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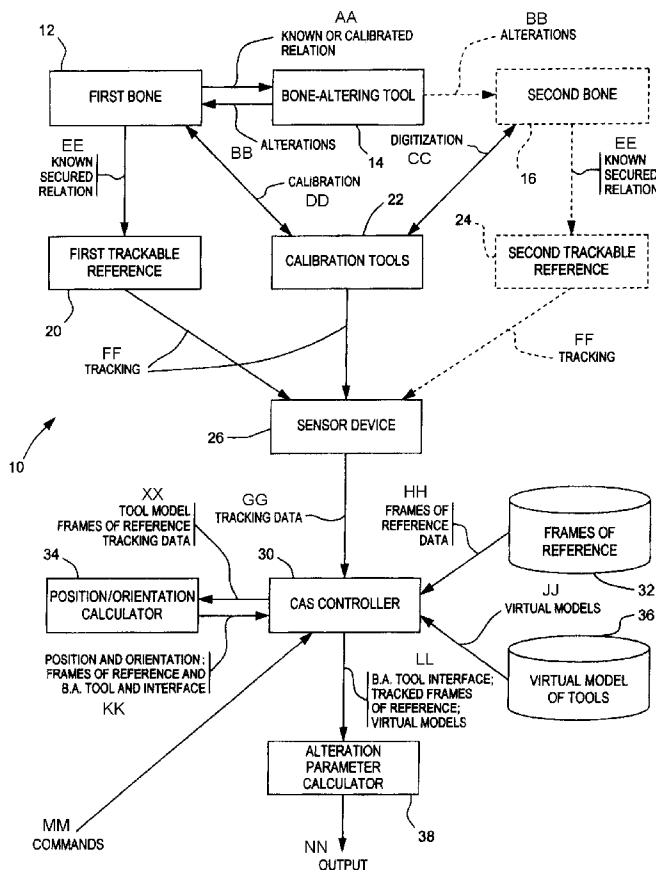
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(54) Title: METHOD AND SYSTEM FOR TRACKING TOOLS IN COMPUTER-ASSISTED SURGERY



(57) Abstract: A system (10) for tracking a bone-altering tool (14) in computer-assisted surgery, comprising a first trackable reference (20) secured to a first bone (12), with a first frame of reference being associated with the first trackable reference (20). A bone-altering tool (14) is securable to the first bone (12) in a secured configuration. Sensors (26) track the trackable reference (20) for position and orientation. A position/orientation calculator (34) is connected to the sensor device (26) to calculate a position and orientation of the first frame of reference. An alteration parameter calculator (38) is associated with the position/orientation calculator (34) to determine a position and orientation of the bone-altering tool (14) in the secured configuration as a function of the position and orientation of the first frame of reference and of the secured configuration. A method (100) for tracking tools using the tracking of a bone is provided.

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PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Published:

— *with international search report*

METHOD AND SYSTEM FOR TRACKING
TOOLS IN COMPUTER-ASSISTED SURGERY

CROSS-REFERENCE TO RELATED APPLICATION

This patent application claims priority on
5 United States Provisional Patent Application
No. 60/784,789, filed on March 23, 2006, by the present
applicants.

BACKGROUND OF THE INVENTION

1. Field of the Invention

10 The present invention relates to computer-
assisted surgery and, more particularly, to the tracking
of tools during orthopedic surgery.

2. Background Art

15 Orthopedic surgery is constantly evolving to
lessen the effects of surgery on patients. In order to
reduce the amount of post-surgical pain, new methods and
tools have been developed to minimize the invasiveness
of surgery.

20 Also, computer-assisted surgery is more
commonly used in surgical rooms, so as to provide
precision and accuracy to the surgeon. By way of
computer-assisted surgery, position and orientation
information is gathered during the surgical procedures,
so as to provide to the surgeon real-time visual/digital
25 data about bone alterations, tool navigation, and
surgical parameters.

In parallel, apparatuses and methods have been
developed to render orthopedic surgery minimally
invasive. For instance, International Publication
30 No. WO 03/068078, by Johnson et al., published on
August 21, 2003, describes an apparatus and method for

minimally invasive total joint replacement. In that application, a bone-sculpting tool is attached directly to the femur, and an articular surface (i.e., acetabulum) between adjacent bones is sculpted with the joint between the bones reduced and one of the bones moving with respect to another.

In such minimally invasive applications, the tools used often have expandable geometries so as to be fitted within the small incisions. As tools have typically been tracked in computer-assisted surgery by trackers positioned directly on the tool, the tracking of tools in such minimally invasive applications is problematic, as, in some specific manipulations (e.g., bone sculpting of articular surfaces), there is a clear lack of space for trackers on the tools.

SUMMARY OF INVENTION

It is therefore an aim of the present invention to provide a novel system and method to track tools in computer-assisted surgery.

