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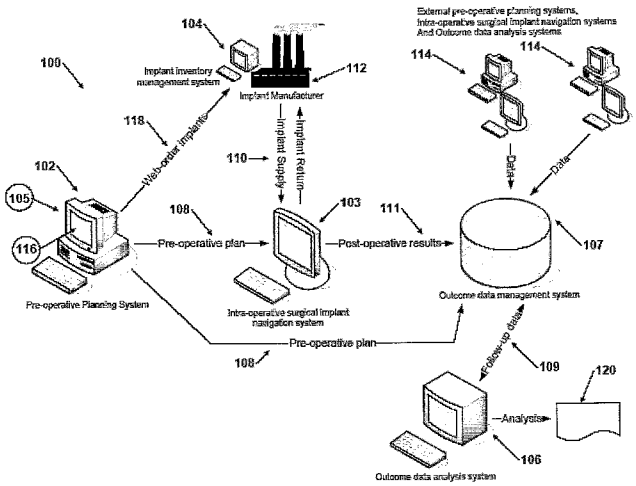

(57) Abstract: A method is provided for maintaining a data set associated with an implant device intended for use during implant surgery on a selected patient. The method includes the steps of: storing pre-operative planning information in the data set configured for use during the implant surgery, the pre-operative planning information comprising image data representing the anatomy of the selected patient, a definition of the implant device based on an analysis of the anatomy represented in the image data such that the definition of the implant device includes one or more implant devices each having at least one different implant property, and surgical information including placement information of the implant device on the anatomy. The data set can then be amended to include intra-operative information including the actual implant device used during the implant surgery and details of the actual placement of the implant device used during the implant surgery. The amended data set is stored for subsequent access to facilitate outcome analysis (i.e. post-operative analysis) of the pre-operative planning information and the intra-operative information associated with the implant device.

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IMPLANT INVENTORY MANAGEMENT SYSTEM AND METHOD USING DIGITAL IMAGE PLANNING

The present invention relates generally to surgical implant usage and more specifically to an implant inventory management system.

BACKGROUND OF THE INVENTION

Surgical implants are becoming more common in recent years due to surgeons operating on younger patients who want to maintain an active lifestyle. This puts a financial burden on the implant manufacturers, who need to maintain an adequate implant inventory due to the variety of implant types and configurations that meet the specific needs of the patients. There is a need for Just-In-Time delivery and inventory control to help reduce these implant inventory costs.

Another way to reduce the inventory is by recording the usage and outcome of these implants and to discontinue those that show a poor outcome. Current medical implant planning and inventory systems are poor in tracking such usage and outcomes.

The process of selecting an ideal implant to be used is often time consuming for the clinicians. It can for example include a combination of image manipulations, measurements and templating. Since these processes are often not reimbursed by medical insurance, it places the clinicians in a situation where they need to choose between best outcome to the patient by doing precise and careful planning and optimizing their efficiency to do more procedures for which they get reimbursed.

A further problem that exists in implant planning a surgical placement is the lack of adequate flow of information between the planning and surgical systems.

A different, yet related problem that exists is when a patient requires revision surgery to replace existing implants that need to be replaced but the existing implants are not

known. Unique hardware is used to remove different sets of implants. Thus, by not knowing what implants a patient has at a certain time, necessitates having a large variety of surgical tools available and sterilized in the operating room.

There is therefore a need for an implant inventory management system and method which overcomes or mitigates at least some of the above-presented disadvantages.

SUMMARY OF THE INVENTION

In its broad aspect, there is provided a method for maintaining a data set associated with an implant device intended for use during implant surgery on a selected patient, the method comprising the steps of: storing pre-operative planning information in the data set configured for use during the implant surgery, the pre-operative planning information comprising image data representing the anatomy of the selected patient, a definition of the implant device based on an analysis of the anatomy represented in the image data such that the definition of the implant device includes one or more implant devices each having at least one different implant property, and surgical information including placement information of the implant device on the anatomy; amending the data set to include intra-operative information including the actual implant device used during the implant surgery and details of the actual placement of the implant device used during the implant surgery; and storing the amended data set configured for subsequent access to facilitate post-operative analysis of the pre-operative planning information and the intra-operative information associated with the implant device.

In another aspect, the method further comprises the step of using a portion of the definition of the implant device to order the implant device from an implant device supplier for obtaining the implant device suitable for the selected patient.

In another aspect, there is provided a system for maintaining a data set associated with an implant device intended for use during implant surgery on a selected patient, the system comprising: a planning system configured for storing pre-operative planning information

in the data set configured for use during the implant surgery, the pre-operative planning information comprising image data representing the anatomy of the selected patient, a definition of the implant device based on a analysis of the anatomy represented in the image data such that the definition of the implant device includes one or more implant devices each having at least one different implant property, and surgical information including placement information of the implant device on the anatomy; an intra-operative system configured for amending the data set to include intra-operative information including the actual implant device used during the implant surgery and details of the actual placement of the implant device used during the implant surgery; and an analysis system configured for storing the amended data set for subsequent access to facilitate post-operative analysis of the pre-operative planning information and the intra-operative information associated with the implant device.

In another aspect, there is provided a method for determining an implant device intended for use during implant surgery on a selected patient, the method comprising the steps of: obtaining digital image data for representing anatomical features of the patient anatomy related to a region suitable for placement of the implant device; providing a group of generic anatomical features related to the region, the group of anatomical features contained in an anatomical model; identifying the anatomical features of the patient anatomy in the digital image data; correlating the identified anatomical features to at least some of the generic anatomical features of the group of generic anatomical features in the anatomical model; and selecting the implant device based on the results of said step of correlating, and generating placement information of the implant device with respect to the patient anatomy.

In yet another aspect, there is provided a method for determining an implant device intended for removal during surgery on a selected patient, the method comprising the steps of: obtaining digital image data for representing implant device features of the implant; providing a group of generic implant device features related to the implant device, the group of generic implant device features represented as a library of known implant devices; identifying the implant device features in the digital image data; correlating the identified implant device features to at least some of the generic implant

device features in the library ; and selecting the implant device from the library based on the results of said step of correlating.

In yet another aspect, there is provided a planning system for determining an implant device intended for use during implant surgery on a selected patient, the method comprising the steps of: a storage including a set of digital image data for representing anatomical features of the patient anatomy related to a region suitable for placement of the implant device; a generic anatomical model for providing a group of generic anatomical features related to the region; a matching module configured for identifying the anatomical features of the patient anatomy in the digital image data and for correlating the identified anatomical features to at least some of the generic anatomical features of the group of generic anatomical features in the anatomical model; and a selection module for selecting the implant device based on the results of said step of correlating, and generating placement information of the implant device with respect to the patient anatomy.

