherein outputting the patient specific instrument model comprises outputting a receptacle in the patient specific instrument model for receiving the inertial sensor unit in the connection configuration.

**[0012]** In accordance with a second embodiment of the present disclosure, there is provided a method for tracking a bone with a patient specific instrument with an inertial sensor unit, comprising: obtaining a patient specific instrument with an inertial sensor unit, the inertial sensor unit being preset with orientation data related to the bone; placing the patient specific instrument on the bone by complementary contact between a surface of the bone and a negative patient specific surface of the patient specific instrument; initializing the inertial sensor unit in the complementary contact to relate the orientation data to the bone; and tracking the bone using data provided by the inertial sensor unit.

2013296108 16 Aug 2017

**[0013]** Still further in accordance with the second embodiment, initializing the inertial sensor unit comprises aligning an axis of the orientation data of the inertial sensor unit with an axis of the bone obtained with the patient specific instrument.

**[0014]** Still further in accordance with the second embodiment, obtaining a patient specific instrument with an inertial sensor unit comprises obtaining the patient specific instrument with the inertial sensor unit separately, and further comprising connecting the inertial sensor unit to the patient specific instrument in a known connector configuration.

**[0015]** In accordance with a third embodiment of the present disclosure, there is provided an assembly of a patient specific instrument and tracking system comprising: a patient specific instrument having a body with a patient specific contact surface negatively shaped relative to a corresponding surface of a bone for complementary contact therewith, and an inertial sensor unit programmed with a preset virtual orientation, the inertial sensor unit being received in a receptacle on the body to be fixedly connected to the body in a planned connection configuration, such that a geometrical relation between the contact surface and the inertial sensor unit is known when the body and the inertial sensor unit are fixed to the bone; and a tracking system having a tracking processor connected to the inertial sensor unit, a user interface, and bone orientation data related to the patient specific contact surface, the tracking processor producing orientation tracking data for the bone using the geometrical relation and the bone orientation data when the preset virtual orientation of the inertial sensor unit is initialized, to output the orientation tracking data on the user interface.

**[0016]** Further in accordance with the third embodiment, the patient specific instrument comprises a tool interface in the body, with a geometrical relation between the tool interface and the inertial sensor unit being known.

**[0017]** Still further in accordance with the third embodiment, the tool interface is one of a cut guide and a drill guide.

**[0018]** Still further in accordance with the third embodiment, the bone orientation data is a file comprising at least one axis of the bone.

**[0019]** Still further in accordance with the third embodiment, the body comprises a receptacle for releasably receiving the inertial sensor in the connection configuration.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0020]** Fig. 1 is a flowchart of a method for creating a patient specific instrument model with a preset MEMS unit, and for tracking bones using same, in accordance with the present disclosure; and

**[0021]** Fig. 2 is a block diagram of a patient specific instrument with MEMS unit and tracking processor, in accordance with the present disclosure.

## DESCRIPTION OF THE EXEMPLARY EMBODIMENTS

**[0022]** Referring to the drawings and more particularly to Fig. 1, there is provided a method for creating a patient specific instrument model with a preset microelectro-mechanical sensors unit, and for tracking a bone using same. The microelectromechanical sensors unit (hereinafter MEMS unit, a.k.a., inertial sensor unit) produces readings pertaining to at least two degrees of freedom (DOFs) in orientation (rotation about axes), although the MEMS could provide readings for more degrees of freedom, in orientation and/or translation, if appropriately equipped. The MEMS unit may comprise a gyroscope and/or accelerometer, or sets thereof, among other possibilities. The MEMS unit may be of the preset type, in that it is preset with axes whose orientation are known relative to landmarks when the MEMS unit is initialized (i.e., initially turned on).

**[0023]** Referring to Fig. 1, a method 20 is illustrated for the creation of the PSI and initialization thereof for subsequent surgical steps to be performed on the bone.