Therefore, in accordance with the present invention, there is provided a system for tracking a bone-altering tool in computer-assisted surgery, comprising: a first trackable reference secured to a first bone, with a first frame of reference being associated with the first trackable reference; a bone-altering tool securable to the first bone in a secured configuration; sensors to track at least the trackable reference for position and orientation; a position/orientation calculator connected to the sensor device to calculate a position and orientation of the first frame of reference; and an alteration parameter calculator associated with the position/orientation calculator to determine a position and orientation of

the bone-altering tool in said secured configuration as a function of the position and orientation of the first frame of reference and of said secured configuration.

Further in accordance with the present invention, there is provided a method for tracking a tool secured to a bone/bone implant in computer-assisted surgery, comprising the steps of: tracking a first trackable reference secured to a first bone/bone implant for position and orientation; obtaining an interface relation of the tool secured to the first bone/bone implant; obtaining a model of the tool; and calculating at least a position of the tool secured to the first bone/bone implant as a function of the tracking of the first trackable reference, of the interface relation and of the model of the tool.

BRIEF DESCRIPTION OF DRAWINGS

Having thus generally described the nature of the invention, reference will now be made to the accompanying drawings, showing by way of illustration a preferred embodiment thereof and in which:

Fig. 1 is a block diagram of an alteration parameter calculator system constructed in accordance with a preferred embodiment of the present invention;

Fig. 2 is a flowchart of a method for calculating alteration parameters in accordance with another preferred embodiment of the present invention;

Fig. 3 is an exploded view of a rasp and bone-altering tool used with the system of Fig. 1; and

Fig. 4 is an assembly view of the rasp and bone-altering tool of Fig. 3.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring now to Fig. 1, an alteration parameter calculator system in accordance with a preferred embodiment is generally shown at 10. The system 10 has controller, calculator and database components that are typically part of a computer-assisted surgery system (hereinafter CAS for computer-assisted surgery).

The system 10 is used in CAS to track tools and to provide alteration parameters associated with the alterations of a first bone 12 by a bone-altering tool 14, with the bone-altering tool 14 being anchored to the first bone 12 during the alterations. Alternatively, the bone-altering tool 14 may perform alterations on a second bone 16 while being anchored to the first bone 12. This technique is commonly used for sculpting/altering joint surfaces (such as the hip joint). The bone-altering tool 14 may be taken from a plurality of tools used to alter the bone surface of a bone (e.g., reamer), or used to insert and position an implant in a bone (e.g., cup impactor for acetabular implant).

The first bone 12 is provided with a first trackable reference 20. The first trackable reference 20 is secured to the first bone 12, and hence defines a first frame of reference of the first bone 12. Accordingly, the first trackable reference 20 is tracked such that information gathered with respect to the first bone 12 (e.g., landmarks, digitized surfaces, a coordinate system) is known with respect to the first frame of reference.

A calibration tool 22 is optionally used to determine the interface between the first bone 12 and the bone-altering tool 14, and to digitize information

relating to the bones 12 and 14 with respect to the relevant frames of reference. This information may already be available, whereby the calibration tool 22 is optional.

5 The bone-altering tool 14 may alternatively be used to perform alterations on the second bone 16 while being anchored to the first bone 12, especially at the joint between the first bone 12 and the second bone 16. In such a case, a second trackable reference 24 is
10 anchored to the second bone 16, so as to have a second frame of reference associated with the second bone 16. The second trackable reference 24 is tracked such that information gathered with respect to the second bone 16 (e.g., landmarks, digitized surfaces, a coordinate
15 system) is known as a function of the second frame of reference.

Sensors 26 (i.e., a sensor device 26) are provided to track the first trackable reference 20, and, if applicable, the calibration tool 22 and the second
20 trackable reference 24. It is contemplated to use various types of technologies for the sensors 26, such as optical, RF, magnetic sensors or the like. The sensors 26 are connected to the alteration parameter calculator system 10, such that the tracking data of the
25 first trackable reference 20 and, if applicable, of the calibration tool 22 and the second trackable reference 24 is received and interpreted by the system 10.

The system 10 uses the CAS controller 30 of a CAS system. The CAS controller 30 receives commands
30 during the course of surgery, and coordinates the tracking information received between the various components of the CAS system and of the alteration parameter calculator system 10. The CAS controller 30 is typically a processing unit of a computer.

Depending on the moment in surgery when the alteration parameter calculator system 10 is to be used, some information will already be available. In an embodiment, frames of reference associated with the first trackable reference 20 and, if applicable, the second trackable reference 24 are already known, as such frames of reference have been defined and used in prior steps for the navigation of tools during surgery. For instance, reference is made to International Publications No. WO 2004/030556 and WO 2004/030559, by Jansen et al., published April 15, 2004, in which the definition and use of suitable frames of reference is described.

Accordingly, the frames of reference of the first bone 12 and, if applicable, of the second bone 16 are provided by the database of frames of reference 32, as well as associated data (e.g., landmarks, digitized surfaces, a coordinate system), as all information has been obtained prior to the steps of using the bone-altering tool 14.