In yet another aspect, there is provided a method for generating information related to an implant device, the implant device for use during implant surgery on a selected patient, the method comprising the steps of: obtaining a set of image data of the selected patient including anatomy associated with the intended location of the implant device, the image data adaptable for use in performance of the implant surgery; performing a dimensional analysis of the anatomy represented in the image data to determine a first size of the implant device; generating a description of the implant device comprising a plurality of device features including at least a selected model and a second size different from the first size; associating at least some of the plurality of device features with the image data; and generating an order to include selected ones of the plurality of device features including the selected model and the first and second sizes of the implant device, the order configured for sending to an implant device supplier for obtaining the implant device suitable for the selected patient.

Additionally, the method further comprises the step of generating surgical information including placement information of the implant device on the anatomy, the surgical information adaptable for use in performance of the implant surgery. In one embodiment, the method further comprises the step of positioning the placement information on the image data. In another embodiment, the surgical information includes details of a surgical path.

In yet another embodiment, the method further comprises the step of generating a preoperative plan data set configured for facilitating the implant surgery, the preoperative plan data set including the image data, the description of the implant device, and the surgical information.

In yet another embodiment, the method further comprises the step of adding information on a second implant device to the description, the second implant device for use in conjunction with said implant device during the implant surgery.

In another aspect, there is provided a method for maintaining a data set during implant surgery on a patient, the data set associated with an implant device used during the implant surgery, the method comprising the steps of: loading preoperative planning information included in the data set, the preoperative planning information comprising preoperative image data representing the anatomy of the patient, a definition of the implant device including at least two different sizes of the implant device, and surgical information including placement information of the implant device on the anatomy; amending the data set to include intra-operative information including at least the actual size of the implant device implanted and details of the actual placement of the implant device implanted; and storing the amended data set upon completion of the implant surgery, the stored amended data set configurable for subsequent access to facilitate post-operative analysis of the preoperative planning information and the intra-operative information associated with the implant device. The method further comprises the step of obtaining the least two different sizes of the implant device in response to an order including a plurality of device features selected from the definition of the implant device.

In one embodiment, the method further comprises the steps of recording a set of intra-operative image data of the patient anatomy in a region associated with the implant device and amending the data set to include the intra-operative image data.

In another embodiment, the method further comprises the step of co-registering the intra-operative image data with the preoperative image data such that the definition of the implant device becomes registered with the intra-operative image data.

In another embodiment, the definition of the implant device includes a graphical representation of the implant device suitable for display with the preoperative image data.

In yet another aspect, there is provided a system for maintaining a data set during implant surgery on a patient, the data set associated with an implant device used during the implant surgery, the system comprising: a processing module for receiving and loading preoperative planning information included in the data set, the preoperative planning information comprising preoperative image data representing the anatomy of the patient, a definition of the implant device including at least two different sizes of the implant device, and surgical information including placement information of the implant device on the anatomy; an input module for receiving intra-operative information and amending the data set to include the intra-operative information, wherein the intra-operative information includes at least the actual size of the implant device implanted and details of the actual placement of the implant device implanted; and a data set storage for storing the amended data set upon completion of the implant surgery, the stored amended data set configurable for subsequent access to facilitate post-operative analysis of the preoperative planning information and the intra-operative information associated with the implant device.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features of the preferred embodiments of the invention will become more apparent in the following detailed description in which reference is made to the appended example drawings wherein:

Figure 1 is a block diagram of an implant monitoring system;

Figure 2 is an example computer of the system of Figure 1;

Figure 3a is example planning information of the planning system of Figure 1;

Figure 3b is further example planning information of the planning system of Figure 1;

Figure 3c is a further example planning information of the planning system of Figure 1;

Figures 4a is a further example planning information of the planning system of Figure 1;

Figure 4b is a further example planning information of the planning system of Figure 1;

Figure 4c is a further example planning information of the planning system of Figure 1;

Figure 5 is an example configuration of the inventory management system in Figure 1;

Figure 6 is an example of image linking between the planning and navigation systems of Figure 1;

Figure 7 is an example of planning for a revision case;

Figure 8 is a further example planning information of the planning system of Figure 1;

Figure 9 is an example operation of the pre-operative planning system of Figure 1;

Figure 10 is an example data set used by the implant monitoring system of Figure 1;

Figures 11a and 11b are example interfaces shown at the pre-operative planning system of Figure 1;

Figure 12 is an example template selection interface used by the pre-operative planning system of Figure 1;

Figure 13 is an example template saving interface used by the pre-operative planning system of Figure 1;

Figure 14 is an example of automatic templating performed on a pelvic image by the pre-operative planning system of Figure 1;

Figure 15 shows one embodiment of the pre-operative planning system of Figure 1; and,

Figures 16a and 16b illustrate an example report generated by the implant ordering module of Figure 15.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Implant monitoring system 100

Referring to Figure 1, an implant monitoring system 100 is shown comprising an integrated pre-operative planning system 102 with implant inventory management system 104 is shown in conjunction with an outcome data management system 107. Also shown is a surgical navigation system 103 and outcome data analysis system 106. Digital planning information 108 (e.g. images 116 of a patient's anatomy, implant information, and surgical path indication) and surgeons preferences 105 (e.g. preferred type of implant used) of a surgical procedure (using the preoperative planning system 102) are linked with implant inventory management control system 104 to provide for planned implant 110 materials (e.g. implant types and sizes) ordered and received from an implant manufacturer 112 or supplier. It is also recognized that the planning information 108 is shared with the outcome data management system 107, as well as any surgical information 111 (e.g. actual implant 110 sizes used, patient surgery details, etc.) gathered during the surgical procedure (using the system 103) for assisting in the placement of the implant 110 materials.

Referring again to Figure 1, the implant monitoring system 100 provides the following functionalities using the above-described components:

1) accurate digital pre-operative surgical planning on one or more medical images 116 using the pre-operative planning system 102, the planning consisting of such as but not limited to (semi) automated implant 110 sizing and placement, (semi) automated ordering of planned implant 110 components, and saving & sending pre-operative planning information 108 directly to the outcome data management system 103, and auto detection of patient anatomy and implant 110 size and placement further described below and shown in Figure 10;
2) accurate intra-operative navigation system of implant 110 positioning using the surgical navigation system 103, the navigation consisting of such as but not limited to, (semi) automated registration of implant 110 sizing and placement with the images 116 obtained pre-operatively, navigation of implant 110 component placement, (semi) automated recording of used implant 110 component and automated ordering via order 118 (e.g. network communication and/or paper form) of replacement implant 110 inventory, and recording of implant 110 component final surgical placement by the surgeon in assistance by system 103 and direct link of the surgical information 111 with the outcome data management and system 107 for post operative tracking of the planning information 108 and the surgical information 111 (as shown in Figure 10), and analysis of such data using the outcome data analysis system 106; and
3) Post-operative surgical outcome analysis using the system 106 through such as but not limited to, direct digital link between pre-operative planning information 108, intra-operative navigation and surgical information 111 and data analysis reports 120 of the clinical data management system 106 and (multi-center) collection of implant 110 component usage and outcome results from external systems 114.