**[0024]** According to a first sequence of steps, PSI model generation planning is performed. The first sequence of steps results in the creation of a PSI model for subsequent manufacturing of the PSI according to the present disclosure.

**[0025]** According to step 21, a bone model is obtained. The bone model is typically a 3-D model that is created from pre-operative imagery (e.g., CT scans, etc) and model generation, and is hence patient specific as it is a physiological model of the specific patient's bone/cartilage. Depending on the number of bones involved in the surgery, step 21 may involve the creation of more than one patient specific bone model. Moreover, although reference is made to a bone model, it should be understood that the models may be for parts of a bone, as opposed to the complete bone. The generation of the model may include cartilage and/or other anatomical material. The imaging may be done by any appropriate technology such as CT scanning (computerized tomography), fluoroscopy, or like radiography methods, providing suitable resolution of images. It is also considered to use other methods to generate the bone model, such as digitizing points on the bone, etc.

**[0026]** According to step 22, contact surfaces are identified on the bone from the model(s) of 21. The anchor surfaces are selected as being sufficiently large to support a PSI. Moreover, the PSI may be anchored (e.g., screwed, fastened) to the bone whereby the contact surface or adjacent surfaces should be capable of being altered (e.g., pierced, drilled).

**[0027]** Still in step 22, orientation data is obtained from the model(s) of step 21. More specifically, the orientation data may be axes of the modeled bone, rotational axes of a joint, etc. As the orientation data is obtained from the patient specific bone model, the orientation data

is also specific to the patient. The 3-D models of step 21 or like images (e.g., 2-D images) may provide sufficient resolution or data to identify this orientation data. For instance, bone landmarks may be visible from the images of step 21 to obtain this orientation data. Alternatively, landmarks may be taken manually directly on the bone (e.g., using tracking devices, etc), and the orientation data may be obtained with these landmarks. It is pointed out that the geometrical relation between the orientation data and the contact surfaces is known, as this geometrical relation is obtained from images of step 21, or from any manual operation performed for this purpose.

**[0028]** According to an embodiment, the bone model of step 21 is obtained from a pre-operative scan (e.g., in a MRI, calibrated X-ray or CT-Scan) in which the bone is in a known relationship with respect to the ground. A 3D model of the bone is obtained from the images, but the relationship to ground is maintained, and is used in step 22 as orientation data. This may be performed for one or more bones. With multiple bones, the orientation data may comprise geometrical data relating bones to one another.

**[0029]** According to step 23, using the contact surfaces and orientation data as obtained from the bone model(s) and/or manipulations, and the geometrical relation between the contact surfaces and the orientation of the bone, a PSI model is generated. The PSI model will have a negative contact surface(s) defined to complementarily abut against the contact surface(s) obtained in step 22, in a predictable and precise manner.

**[0030]** Moreover, the PSI model may have a connection configuration for receiving any appropriate MEMS unit, if the MEMS unit is to be provided as a separate component attachable to the PSI resulting from the PSI model. The connector configuration of the PSI model is defined using the orientation data of step 22 and the geometrical relation between the orientation data and the contact surface(s). For instance, the connection configuration may be a receptacle

defined in the PSI for receiving a preset MEMS unit. The connection configuration is defined such that the orientation of the MEMS unit is known relative to the PSI when the MEMS unit is installed in the PSI, and therefore known relative to the contact surface(s) and to the orientation data. In other words, when the MEMS unit is initialized, its orientation along at least one axis will be known relative to the PSI. If the PSI is secured to the bone in the planned manner (step 22), the initialization of the MEMS unit will result in the automatic calibration of the MEMS unit relative to the orientation of the bone to which the PSI connected.

**[0031]** According to an embodiment, the PSI may be used with other components and/or tools. For instance, the PSI may incorporate or support a cutting block or cutting guide that will allow to cut planes upon which will be anchored the implant. The PSI model of step 23 may therefore comprise cutting planes, guides, slots, or any other tooling interface or tool, oriented and/or positioned to allow bone alterations to be formed in a desired location of the bone, relative to the contact surface(s). Thus, PSI model may also take into consideration any planning done by the operator (e.g., surgeon), to therefore allow the removal of sufficient bone material to reproduce desired gaps between cut planes on adjacent bones, etc.