The frame-of-reference data and the tracking data of the first trackable reference 20 and, if applicable, of the calibration tool 22 and the second trackable reference 24 are received by a position/orientation calculator 34, which will calculate the position and orientation of the frames of reference in real time, as well as other information such as the interface between the first bone 12 and the bone-altering tool 14, from the tracking of the first trackable reference 20 and of the second trackable reference 24.

In some instances, the interface between the first bone 12 and the bone-altering tool 14 is a protruding portion of an implant. The above-referenced

PCT publications by Jansen et al. have described methods to track the tools involved in the insertion of the implant in the bone (e.g., rasps), in such a way that the interface between the first bone 12 and the tool 14 is known as data associated with the frames of reference (and thus present in database 32).

Alternatively, the calibration tool 22 is used to calibrate the interface, by being connected in a known relation to the first bone 12 or protruding implant, or by digitizing points on a tool anchored to the bone 12, with respect to the first frame of reference. One calibration device suited to be used for the calibration of an implant interface is the device described in International Publication No. WO 2005/023110, by Amiot et al., as published on March 17, 2005. Also, U.S. provisional applications serial nos. 60/682,872 and 60/682,852 describe digitization methods and devices which are suitable for use with the system 10. A virtual model of the tool 14 is obtained from the database 36 (e.g., resulting from a previous tool calibration), such that the position and orientation of the interface is calculable with respect to the first frame of reference by the position/orientation calculator 34, as a response from commands received by the CAS controller 30.

When the frames of reference are tracked in real time by the tracking of the first trackable reference 20 and, if applicable, of the second trackable reference 24, and the position and orientation of the interface between the first bone 12 and the bone-altering tool 14 is known with respect to the first frame of reference, the position and orientation of the tool 14 is calculable from the tracking of the first frame of reference. More specifically, a virtual model

of the bone-altering tool 14 is provided by the database 36. The virtual model of the tool 14 is associated with the position and orientation of the interface between bone 12 and tool 14 with respect to the first frame of reference, such that a working surface of the tool 14 is known. Accordingly, as the position and orientation of the tool 14 is tracked, the effect of the tool 14 on the bone 12 or the bone 16 is calculable.

The alteration parameter calculator 38 calculates alteration parameters for alterations performed on the first bone 12 with the tracking of the tool 14 and the first frame of reference. Alternatively, if alterations are performed on the second bone 16, the alteration parameter calculator 38 calculates the alteration parameters with respect to the second frame of reference. In such a case, a digital model of the second bone 16, as obtained previously as described in the International Publications by Jansen et al., is provided by the database 32.

Referring concurrently to Figs. 1 and 2, a practical example of the use of the alteration parameter calculator system 10 is described for hip joint replacement surgery, by method 100.

In Step 102, a frame of reference for the first bone is obtained and tracked. As described in the International Publications by Jansen et al., the first trackable reference 20 is secured to the femur (i.e., the first bone 12), and a frame of reference has been digitized, which frame of reference typically has a coordinate system with frontal, sagittal and transverse planes.

The method 100 is often performed once the frames of reference of the femur (with respect to the first trackable reference 20), and of the pelvis (i.e.,

second bone 16, with respect to the second trackable reference 24). Otherwise, the various steps described in the International Publications by Jansen et al. can be performed to obtain suitable frames of reference for the femur and for the pelvis, along with additional information associated with the frames of reference, such as digitized bone surfaces (e.g., acetabulum), position and orientation information data associated with implants inserted in the bones (e.g., femoral rasp/broach).

In Step 104, the interface between the bone-altering tool 14 and the femur is obtained with respect to the first frame of reference (i.e., associated with the first trackable reference 20 secured to the femur).

Referring to Fig. 3, a femoral broach A has a body A1 and a ball head connector A2 (i.e., the neck). The ball head connector A2 will be used with the bone-altering tool 14 (Fig. 1), which is represented in Fig. 3 by reamer B. The reamer B has a driveshaft B1, at the end of which a connector socket B2 is positioned opposite an actuator head B3. As shown in Fig. 4, the broach A and the reamer B are interconnected by the mating engagement of the ball head connector A2 in the connector socket B2.

In computer-assisted surgery, the insertion of a femoral implant (rasp/broach) is frequently tracked with respect to the femoral frame of reference (e.g., by tracking the impacting tool), such that a position and orientation of the implant is known. In such a case, the position and orientation of the ball head connector A2 is known with respect to the femoral frame of reference.

Alternatively, if it is not available, the position and orientation data of the interface is

readily obtained by digitizing the surface of the interface, for instance using a positioning tool having a socket mated to the ball head connector A2 or a registration pointer.

5 In Step 106, a calculation and tracking of a position and orientation of a working surface of the tool is performed. A virtual model of the tool 14/reamer B (including the relation between the tool 14 and the bone/implant) is associated with the first frame
10 of reference through the tracking of the first trackable reference 20 on the femur, by knowing the position and orientation of the interface between bone and tool, during this calculation. This calculation is performed by the alteration parameter calculator 38 (Fig. 1).