Data Set 950

Thus, the information provided by the pre-operative planning system 102 (i.e. the planning information 108), and the surgical navigation system 103 (i.e. the surgical information 111) described above comprise a portion of a data set 950 shown in Figure 10. This data set 950 is sent to and stored by the outcome data management system 107 for subsequent analysis thereon. As shown in Figure 10, the data set 950 comprises

planning information 108 provided by the pre-operative planning system 102, surgical information 111 as provided by the surgical navigation system 103, follow-up information 109 as provided by the outcome data analysis system 106 and other surgery, implant, patient information 113 (e.g. patient ID, medical test results pertaining to implant surgery, status and other information on existing implants, etc) as provided through a user interface 920 or through a data storage device. The planning information 108 as described earlier may comprise: implant type, size, location, and geometrical measurements of the patient's anatomy to facilitate the surgeon during surgery.

The planning information 108 can also include the digital images 116 of the patient anatomy, including 2D images including groupings of pixels (e.g. according to the DICOM standard) which show a number slice planes taken through a volume of the relevant portion of the patient's anatomy for facilitating placement of the implant. In addition, the 2D images can be processed and transformed into 3D graphical models (i.e. voxels) for visualization of the volume of the relevant portion (e.g. 3D contour slices) pertaining to the intended location of the implant device 110.

The surgical information 111 can update or modify the information obtained as part of the planning information as well as add new information obtained during the surgical procedure. For example, the surgical information 111 may reflect the actual type and size of implant used, new geometrical measurements of anatomical components calculated during surgery, additional patient surgery details (i.e. information as to the patient's condition) as well as any comments by the surgeon. For example, these comments may include notes made by the surgeon (obtained either through video, text or audio) and associated with the image 116 on the capability of the patient to handle subsequent implants. In summary, the surgical information 111 includes all information for use in evaluating the performance of the implant 110 components, including generated statistics as facilitated by the outcome data analysis system 106.

In addition, as described earlier, an outcome data analysis system 106 may be used to keep statistics on the specific implant used 110 and provide follow-up information 109,

including data on implant 110 performance and basic patient health information related thereto as obtained following patient-healthcare provider visits. The follow-up information 109 may be used to aid the surgeon during subsequent surgeries on the patient.

Data Management System 107

It is also recognized that external systems 114 (e.g. pre-operative information such as 108, surgical information such as 111, and other follow-up information 109) from other third party sources could be sent to the outcome data management system 107 for association with the planning information 108 and surgical information 111 to help track and monitor implant 110 performance. It is also recognized that outcome data analysis system 106 can be used to analyze planning information 108, surgical information 111, and follow-up information 109 to generate reports 120 for use in evaluating the performance of the implant 110.

Referring to Figure 2, the systems 102, 103, 104, 106, 107, 114, hereafter generally referred to as system 50 in reference to this figure, can be implemented on a computer system 10 having a memory 12 coupled to a processor 14 via a bus 16. The memory 12 has software 30 for operating the selected system 50 functionality (e.g. viewing and manipulating images 116, assisting in conducting the surgical procedure, generating and analyzing the outcome reports 120). The computer 10 also has a user interface 32, coupled to the processor 14 via the bus 16, to interact with a user (not shown). The user interface 32 can include one or more user input devices such as but not limited to a QWERTY keyboard, a keypad, a trackwheel, a stylus, a mouse, a microphone and the user output devices such as but not limited to a display and speakers. If the display is touch sensitive, then the display can also be used as a user interface device controlled by the processor 14. The user interface 32 is employed by the user of the computer 10 to manipulate the selected system 50 as desired. The output data set 950 of the computer 10 (e.g. planning information 108, surgical information 111, outcome reports 120) can be represented by digital images displayed on the screen and/or saved as a file in the memory 12, as a set of descriptive data providing information associated with the

resultant output or a combination thereof. Further, it is recognized that the computer 10 can include a computer readable storage medium 34 coupled to the processor 14 via the bus 16 for providing instructions to the processor 14 and/or to load/update the software 30. The computer readable medium 34 can include hardware and/or software such as, by way of example only, magnetic disks, magnetic tape, optically readable medium such as CD/DVD ROMS, and memory cards. In each case, the computer readable medium 34 may take the form of a small disk, floppy diskette, cassette, hard disk drive, solid state memory card, or RAM provided in the memory 12. It should be noted that the above listed example computer readable mediums 34 can be used either alone or in combination. It is also recognized that the instructions to the processor 14 and/or to load/update software 30 in the memory 12 can be provided over a network (not shown).

Integrated Preoperative Planning system 102

The pre-operative planning system 102 uses automated planning methods and surgeon preferences 105 to create the plan 108 and select the ideal implant 110. Operation of the pre-operative planning system 102 can provide for (semi) automatic selection of implant 110 type and implant 110 size based on the anatomic characteristics of the patient recognised by the system 102 automatically in the digital images 116. Implant manufacturer 112 can be manually selected or automatically chosen based on surgeon preferences 105.

Referring to Figure 15, shown is the pre-operative planning system 102. The system 102 comprises an implant type selection module 1502 that communicates with a user interface 920, pre-selected templates 926, and library of templates 918 to allow the selection of the type of implant 110 desired for surgery. The user interface 920 can receive surgeon/patient preferences 105 directly from the user as well as other surgeon information 924 such as the operative side of the patient, comments for the surgeon, optimal tools for placement of implant 110 or for later removal of implant 110. The system 102 further comprises an image correction module 1510, an automatic implant correlation module 1508, and an image atlas 916. The image correction module 1510 automatically corrects images 116 for magnification and provides the corrected image

116 to the automatic implant correlation module 1508 for further analysis. The automatic implant correlation module 1508 further comprises the image analysis module 1504 and the implant matching module 1506. The image analysis module 1504 analyzes the corrected images 116 using the image atlas 916 and provides geometrical measurements regarding the patient's anatomy and optimal placement of the implant 110 to the implant matching module 1506 which selects the appropriate size and location of the implant 110, for example. The pre-operative planning system 102 further comprises an implant ordering module 1512 which synthesizes and sends the implant order information 118 to an implant inventory management system 104 and a planning module 1514 which synthesizes and sends the planning information 108 to the surgical navigation system 103.

Operation 900 of Planning System 102

Referring to Figure 9, shown is an example operation 900 of the pre-operative planning system 102 and the modules described above in reference to Figure 15. First, at step 902, the user selects the specific patient study, and images 116 to be planned. An example of this interface is shown in Figure 11b. This may be done through the use of the user interface 920 that provides a list of available digital images 116 and corresponding patients such that once the selection is made (Figure 11a), the images 116 in the selected study are automatically loaded from the storage 34 (see Figure 2) to the user interface 920 as shown in Figure 11b. Alternatively, the desired image 116 for a specific patient and corresponding patient information 113 (see Figure 10) are loaded directly by the user. It is recognised that the images 116 contain anatomical features of the patient in a region suitable for placement of the implant device 110. The anatomical features include identifiable anatomical features 1403 (see Figure 14) for use in selecting the implant device 110, further described below.