**[0032]** Once the PSI model has been generated, the PSI may be created. The PSI incorporates a preset MEMS unit or the preset MEMS unit may be separate, but in both cases the connection configuration between the PSI and MEMS unit is known.

**[0033]** According to a second sequence of steps, the surgery may be performed. According to step 24, the PSI with the preset MEMS unit may be obtained by the surgeon or operator.

**[0034]** According to step 25, the PSI with preset MEMS unit may be installed on the bone as planned. Therefore, when installing the PSI on the bone, the negative contact

surface(s) on the PSI (as discussed in step 22) is(are) applied against the corresponding surface(s) of the bone. The complementary engagement of the negative contact surface and the bone will self-align the placement of the PSI. Accordingly, by installing the PSI as planned, the orientation data preset into the MEMS unit of the PSI (step 22) may be transposed to the bone.

**[0035]** Therefore, according to step 26, the preset MEMS unit may be initialized. When the MEMS unit of the PSI is ready to be initialized, the PSI has been secured to the bone. At the moment at which the MEMS unit on the PSI is initialized, the relation is established between the bone and the orientation data preset into the MEMS unit. From this point on, the orientation may be tracked for the bone from the readings of the initialized MEMS unit.

**[0036]** In the embodiment at which the orientation data comprises an orientation relative to the ground, it is possible to track the position and/or orientation of the bone in space relative to the ground plane provided by the pre-operative imaging. It is also possible to know the relative position and/or orientation of one bone with respect to the other. In this configuration, the movement of one bone may be navigated with respect to the other, giving range-of-motion data.

**[0037]** According to step 27, bone alterations may be performed using the tracking provided by the initialized MEMS unit. Step 27 may comprise the connection of additional components on the PSI, the use of the PSI as a guide, etc. As an alternative, step 27 may comprise additional calibration steps to confirm that the orientation data produced by the MEMS unit accurately represents the actual orientation of the bone. For instance, various methods have been developed and described to create frames of reference using MEMS reference trackers for tracking of bones, for the subsequent tracking of the bones. A method is described in United States Patent Application Publication No. 2009/0247863, published on October 1, 2009, incorporated

herein by reference. Another method is described in United States Patent Application Publication No. 2009/0248044, published on October 1, 2009, incorporated herein by reference. Yet another method is described, for a femoral application, in United States Patent Application No. 12/846,934, filed on July 30, 2010, also incorporated herein by reference. Of interest in these references are the methods and systems to create a frame of reference (e.g., a coordinate system) with a MEMS sensor unit (i.e., reference tracker) with respect to a bone for the subsequent tracking of the bone in orientation Any of the methods described in these patent applications and, more importantly, simplifications thereof, may be performed to confirm that the orientation data provided by the MEMS unit accurately represents the actual orientation of the bone. For instance, if a prior art method requires multiple points to be obtained, it may be possible to obtain fewer points in such methods as these methods would be use as a validation.

**[0038]** In other words, tools or references with MEMS unit may be fixed to the bone, and then the relationship to the contact surface of the PSI may be used to shorten the usual MEMS registration process (for instance less points to digitize on the femur). This can be done if PSI cannot provide enough accuracy, but could be used to substantially simplify the registration of bones.

**[0039]** It is pointed out that the aforedescribed method may be performed on bone models or cadavers. The sequence of steps of the method may also be in any other suitable order.

**[0040]** In one embodiment, the MEMS unit of the cutting block is a "zero" initial orientation for each rotational axis it tracks. In the "zero" initial orientation, the rotational axes are orthogonal to the MEMS unit of the PSI. Other initial configurations are possible as well.