15 In the case of hip-joint surgery, the reamer B of Fig. 4 extends a known distance along direction D1. This translational degree of freedom is provided in order to minimize the size of the reamer B for being fitted in small incisions, while expanding to simulate
20 the size of a finished implant/femoral neck when actuated to ream the surface of the acetabulum from its anchored position on the femur/femur implant.

 Accordingly, in Step 108, alterations (i.e., alteration parameters) on the first bone 12 or the
25 second bone 16 are calculated as they are performed. The calculations are performed by the alteration parameter calculator 38 from the tracking of the working surface of the tool 14 through the first frame of reference, and from the tracking of bone surface
30 information associated with either the first trackable reference 20 (first bone 12) or the second trackable reference 24 (second bone 16).

 In the case of hip-joint surgery, the tracked bone surface information relates to the geometry of the

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acetabulum (second bone 16), which data has been obtained and is part of the data associated with the second frame of reference through the database 32. As the position and orientation of the working surface of the reamer B is tracked as a function of the first trackable reference 20, the effect of the reamer B on the acetabulum is calculated by relating the tracking of the second frame of reference (and associated acetabulum surface data) with the position and orientation of the working surface of the reamer B.

Therefore, the alteration parameter calculator system 10 calculates the position and orientation of a bone-altering tool (e.g., 14) from the tracking of a trackable reference (e.g., 20) secured to a bone (e.g., 12) upon which the bone-altering tool is also secured during actuation of the tool.

Another alteration parameter that may be calculated is the amount of bone material removed from the bone on which the tool 14 is secured, or the amount of bone material removed from the bone adjacent to the tool 14 (as is the case for the hip-joint surgery described above). In such a case, the other bone (i.e., bone 16) is tracked for position and orientation, and relevant bone data is available (e.g., landmarks, digitized surfaces, a coordinate system).

Also, in the case of hip-joint surgery the anteversion and inclination of the actuation axis of the tool 14, both as a function of the acetabular coordinate system (from a tracking of the second reference 24), can be given numerically (e.g., in degrees) to guide the surgeon in the reaming. More precisely, the anteversion is calculated as the angle between an intersection of the acetabular frontal plane and transverse plane and the projection of the axis of the reamer on the

acetabular transverse plane, and the inclination is the angle between the reamer axis and a cranial-caudal axis (y) on the sagittal plane of the acetabular coordinate system.

5 Also, the distances between the current and the digitized centers of rotation can be displayed. Therefore, the surgeon is guided during the use of the bone-altering tool 14 so as to position the pelvic implant to a given position of the center of rotation
10 thereof, and to a given orientation (with respect to anteversion and inclination) to provide a maximal range of motion and stability of the leg.

 In the case of hip-joint surgery, a femoral target height is calculable as a desired position for
15 the femoral center of rotation, and is calculated as follows:

$$(target\ height) = (\Delta_{PELVIC\ COR}) - (initial\ \Delta_{LL}),$$

 where $(\Delta_{PELVIC\ COR})$ is the deviation of the implant center of rotation with respect to the digitized
20 acetabular center of rotation, in cranial-caudal (y) direction (with a cranial deviation having a positive value), and $(initial\ \Delta_{LL})$ is the initially acquired limb length discrepancy.

 Also in the case of hip-joint surgery, the anteversion of the femoral implant as calculated from
25 the tracked rasp/broach can be displayed numerically (e.g., in degrees) based on the femoral coordinate system obtained in Step 102. It is represented by the angle between the intersection of the frontal plane and
30 the transverse plane and a projection of the neck axis (anticipated for the femoral implant) onto the transverse plane.

 Another guiding parameter to be provided to the surgeon is the distance between the previous femoral

center of rotation and the current femoral center of rotation. The current femoral center of rotation is calculated as a function of the femoral implant geometry (e.g., the ball head size) and the tracking of the rasp/broach. The distance can be given in X, Y and Z values (e.g., in mm) according to the femoral coordinate system.

Another guiding parameter to be provided to the surgeon in hip-joint surgery is the current leg-length discrepancy. The current leg-length discrepancy, (*current* Δ_{LL}), is calculated as follows:

$$(\text{current } \Delta_{LL}) = (\text{initial } \Delta_{LL}) - (\Delta_{PELVIC COR}) + (\Delta_{FEMUR COR}),$$

where ($\Delta_{FEMUR COR}$) is the Y value calculated above, and where ($\Delta_{PELVIC COR}$) and (*initial* Δ_{LL}) have been described above. The current leg-length discrepancy can be displayed by the CAS system as an overall leg length, or as a relative value between leg lengths, with the value 0 representing legs of equal length.

Another guiding parameter used in hip-joint surgery is the offset of the femoral implant. The offset is the distance between the acetabular center of rotation and the axis of the implant (i.e., the anatomical axis of the femur as defined previously) on the transverse plane, and is thus directly related to the size of the femoral implant. It is pointed out that a type of femoral implant contemplated for the above-described method 100 can be provided in various sizes, and a size of femoral implant can have various femoral centers of rotation along the neck of the implant. A proper identification of the size of the femoral implant must therefore be provided as it will have an effect on both the offset and the limb length.