Image Calibration and Correction

At steps 904 & 906, the image is automatically calibrated and image correction occurs. Automatic calibration 904 of the image includes correction for magnification of the

images 116. These images 116 such as X-ray images, are inherently magnified due to the point-source nature of X-ray devices. To correct for this magnification, *automatic detection of a magnification marker* 1102 can be used (shown in Figure 11b). The magnification marker 1102 can be a ball (similar to a ball bearing) that is placed in the image during acquisition. As the size of the ball is known, the software detects the ball and automatically adjusts the zooming factor so that all measurements will be correct according to the ball. This process is referred to as *Automatic Image Calibration*. It is recognised that the image calibration and correction can be done to facilitate automated identification of the identifiable anatomical features 1403 in the images 116.

It would be understood by a person skilled in the art that although the above example describes automatic image calibration using the ball as the magnification marker 1102, other types of markers or identifiers may be used on the image 116 in a similar manner.

In addition, properties of the images 116 such as brightness and contrast of the images 116 or other such display properties may be adjusted at step 906. For example the images 116 such as X-ray images are automatically analyzed during load time into the user interface 920 and the optimal contrast/brightness (also known as width/level) are applied to the image. As will be described later, these adjusted image properties may be used by the pre-operative planning system 102 to facilitate the automated detection of the location and size of the desired implant 110, for example.

Implant Type Selection

Referring again to Figure 9, at step 908, image analysis and implant matching is performed by the pre-operative planning system 102 and the corresponding modules previously discussed in reference to Figure 15. As shown by step 928, the implant type selection interacts with a library 918 of known implants 110, and their characteristics. In addition as in the example shown in Figure 12, the user may select or assign favourites amongst the library 918, referred to as pre-selected templates 926. When templating, the patient's most commonly used implants (as defined in earlier usages) are displayed in the user interface 920 (Figure 12). This avoids having to scan through a large list of

templates 926 each time the user wishes to template a case. The type selection can include selection of the manufacturer(s) for the implant devices 110, as well as the particular implant device 110 configuration suitable for the selected region of the patient anatomy (e.g. a hip type implant device 110 is selected for hip replacement surgery).

In order to further reduce the amount of effort and mouse clicks in the templating, *Automatic Plans* 927 can be saved and applied. As shown in Figure 13, these automatic plans 927 contain a pre-selected set of implants to be used for a case. For example, Figure 13 shows that the auto-plan may be a specific subset of the favourite templates 926 previously assigned.

Thus, as shown in Figure 15, the type of implant 110 can be selected through the user interface 920 either by using surgeon/ patient preferences 105 or by selecting from the library of implants 918 directly or by selecting from the previously defined favourites for the user which has logged into the pre-operative planning system 102.

In addition, as described earlier, Figure 15 illustrates that other surgeon information 924 such as the operative side of the patient, comments for the surgeon etc may also be input through the user interface 920 and later used as part of the planning information 108.

Image Analysis and Implant Matching

Once the surgeon information 924 has been selected and the implant type has been chosen, the image 116 is ready to be analyzed in order to determine which implant 110 features (from the chosen implant family) should be ordered and where the implant 110 should be placed according to the image 116. The implant features can include features such as but not limited to: implant size; implant type; implant thickness; implant material; chemical factors; off sets; angle configuration of adjacent implant components; and geometrical configuration. As will be discussed later, more than one implant device 110 (e.g. size) may be ordered from an implant manufacturer 112 in order to account for errors in calculating the required implant 110 size or other changes to the patient's

anatomy prior to surgery. Further, it is recognized that more than one type of implant 110, and associated size, can be ordered for the implant surgery. One example is a ball and cup joint.

It is recognised that the surgeon (or other user), via user interface 920, can amend the ordering information, based on experience for example, to order more that one related implant device 110, such that each of the implant devices 110 have both similar and dissimilar implant features. For example, the manual adjustment by a user of information related to the identified anatomical features for affecting the selection of the implant device, can include at least one parameter selected from: addition of a further anatomical feature; deletion of at least one of the identified anatomical features; amending a definition of at least one of the identified anatomical features; and changing the calculated feature of the implant device. It is also recognized that at least some of the anatomical features or other landmarks detected from the image 116 described above are automatically identified.

For example, a second (or more) sizes of the implant 110 different from the calculated implant 110 size can be ordered, in order to account for any variability in calculating measurements of the patient's anatomy or differences between the information known at the pre-operative planning stage and that potentially realisable during surgery. Other examples of ordering multiple implant devices 110 for the same implant can include variations such as but not limited to: thickness; off sets; implant material; chemical factors; angle configuration of adjacent implant components; and geometrical configurations.

Referring again to Figure 15, the automatic correlating module 1508 which selects the ideal implant 110 size and location on the image 116 comprises the image analysis module 1504 and implant matching module 1506. This process can be facilitated by an image atlas 916 that is composed of many cases that "teach" the image analysis module 1504 how to analyze the images 116. It is recognised that the correlating module 1508 provides for recognition of the identifiable features 1403 in the digital images 116, as

well as using various anatomical models for matching (in 2D and/or 3D) the identified anatomical features 1403 in order to select an appropriate implant device 110. These anatomical models can include models, both image based and non-image based, such as but not limited to: atlas based models and statistical models.

An example of such image analysis using an atlas based model and measurements are shown in Figure 14. In this figure, automatic correlation of a pelvic image is performed.

This includes the use of an image atlas 916 that has been pre-trained from a number of hip images to detect certain desired anatomical landmarks on the image 116, or other identifiable features 1403. The identifiable features 1403 can include features/ fiducials (both natural and/or man made) such as but not limited to: points; shapes; contours; and/or a collection thereof. The correlation between the current image 116 and the image atlas 916 allows the automatic templating module 1508 to detect certain recognizable anatomical landmarks on the image of the patient's anatomy. For example, for the hip implant shown in Figure 14, the image analysis module 1504 will correlate the current image 116 with the atlas image 916 to determine at least some of the following identifiable features 1403: detection of specific edges of the bones within the femur and determination of central axis on the femur 1402; measurement of the diameter 1404 based on the detected edges. For example, the implant matching module 1506 assigns a corresponding implant 110 size for the specified implant 110 type based on dimensional analysis of the anatomy of the patient in the images 116, e.g. the diameter 1404 provided by the image analysis module 1504, thus resulting in some of the pre-operative planning information 108.

It is recognised that image analysis module 1504 can also performing calculations based on geometrical considerations of the identified anatomical features 1403, the calculations for providing a feature of the implant device selected from the group comprising: placement of the implant device on the patient anatomy; a geometrical configuration of selected parts of the patient anatomy; and a geometrical configuration of components of the implant device. These calculations can include implant features such as but not

limited to: off sets; angle configuration of adjacent implant components; and geometrical configuration.

For example, for a cup implant 110, the following anatomical and/or dimensional identifiable features 1403 may be detected: outline of hip and corresponding edges; and a center point within an inner circle of the pelvis. Based on these measurements, the size of the acetabular cup shells shown in Figure 14 is determined by the implant matching module 1506. In addition, the determination of the physical location of certain landmarks such as the centre axis and the center point relating to the cup as provided by correlating the image 116 to the atlas image 916 allows the implant matching module 1506 to place the corresponding implants on the image 116. It is recognized that the above described identifiable features 1403 can be included as part of the pre-operative planning information 108.