**[0041]** Referring now to Fig. 2, there is illustrated at 30 a PSI of the type created and used in the method 20 of Fig. 1. The PSI 30 comprises a body 31. The body 31 has a

negative contact surface 32 (or contact surfaces 32) specifically manufactured for the patient (i.e., it is patient specific), so as to marry the shape (i.e., complementarily contact) of a bone contact surface of bone B, as planned. A MEMS unit 33, of the type being preset in orientation, is also within the body 31, or may be connectable in a predetermined manner to the body 31 in a receptacle defined in the body and adapted to receive the MEMS unit 33 is a precise and predictable manner. When the body 31 is manufactured, the connection configuration of the MEMS unit 33 therein is also planned such that in orientation of the MEMS unit 33 is known relative to a geometry of the body 31. The body 31 may comprise a tool interface 34, which may also be planned, the tool interface 34 used with tools to perform alterations on the bone. The tools may be any appropriate tool conventionally used for orthopedic surgery.

**[0042]** The PSI 30 is used with a tracking system 40. The tracking system 40 may be integrated in the body 31 or separate therefrom. The tracking system 40 comprises a tracking processor 41 that receives orientation data from the MEMS unit 33. Bone orientation data 42 is provided in the tracking system 40, and results from planning, for instance as set forth in steps 21 to 23 of the method 20 of Fig. 1. Bone orientation data 42 comprises a frame of reference for the bone (e.g., axes) in relation to the contact surface 32, and in relation to the connection configuration between the body 31 and the MEMS unit 33 in the PSI 30. Hence, when the MEMS unit 33 is initialized (i.e. initially turned on), the tracking processor 41 uses the bone orientation data 42 to set the orientation data of the bone with respect to the readings provided by the MEMS unit 33. The tracking system 40 comprises a user interface 43 of any suitable type to provide data to the user relative to the orientation of the bone as tracked.

**[0043]** While the methods and systems described above have been described and shown with reference to particular steps

performed in a particular order, these steps may be combined, subdivided or reordered to form an equivalent method without departing from the teachings of the present disclosure. Accordingly, the order and grouping of the steps is not a limitation of the present disclosure. The methods and systems described above may be used for any appropriate type of orthopaedic surgery (knee, shoulder, hip, resurfacing, replacement, revision), with any suitable type of bone, such as the tibia, femur, humerus, pelvis, etc.

2013296108 16 Aug 2017

The claims defining the invention are as follows:

1. An assembly of a patient specific instrument and tracking system comprising:

a patient specific instrument having a body with a patient specific contact surface negatively shaped relative to a corresponding surface of a bone for complementary contact therewith, and an inertial sensor unit programmed with a preset virtual orientation, the inertial sensor unit being received in a receptacle on the body to be fixedly connected to the body in a planned connection configuration, such that a geometrical relation between the contact surface and the inertial sensor unit is known when the body and the inertial sensor unit are fixed to the bone; and

a tracking system having a tracking processor connected to the inertial sensor unit, a user interface, and bone orientation data related to the patient specific contact surface, the tracking processor producing orientation tracking data for the bone using the geometrical relation and the bone orientation data when the preset virtual orientation of the inertial sensor unit is initialized, to output the orientation tracking data on the user interface.

2. The assembly according to claim 1, wherein the patient specific instrument comprises a tool interface in the body, with a geometrical relation between the tool interface and the inertial sensor unit being known.

3. The assembly according to claim 2, wherein the tool interface is one of a cut guide and a drill guide.

4. The assembly according to any one of claims 1 to 3, wherein the bone orientation data is a file comprising at least one axis of the bone.

5. The assembly according to any one of claims 1 to 4, wherein the body comprises a receptacle for releasably

2013296108 16 Aug 2017

receiving the inertial sensor in the connection configuration.