CLAIMS:

1. A system for tracking a bone-altering tool in computer-assisted surgery, comprising:
a first trackable reference secured to a first
5 bone, with a first frame of reference being associated with the first trackable reference;
a bone-altering tool securable to the first bone in a secured configuration;
sensors to track at least the first trackable
10 reference for position and orientation;
a position/orientation calculator connected to the sensor device to calculate a position and orientation of the first frame of reference; and
an alteration parameter calculator associated
15 with the position/orientation calculator to determine a position and orientation of the bone-altering tool in said secured configuration as a function of the position and orientation of the first frame of reference and of said secured configuration.
- 20 2. The system according to claim 1, further comprising a second trackable reference secured to a second bone, with a second frame of reference being associated with the second trackable reference, the alteration parameter calculator calculating at least one
25 parameter associated with alterations to the second bone by the bone-altering tool in the secured configuration as a function of the position and orientation of the bone-altering tool and of the second frame of reference.
3. The system according to claim 2, further
30 comprising a calibration tool to digitize a model of the second bone with respect to the second frame of reference, with said at least one parameter being alterations to the second bone calculated by the

alteration parameter calculator from the model of the second bone.

4. The system according to claim 1, wherein the secured configuration is represented by position and orientation data associated with an interface between the bone and the bone-altering tool, and with a virtual model of the bone-altering tool.

5. The system according to claim 4, wherein the virtual model of the bone-altering tool is known preoperatively.

6. The system according to claim 4, further comprising a calibration tool to digitize said position and orientation data associated with said interface between the bone and the bone-altering tool.

7. The system according to claim 1, further comprising a calibration tool to digitize said position and orientation data pertaining to said secured configuration of the bone-altering tool with respect to the first frame of reference.

8. The system according to claim 2, wherein the first bone is a resected femur having a broach implanted therein, the bone-altering tool being a reamer securable to the broach in the secured configuration, the second bone being a pelvis and the at least one parameter being a surface of an acetabulum of the pelvis being altered by the reamer.

9. The system according to claim 1, wherein the first bone has an implant, and the bone-altering tool is secured to the implant of the first bone in said secured configuration.

10. A method for tracking a tool secured to a bone/bone implant in computer-assisted surgery, comprising the steps of:

5 tracking a first trackable reference secured to a first bone/bone implant for position and orientation;

obtaining an interface relation of the tool secured to the first bone/bone implant;

obtaining a model of the tool; and

10 calculating at least a position of the tool secured to the first bone/bone implant as a function of the tracking of the first trackable reference, of the interface relation and of the model of the tool.

11. The method according to claim 10, further comprising a step of tracking a second trackable reference secured to a second bone while tracking said first trackable reference, and a step of calculating an alteration performed on the second bone as a function of said position and an orientation of the tool, said tracking of the second trackable reference, and a model of the second bone.

12. The method according to claim 11, further comprising a step of digitizing a surface of the second bone to obtain the model of the second bone.

25 13. The method according to claim 10, wherein the step of obtaining the interface relation is performed by digitizing a surface of the first bone/bone implant with respect to the first trackable reference.

14. The method according to claim 10, wherein the step of obtaining the model of the tool involves retrieving the model created preoperatively.

15. The method according to claim 11, wherein the step of tracking the first trackable reference has the first trackable reference on a femur, the step of obtaining the interface relation involves a reamer
5 secured to an implant in the femur, the step of tracking the second trackable reference has the second trackable reference on a pelvis, and the step of calculating an alteration involves calculating alterations to a surface of an acetabulum of the pelvis.