It should be noted that the above example illustrates a method for analyzing a pelvic image and using an image atlas to facilitate the analysis. It will be understood by a person skilled in the art that the image analysis module 1504 and the implant matching module 1506may use the image atlas 916 as described for analyzing any types of images 116 of the patient relating to implant 110 insertion.

It is recognised that other image atlas methods can be used, such as:
1. Xie-MAICS-2004 for semi-automatic template placement including the steps of
a. Image scaling.
b. Locate stem axis.
(1) Noise reduction using a gaussian filter.
(2) Edge detection using a gradient operator and thresholding. (specifically they do this in the horizontal direction only)
(3) find the centre of the shaft based on the detected edges
(4) other landmarks are selected manually;

2. Ozinian-MIA-2000 for the detection of anatomical landmarks 1403 on the femur from fluoro images 116 for use in fracture analysis including the steps of

a. Detect region of interest for the femoral neck shaft and head. ROI's are determined by analyzing gray-level horizontal profiles in the image, looking for abrupt changes, and are matched to expected profiles for each of the 3 regions.

b. find the neck centre. From the neck ROI above:

(1) find points with high horizontal gradients and assing them to either the top or bottom neck boundary

(2) give each point a confidence value based on it's connectivity with other points

(3) remove low-confidence points

(4) update the confidence values

(5) determine the midpoint between the two point sets

c. find the lateral cortex line

(1) find a set of candidate points using a rule-based procedure

(2) fit an ellipse through them

d find the femoral head centre

(1) Find boundary points belonging to the shaft and fit a line through them.

Further, it is recognised that the statistical models, e.g. http://www.isbe.man.ac.uk/~bim/Papers/asm_aam_overview.pdf can include as follows.

The statistical model can be considered 'generative' since they are able to generate an image of the feature 1403 they are segmenting. Other statistical models (such as classifiers SVM - http://en.wikipedia.org/wiki/Support_vector_machine) determine if a set of pixels matches some description, e.g. the pixels/voxels in the image data 116 match a corresponding description of the anatomical features 1403 described in the statistical model. Historically the statistical generative model were introduced as "smart" active contour (also known as snakes). The Point Distribution Model (PDM) used to "learn" how the points are correlated using a PCA. The next generation was the Active Shape Model (ASM) which model the shape and image's gradient with a PCA. The image

gradient is modeled only in the neighbour of the shape. The third generation was the Active Appearance Model (AAM) which model shape and texture (intensity in the image) with a PCA. ASM and AAM segment an image searching the PCA model's parameters which minimize the difference between the model and the image.

Planning Information 108 and Order Information 118

Referring again to Figure 9, once the image analysis and implant matching step 908 has been performed, the results can be saved back to an image archive, printed out, or a report can be created that contains the patient information, case information, images used for the planning, and the implants chosen for the procedure. This can include updating of the pre-operative planning information 108.

An example of this pre-operative planning information 108 is shown in Figure 16a and 16b. It should be noted that this report is only meant for illustrative purposes and any type of pre-operative planning information 108 containing the order information 118 (as see Figure 1)may be used to place the order for the implant 110. It is recognised that the planning information 108 can be configured for use in surgery.

Thus at step 912, the created pre-operative planning information 108 and order information 118 which includes at least some of the following information: implant type, implant size, operative side and other implant 110 characteristics. The order 118 are transmitted to the implant manufacturer 112 at step 914. The implant order 118, is sent to the manufacturer 112 by the implant ordering module 1512 as part of the software 30 implemented by the system 102 (see Figure 2). The order module 1512 takes the implant 110 information gathered at step 912 and sends the appropriate order 118 to the manufacturer 112, including desired place and time of delivery. Alternatively, the implant ordering information 118 could be automatically mailed or otherwise delivered to the implant representative or manufacturer 112 for delivery on a given date.

In addition, the pre-operative planning information 108 provided by the process 900 and the pre-operative planning system 102 may include at least some of the following data: type of surgery to be performed, operative side, implant type or family, implant 110 size, implant placement on the images 116, surgery details including surgical path and geometry information (e.g. locating of surgical cuts and attachment points of the implant to the patient anatomy), patient information, surgeon information, and surgeon tool preferences for removal/ installation of the implant 110.

One or more of the above noted fields is synthesized by the planning module 1514 shown in Figure 15 to make up the planning information 108, and the planning module 1514 sends this information to the intra-operative surgical navigation system 103 as shown at step 916 in Figure 9. The planning module 1514 can also generate details regarding a second (or more) sizes of the implant 110 different from the ideal implant 110 size, in order to account for any variability in calculating measurements of the patient's anatomy or differences between the information known at the pre-operative planning stage and that realized during surgery. The planning module 1514 can further transpose or overlay at least some of the planning information 108 onto the images 116 as shown in Figure 14 and 16b, or the information may be otherwise linked to an address of the images 116 (e.g. stored on an addressable file separate from the image 116 data file). Alternatively, the planning information 108 may be sent as text without the images 116. It is recognized that the planning information 108 is overlaid or otherwise linked to the images 116 on a slice by slice basis, including graphics depicting the implant 110. Alternatively, the planning information 108 can be dynamically displayed on the images 116 during rendering by the navigation system 103.

Referring to Figure 8 shown is an example of automated anatomy & implant 110 position detection using the automatic templating module 1508 of the pre-operative planning system 102.

The planning information 108 described earlier, may also include specific geometrical measurements (e.g. surgical path) that are calculated on the image 116 of the patient's

anatomy to guide the placement of the implant 110 during surgery. An example of such measurements can be seen in Figures 3a and 3b, 4a and 4b. Figure 3b shows a spine implant 110 where the size of the screw is shown on the image as well as the rod length for a rod that connect multiple vertebrae together. It would be understood by a person skilled in the art, that although these measurements have been shown relative to the hip and spine, each type of surgical procedure may require a different set of geometrical measurements that will aid the surgeon in placing and securing the desired implant.

Referring to Figures 3a, 3b, and 3c shown are examples of planning information 108 generated using the software 30 of the system 102. Figures 4a, 4b, and 4c illustrate an alternate embodiment of Figures 3a, 3b and 3c and also depict planning information generated by the pre-operative planning system 102 to facilitate the surgeon during surgery. Referring to Figures 3a-3c and 4a-4c, the planning information 108 can include such as but not limited to:

1) Total or partial joint replacement planning including measurements and templating 200;
2) Spinal Analysis and planning including such as but not limited to (semi) automatic vertebral detection 202 and cervical, thoracic, and lumbar spine mobility, alignment, and deformity analysis 204;
3) (Semi) automatic 3D modeling of cartilage and other patient anatomy;
4) (Semi) automatic magnification correction using fiducial markers;
5) Planning on biplanar images 206 with fiducial markers 208 for accurate sizing and positioning of the implant 110 in the digital images, where the fiducial markers 208 may be recorded in both images 206 to assist in auto magnification/calibration based on known fiducial sizing and spacing.