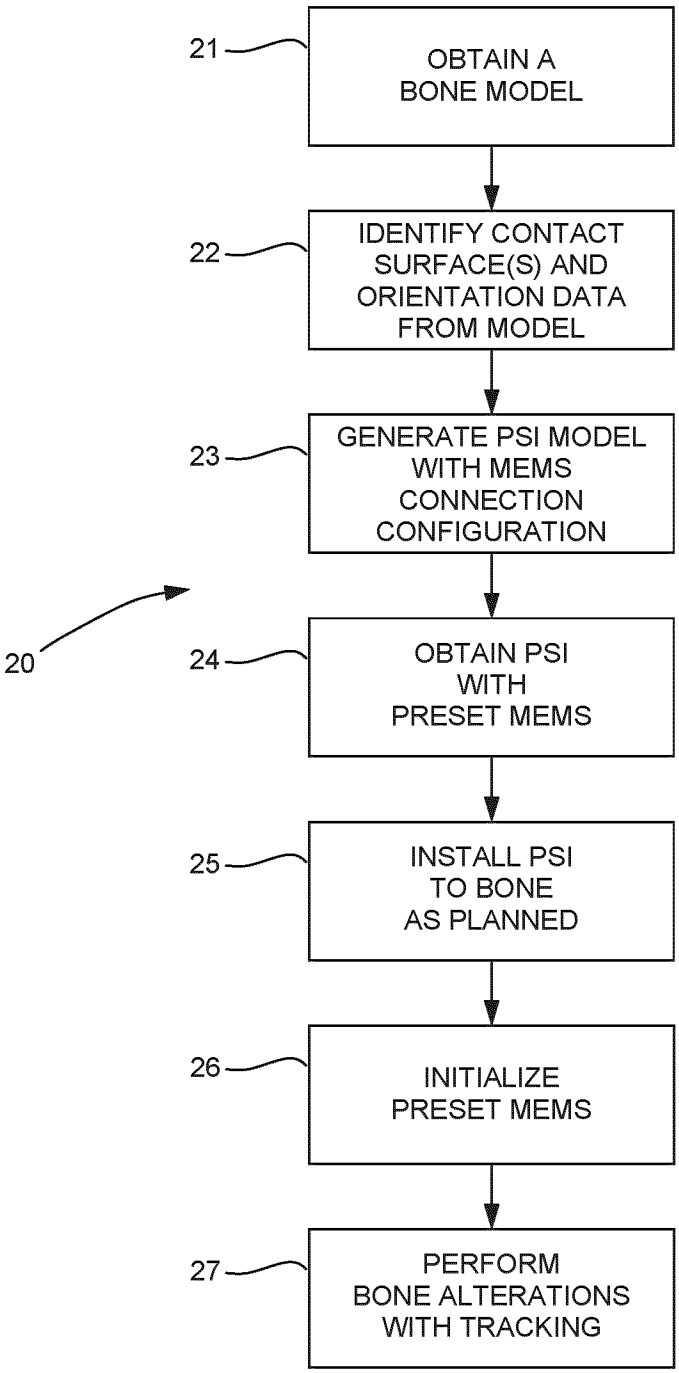

21
OBTAIN A BONE MODEL
22
IDENTIFY CONTACT SURFACE(S) AND ORIENTATION DATA FROM MODEL
23
GENERATE PSI MODEL WITH MEMS CONNECTION CONFIGURATION
20
24
OBTAIN PSI WITH PRESET MEMS
25
INSTALL PSI TO BONE AS PLANNED
26
INITIALIZE PRESET MEMS
27
PERFORM BONE ALTERATIONS WITH TRACKING