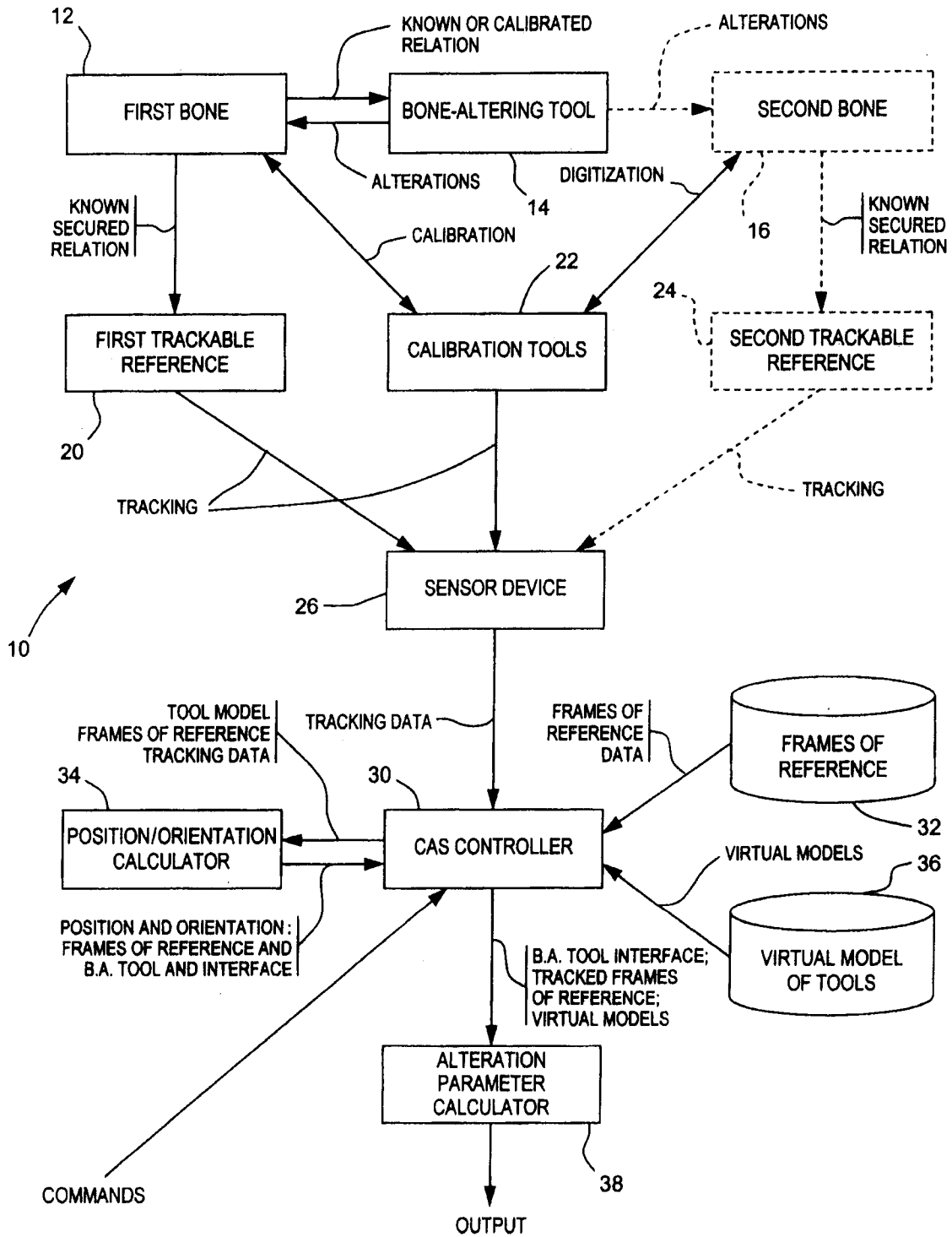


Fig. 1

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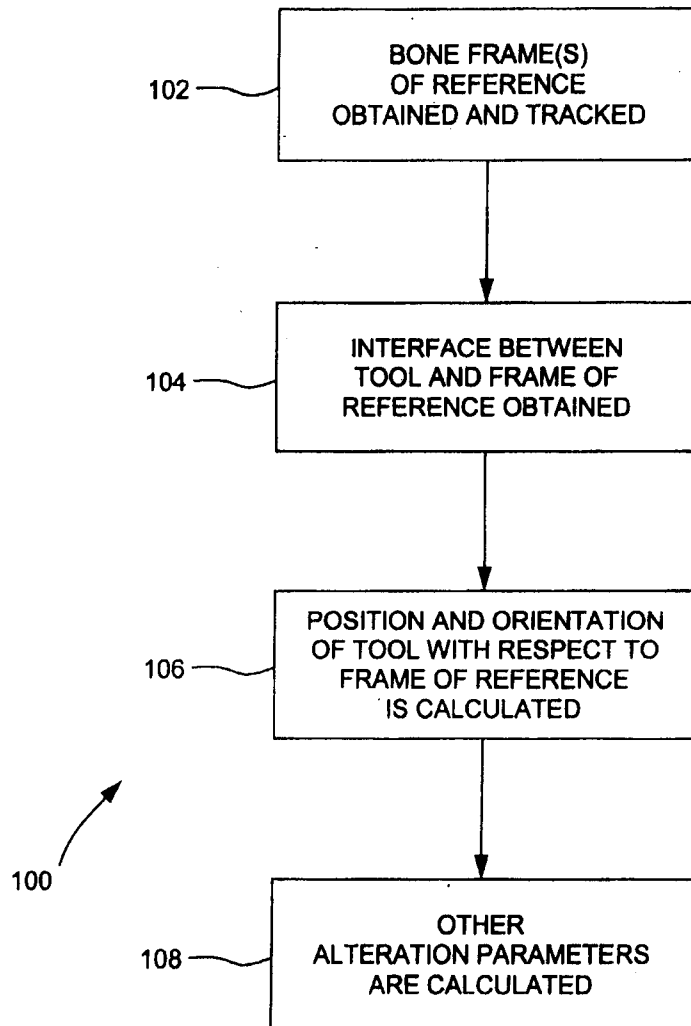