It is recognized that the system 102 can use automatic detection of anatomical information from the images 116 (e.g. tissue characteristics, bone size, bone quality, bone character – soft/hard, bone marrow density, etc.) to assist in planning of the surgical procedure.

Other image 116 processing features used in the planning of the surgical procedure can include such as but not limited to contrast/brightness, image quality analysis, presence of fiducial markers 208, bone density, as well as fiducial marker 208 pairs positioned in front and behind a bone in order to assist in calculation of an average quantity through the depth of the image 116. Further, multiple connected images 116 (e.g. hip, knee, ankle) can be geometrically related to one another using a ruler or other device that contains fiducial markers 208 for which the distance between the fiducial markers 208 is known in order to perform measurements on the connected images 116. Further, an atlas of the software 30 can be used in the systems 102, 103 to automatically recognize patient anatomy in the digital images 116 via outlining and/or contour matching.

Integrated Preoperative Planning system 102 for revision cases

Referring to Figure 7, the planning system 102 contains a geometry library of existing implants 110. Images 116 are analyzed and compared to the library. When a match is found, the information about the type of implant 110 and implant manufacturer 112 is saved as preoperative information 108. A web or manual order 118 is placed to the implant manufacturer 112 to order the necessary tools 110 to extract the existing implant 110 in the operating room 150.

The case for removal of an existing implant device 110 in the patient, e.g. by the planning system 102, can include the following steps:

a) obtaining digital image data 116 for representing implant device features of the implant device 110;

b) providing a group of generic implant device features related to the implant device 110, the group of generic implant device features represented as a library 918 of known implant devices 110;

c) identifying the implant device features in the digital image data 116 through atlas-based segmentation/detection, for example;

d) correlating the identified implant device features to at least some of the generic implant device features in the library ;

e) identifying the implant device 110 from the library 918 based on the results of the step of correlating; and;

f) generate order information 118 for removal of the identified implant device 110, the order information 118 including data such as but not limited to: removal tools for extracting the existing implant in the operating room 150.

Surgical Navigation System 103

As shown in Figure 6, the surgical navigation system 103 uses automatic methods to link the pre-operative planning information 108 with intra-operative navigation. The registration of images (via a registration module 1704) obtained from the pre-operative planning system 102 through the planning information 108 and the intra-operative images 1702 are done through the recognition of similar anatomical features on each of said images. The registration of the two sets of images can also be done by mapping a coordinate on the patient or the surgery table to the pre-operative image. In this manner, the implant 110 information obtained through the planning information 108 may be transposed onto or otherwise linked with the intra-operative images 1702.

Referring to Figure 16, the surgical navigation system 103 comprises: a processing module 1710 for receiving and loading the planning information 108 from the pre-operative planning system 102; an input module 1708 for receiving intra-operative information including intra-operative images 1702 obtained from the patient, the actual size of the implant 110 device used by the surgeon during the surgery and details of the actual location of placement of the implant device on the patient. The input module 1708 amends the data set 950 to include the intra-operative information. In addition, the surgical navigation system 103 communicates with a data set storage 1712 for storing the amended data set 950 upon completion of the implant surgery, the stored amended data set configurable for subsequent access to facilitate post-operative analysis of the preoperative planning information 108 and the intra-operative information associated with the implant device 110.

As described earlier in reference to Figure 6, the surgical navigation system 103 provides (semi) automated registration of the pre-operative image 116 to the intra-operative image of the patient 1702 shown in Figure 17. Since, there is an unknown spatial relationship between the pre-operative information (i.e. pre-operative image 116 and planning information 108 associated therewith) and the patient on the operating room table, the intra-operative registration 1704 allows for a precise spatial correspondence between them such that locations within the pre-operative image 116 and associated planning information 108 are mapped to corresponding anatomical locations on the actual patient in the operating room. The registration process can be performed through techniques known in the art such as the placement of reference markers (fiducial markers) or landmarks attached to a patient's anatomy prior to the pre-operative image 116 scan and again during the intra-operative image 1702 scan. As discussed earlier, the positioning of the fiducial markers obtained pre-operatively can be passed as part of the planning information 108 to the surgical navigation system 103. For example, once measurements regarding the location of the fiducial markers are obtained on both pre-operative and intra-operative image 116, 1702 then fiducial registration is performed to determine the spatial transformation between them. This spatial transformation allows any co-ordinate on either one of images 116, 1702 to be located on the patient during surgery and vice versa. It would be recognized that although the above example describes fiducial based registration, other known registration method such as, but not limited to, shape based registration including the detection of graphical shapes on the images pre and intra-operatively may be used.

The above procedure allows for intra-operative navigation of images along with the planning information 108 provided by the pre-operative planning system 102 as shown in Figure 6.

Referring again to Figure 17, the surgical information 111 may be provided by the surgeon intra-operatively in the form of audio (i.e. using a dictation device), text (i.e. using a keyboard) or video (recording device) and stored using any combinations thereof as part of the data set 950.

In addition, as discussed earlier, the planning information 108 that is either inserted physically on the pre-operative image 116 or otherwise linked thereto is stored as part of the data set 950. The surgical information 111 can update, modify or add to the planning information 108. As mentioned previously, the surgical information 111 can include, for example: measurements of the surgical cuts made; measurements between parts of the patient's anatomy; implants 110 used during surgery including details regarding the type, size and location of the implant 110 (if different than those suggested by the planning information 108); any details relating to the surgery and patient conditions; comments regarding major alterations made to the planning information and reasons for the modifications (i.e. detected bone disease in patient during surgery). The surgical information 111 can further includes intra-operative images 1702 and post-operative images or links thereto.

The surgical navigation system 103 also allows other parties 1706 to view, modify, or delete the surgical information 111, the planning information 108 and any other information related to the patient/surgery/implant stored on the data set 950. These changes can be done through the input module 1708 which can also keep track of the identification of the user making each of the changes in order to keep an audit trail such as that discussed earlier.

The other parties 1706 shown in Figure 17 that can amend or view the data set 950 can for example, include: the implant manufacturer 112 who views the data set 950 in order to track the usage of their own implants and any changes made between the pre-operative and intra-operative implant selections.

It is recognized that the general system 100 may apply to any medical area involving inventory for implants, such as but not limited to orthopaedic implants, stents, dental implants, cochlear implants, and the like.

Operation of the surgical navigation system 103 provides for monitoring and recording of the surgical information 111 as a result of surgical procedure performed using the planning information 108, including such as but not limited to saving the image 116 with the implant 110 actually used in the surgery versus implant 110 planned (e.g. helping to provide an audit trail of implant 110 planning and usage). The surgical information 111 may be obtained from a surgeon or other parties through an audio interface (i.e. a dictation device), text (i.e. a keyboard), video (i.e. a camera).

Implant Inventory Management system 104

Operation of the system 104 can include the implant 110 material package sent by the manufacturer 112 to the surgeon (operating the navigation system 103) as a kit including a number of different implants 110 and corresponding sizes. Further, operation of the data management system 107 can be used to monitor and access implant/patient performance over time and can include confidential patient information. For example, the outcome data analysis system 106 can be used to assemble implant statistics. These statistics may reflect, for example, selected patient populations, implant types, or other demographics.