*Fig. 1*

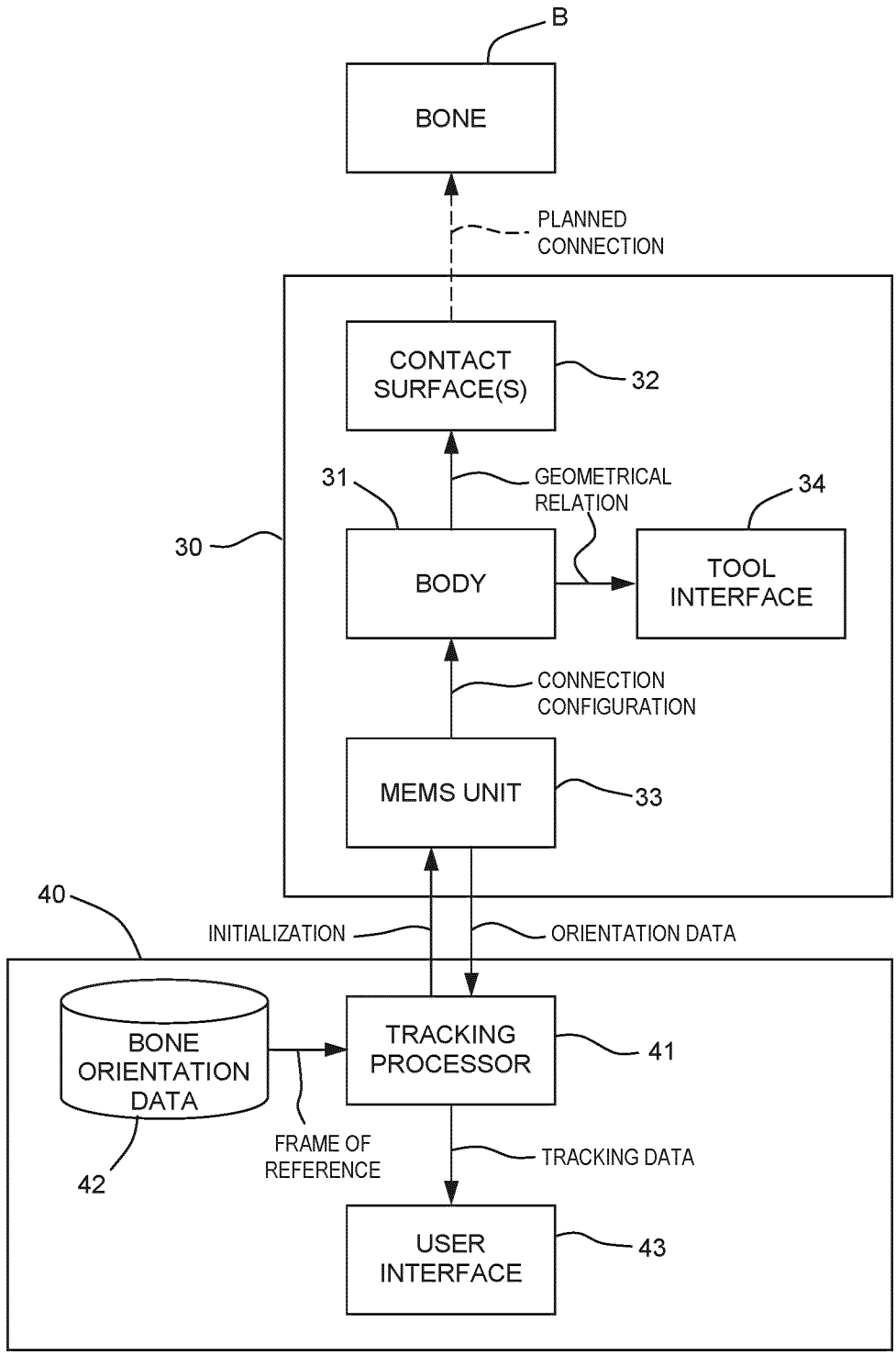

B
BONE
PLANNED
CONNECTION
CONTACT
SURFACE(S)
32
31
GEOMETRICAL
RELATION
34
30
BODY
TOOL
INTERFACE
CONNECTION
CONFIGURATION
MEMS UNIT
33
40
INITIALIZATION
ORIENTATION DATA
BONE
ORIENTATION
DATA
TRACKING
PROCESSOR
41
FRAME OF
REFERENCE
TRACKING DATA
42
USER
INTERFACE
43

*Fig. 2*