Fig. 2

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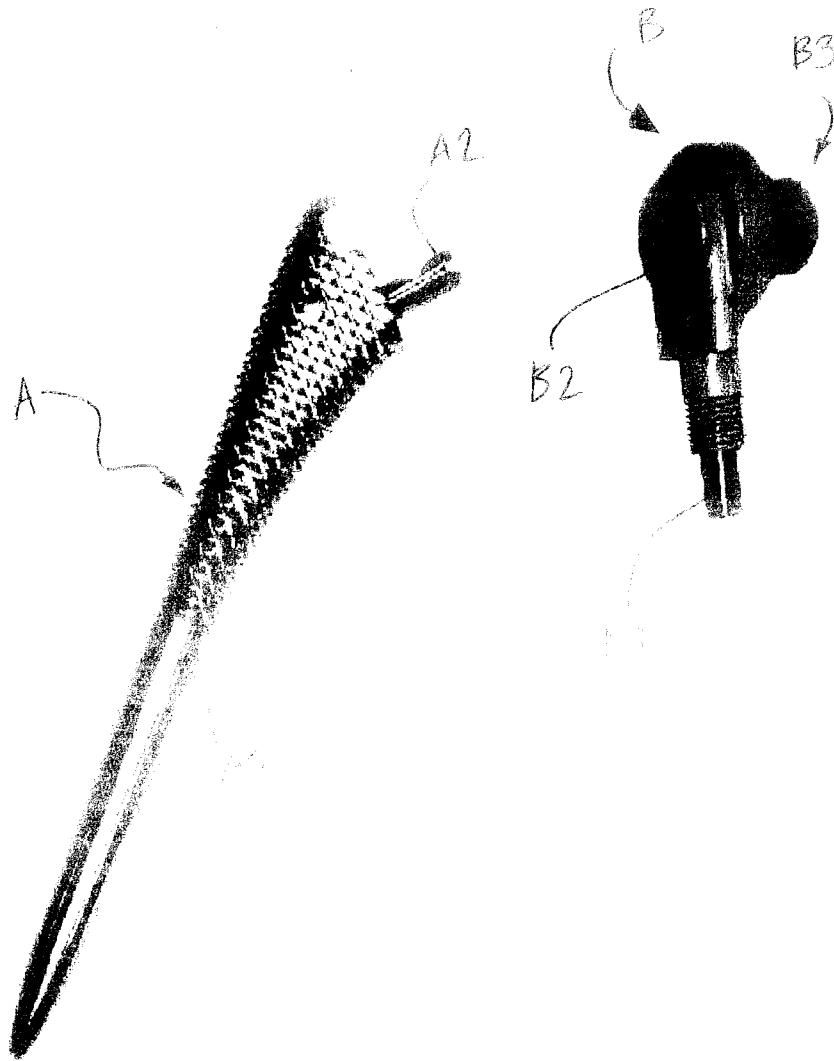


Fig. 3

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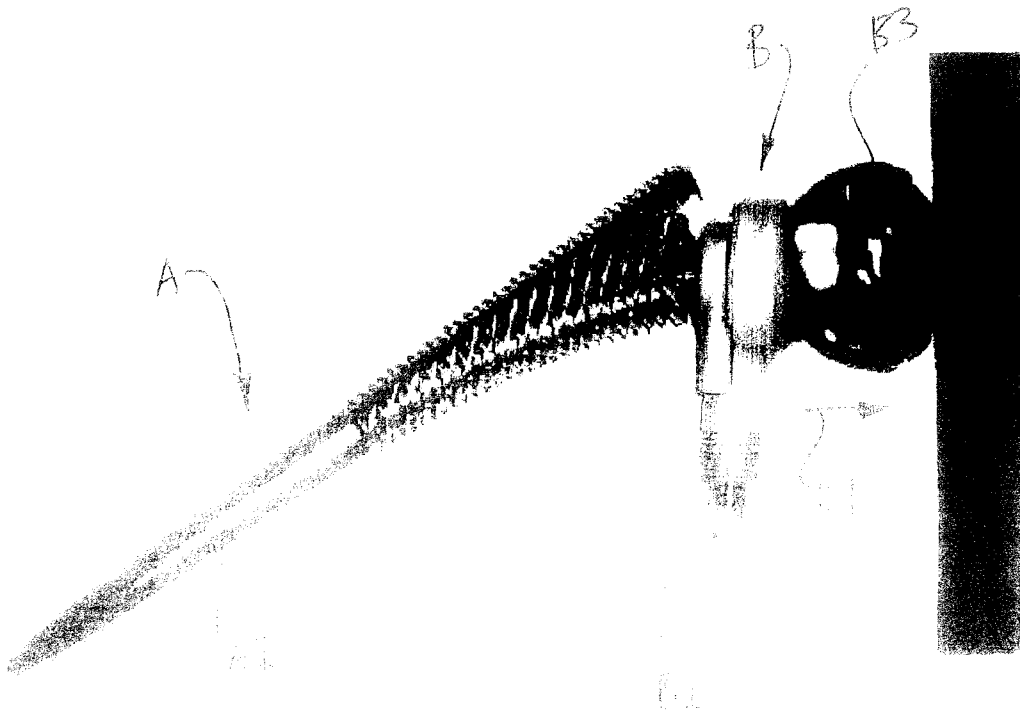