Referring to Figure 5, the implant inventory management system 104 is shown, which includes automated implant 110 ordering. The system 102 is used to plan the anticipated implant 110 size and type (as well as ancillary surgical supplies) for the surgical operation performed using the system 103. The order 118 is sent to the manufacturer 112 as an order module of the software 30 implemented by the system 102. The order module takes the implant 110 information gathered from the planning information 108 and sends the appropriate order 118 to the manufacturer 112, including desired time of delivery. The implant inventory management system 104 also notes the returned surgical materials 220 sent as part of the implant materials 110 but not used during the surgical procedure. An update 122 can also be sent to system 104 in the event of changes required to the implant materials 110, as well as changes to other related implant 110 orders dependent upon the outcome of the present surgical procedure (e.g. surgical results

on one patient hip may influence implant materials needed/not needed for subsequent operation on the second hip).

Referring to Figure 6, the link through the planning information 108 between systems 102, 103 is shown. Shown are Automated anatomy & implant 110 detection pre- and intra-operatively allowing registration of the planning information 108 with the navigation system 103. The link is performed by automated recognition of the patient demographics and/or same patient anatomy in the images 116 pre- and intra-operatively. It is recognized that the planning information 108 could be augmented by intra-operative images (not shown) that are registered with the planning images 116 using the automatic detection procedure described.

It will be appreciated that the above description relates to preferred embodiments by way of example only. Many variations on the systems 102, 103, 106 will be obvious to those knowledgeable in the field, and such obvious variations are within the scope of the invention as described herein, whether or not expressly described.

CLAIMS

WE CLAIM

1. A method for maintaining a data set associated with an implant device intended for use during implant surgery on a selected patient, the method comprising the steps of:

storing pre-operative planning information in the data set configured for use during the implant surgery, the pre-operative planning information comprising image data representing the anatomy of the selected patient, a definition of the implant device based on an analysis of the anatomy represented in the image data such that the definition of the implant device includes one or more implant devices each having at least one different implant property, and surgical information including placement information of the implant device on the anatomy;

amending the data set to include intra-operative information including the actual implant device used during the implant surgery and details of the actual placement of the implant device used during the implant surgery; and

storing the amended data set configured for subsequent access to facilitate post-operative analysis of the pre-operative planning information and the intra-operative information associated with the implant device.

2. The method according to claim 1 further comprising the step of using a portion of the definition of the implant device to order the implant device from an implant device supplier for obtaining the implant device suitable for the selected patient.

3. The method according to claim 2 further comprising the step of storing the definition of the implant device on the image data for facilitating concurrent display of the definition and the image data.

4. The method according to claim 1, wherein the definition of the implant device further includes at least one of: implant size information; implant type information; identification of insertion tools for the implant device; identification of removal tools for the implant

device; identification of an operative side of patient for insertion of the implant during implant surgery; and a graphical representation of the implant device.

5. The method according to claim 1, wherein the actual implant device is selected based on the implant property selected from the group comprising: implant size; implant type; implant thickness; implant material; chemical factors; off sets; angle configuration of adjacent implant components; and geometrical configuration.

6. The method according to claim 1 further comprising the step of adding patient identification information to the pre-operative planning information selected from the group comprising: the patient's name; date of birth; patient age; patient's sex; and date of surgery.

7. The method according to claim 1 further comprising the step of adding patient anatomy information to the intra-operative information selected from the group comprising: tissue characteristics; bone density; and geometrical measurements of the patient anatomy.

8. The method according to claim 7, wherein the intra-operative information collected during surgery further includes details of the actual surgical path used to insert the implant device.

9. The method according to claim 8, wherein the intra-operative information is collected from the group consisting of a surgeon, medical professionals associated with the implant surgery, and surgical sensing devices used during surgery.

10. The method according to claim 9 further comprising the step of updating the data set to indicate an audit trail of which of the surgeon and other medical professionals amended the data set during the implant surgery, thereby tracking the updating of the data set and associating each of the updates to the associated user.

11. The method according to claim 8, wherein the intra-operative information is collected from at least one of an audio interface, a text interface, and a video interface.

12. The method according to claim 3 further comprising the step of obtaining a set of intra-operative images of the patient and adding the intra-operative images to the intra-operative information of the data set.

13. The method according to claim 3 further comprising the step of placing a graphical image of the implant device associated with the pre-operative planning information on the image data, wherein the graphical image is aligned with the image data.

14. The method according to claim 5 further comprising the step of providing a group of generic anatomical features_for facilitating automatic selection_of the implant device by identification of anatomical features of the patient anatomy that match the group of generic anatomical features.

15. The method according to claim 14, wherein the selection of the implant device is from a library of implant device templates in accordance with at least one of a user pre-defined preference, and a user selection from the library of templates.

16. The method according to claim 14, wherein the matching of the anatomical features of the patient anatomy represented in the image data to the group of generic anatomical features is based on an analysis technique selected from the group comprising: application of a trained image atlas to the image data; and use of a statistical model to represent a generic anatomical model similar to an anatomical region containing the anatomical features of the patient anatomy represented in the image data.

17. The method according to claim 1 further comprising the step of automatically detecting an image of an existing implant in the image data by using a standard atlas comprising of a library of existing implants, the detection including matching identifiable

implant features in the image of the existing implant to corresponding known features of implants in the library of implants.

18. The method according to claim 1 further comprising the step of updating the data set post-operatively to facilitate the performance analysis of the implant device used during surgery.

19. The method according to claim 1 further comprising the step of comparing the planned pre-operative information and the intra-operative information to evaluate the effectiveness of pre-operative planning.

20. A system for maintaining a data set associated with an implant device intended for use during implant surgery on a selected patient, the system comprising:

a planning system configured for storing pre-operative planning information in the data set configured for use during the implant surgery, the pre-operative planning information comprising image data representing the anatomy of the selected patient, a definition of the implant device based on a analysis of the anatomy represented in the image data such that the definition of the implant device includes one or more implant devices each having at least one different implant property, and surgical information including placement information of the implant device on the anatomy;

an intra-operative system configured for amending the data set to include intra-operative information including the actual implant device used during the implant surgery and details of the actual placement of the implant device used during the implant surgery; and

an analysis system configured for storing the amended data set for subsequent access to facilitate post-operative analysis of the pre-operative planning information and the intra-operative information associated with the implant device.

21. A method for determining an implant device intended for use during implant surgery on a selected patient, the method comprising the steps of:

obtaining digital image data for representing anatomical features of the patient anatomy related to a region suitable for placement of the implant device;

providing a group of generic anatomical features related to the region, the group of anatomical features contained in an anatomical model;

identifying the anatomical features of the patient anatomy in the digital image data;

correlating the identified anatomical features to at least some of the generic anatomical features of the group of generic anatomical features in the anatomical model; and

selecting the implant device based on the results of said step of correlating, and generating placement information of the implant device with respect to the patient anatomy.