Fig. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2007/000464

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

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

1. Claim Nos. : 10-15
because they relate to subject matter not required to be searched by this Authority, namely :

A method of medical treatment by surgery.
2. Claim Nos. :
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 :
3. Claim Nos. :
because they are dependant claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

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 additional fees, 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 claim 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 claim 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.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2007/000464

<p>A. CLASSIFICATION OF SUBJECT MATTER IPC: A61B 19/00 (2006.01) , A61B 17/56 (2006.01) , A61B 6/00 (2006.01) , A61B 5/06 (2006.01) According to International Patent Classification (IPC) or to both national classification and IPC</p>																										
<p>B. FIELDS SEARCHED</p> <p>Minimum documentation searched (classification system followed by classification symbols) IPC: A61B 19/00; A61B 17/56; A61B 6/00; A61B 5/06 USC: 606/*</p> <p>Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched</p> <p>Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used) CPD: classification; track* Delphion: classification; track*; knee; tool; reference; cas; bone</p>																										
<p>C. DOCUMENTS CONSIDERED TO BE RELEVANT</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 10%;">Category*</th> <th style="width: 60%;">Citation of document, with indication, where appropriate, of the relevant passages</th> <th style="width: 30%;">Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">X</td> <td>US 2005/0137599 A1 (MASINI, M.) 23 June 2005 (23-06-2005) -whole document</td> <td style="text-align: center;">1-9</td> </tr> <tr> <td style="text-align: center;">A</td> <td>WO 2004/030559 A1 (JANSEN, A. et al) 15 April 2004 (15-04-2004) -whole document</td> <td style="text-align: center;">1-9</td> </tr> <tr> <td style="text-align: center;">A</td> <td>US 2005/0216032 A1 (HAYDEN, A.) 29 September 2005 (29-09-2005) -whole document</td> <td style="text-align: center;">1-9</td> </tr> <tr> <td style="text-align: center;">P, A</td> <td>US 2006/0122616 A1 (BENNETT, T. et al) 08 June 2006 (08-06-2006) -whole document</td> <td style="text-align: center;">1-9</td> </tr> <tr> <td style="text-align: center;">P, A</td> <td>EP 1679047 A2 (JUTRAS, S. et al) 12 July 2006 (12-07-2006) -whole document</td> <td style="text-align: center;">1-9</td> </tr> <tr> <td style="text-align: center;">A</td> <td>US 6917827 B2 (KIENZLE, III, T.) 12 July 2005 (12-07-2005) -whole document</td> <td style="text-align: center;">1-9</td> </tr> <tr> <td style="text-align: center;">A</td> <td>US 6450978 B1 (BROSSEAU, E. et al) 17 September 2002 (17-09-2002)</td> <td style="text-align: center;">1-9</td> </tr> </tbody> </table>			Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	X	US 2005/0137599 A1 (MASINI, M.) 23 June 2005 (23-06-2005) -whole document	1-9	A	WO 2004/030559 A1 (JANSEN, A. et al) 15 April 2004 (15-04-2004) -whole document	1-9	A	US 2005/0216032 A1 (HAYDEN, A.) 29 September 2005 (29-09-2005) -whole document	1-9	P, A	US 2006/0122616 A1 (BENNETT, T. et al) 08 June 2006 (08-06-2006) -whole document	1-9	P, A	EP 1679047 A2 (JUTRAS, S. et al) 12 July 2006 (12-07-2006) -whole document	1-9	A	US 6917827 B2 (KIENZLE, III, T.) 12 July 2005 (12-07-2005) -whole document	1-9	A	US 6450978 B1 (BROSSEAU, E. et al) 17 September 2002 (17-09-2002)	1-9
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<p><input type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tbody> <tr> <td style="width: 50%; vertical-align: top;"> <p>* Special categories of cited documents :</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"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)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </td> <td style="width: 50%; vertical-align: top;"> <p>"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</p> <p>"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</p> <p>"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</p> <p>"&" document member of the same patent family</p> </td> </tr> </tbody> </table>			<p>* Special categories of cited documents :</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"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)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p>	<p>"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</p> <p>"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</p> <p>"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</p> <p>"&" document member of the same patent family</p>																						
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<p>Date of the actual completion of the international search 19 June 2007 (19-06-2007)</p>		<p>Date of mailing of the international search report 11 July 2007 (11-07-2007)</p>																								
<p>Name and mailing address of the ISA/CA Canadian Intellectual Property Office Place du Portage I, C114 - 1st Floor, Box PCT 50 Victoria Street Gatineau, Quebec K1A 0C9 Facsimile No.: 001-819-953-2476</p>		<p>Authorized officer Elizabeth Gojkovic 819- 934-3468</p>																								

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/CA2007/000464

Patent Document Cited in Search Report	Publication Date	Patent Family Member(s)	Publication Date
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