22. The method according to claim 21, wherein the correlating of the identified anatomical features to the group of generic anatomical features is based on the anatomical model selected from the group comprising: a trained image atlas; for representing a generic anatomical model similar to the region containing the anatomical features of the patient anatomy represented in the image data.

23. The method according to claim 21 wherein the step of correlating further comprises the step of performing calculations based on geometrical considerations of the identified anatomical features, the calculations for providing a feature of the implant device selected from the group comprising: placement of the implant device on the patient anatomy; a geometrical configuration of selected parts of the patient anatomy; and a geometrical configuration of components of the implant device.

24. The method according to claim 23 further comprising the step of manual adjustment by a user of information related to the identified anatomical features for affecting the selection of the implant device, the manual adjustment including changing at least one parameter selected from: addition of a further anatomical feature; deletion of at least one of the identified anatomical features; amending a definition of at least one of

the identified anatomical features; and changing the calculated feature of the implant device.

25. The method according to claim 21, wherein the implant device is selected based on an implant feature selected from the group comprising: implant size; implant type; implant thickness; implant material; chemical factors; off sets; angle configuration of adjacent implant components; and geometrical configuration.

26. A method for determining an implant device intended for removal during surgery on a selected patient, the method comprising the steps of:

obtaining digital image data for representing implant device features of the implant;

providing a group of generic implant device features related to the implant device, the group of generic implant device features represented as a library of known implant devices;

identifying the implant device features in the digital image data;

correlating the identified implant device features to at least some of the generic implant device features in the library ; and

selecting the implant device from the library based on the results of said step of correlating.

27. A planning system for determining an implant device intended for use during implant surgery on a selected patient, the method comprising the steps of:

a storage including a set of digital image data for representing anatomical features of the patient anatomy related to a region suitable for placement of the implant device;

an generic anatomical model for providing a group of generic anatomical features related to the region;

a matching module configured for identifying the anatomical features of the patient anatomy in the digital image data and for correlating the identified anatomical features to at least some of the generic anatomical features of the group of generic anatomical features in the anatomical model; and

a selection module for selecting the implant device based on the results of said step of correlating, and generating placement information of the implant device with respect to the patient anatomy.

28. The system of claim 27 further comprising a planning module for generating a description of the selected implant device based on the plurality of device features of the selected implant device, the planning module further transposing at least some of the plurality of device features on the digital image data.

29. The system of claim 27 further comprising an implant ordering module for generating an order of the selected implant device to include device features selected from the description , the order configured for sending to an implant device supplier for obtaining the implant device suitable for the selected patient.

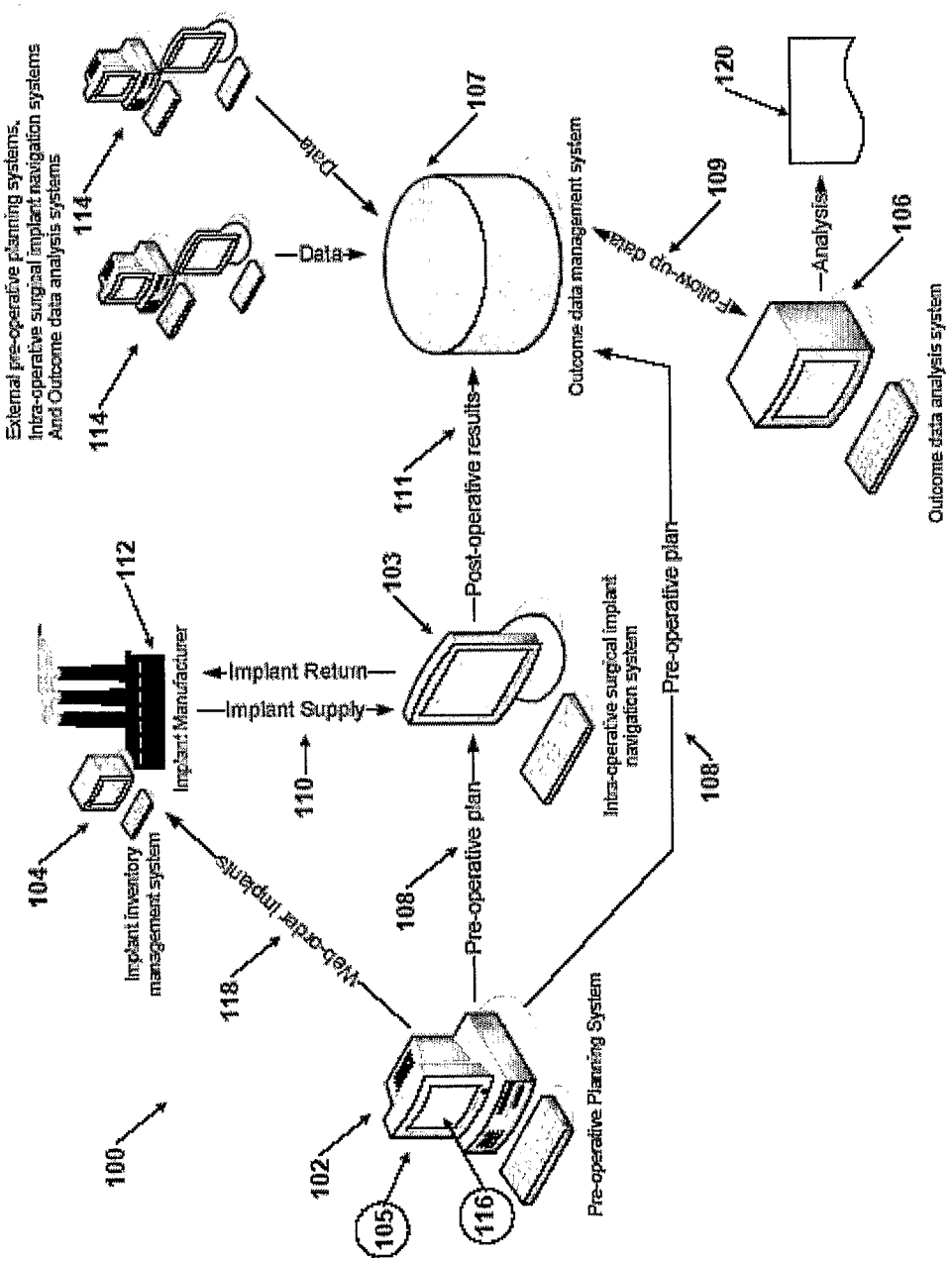

External pre-operative planning systems,
Intra-operative surgical implant navigation systems
And Outcome data analysis systems
114
114
Data
Data
107
Outcome data management system
109
Follow-up data
120
Analysis
106
Outcome data analysis system
111
Post-operative results
112
Implant Manufacturer
Implant Return
Implant Supply
103
Intra-operative surgical implant navigation system
Pre-operative plan
108
Pre-operative plan
110
104
Implant inventory management system
Web-order implants
118
108
100
102
105
116
Pre-operative Planning System

Figure 1

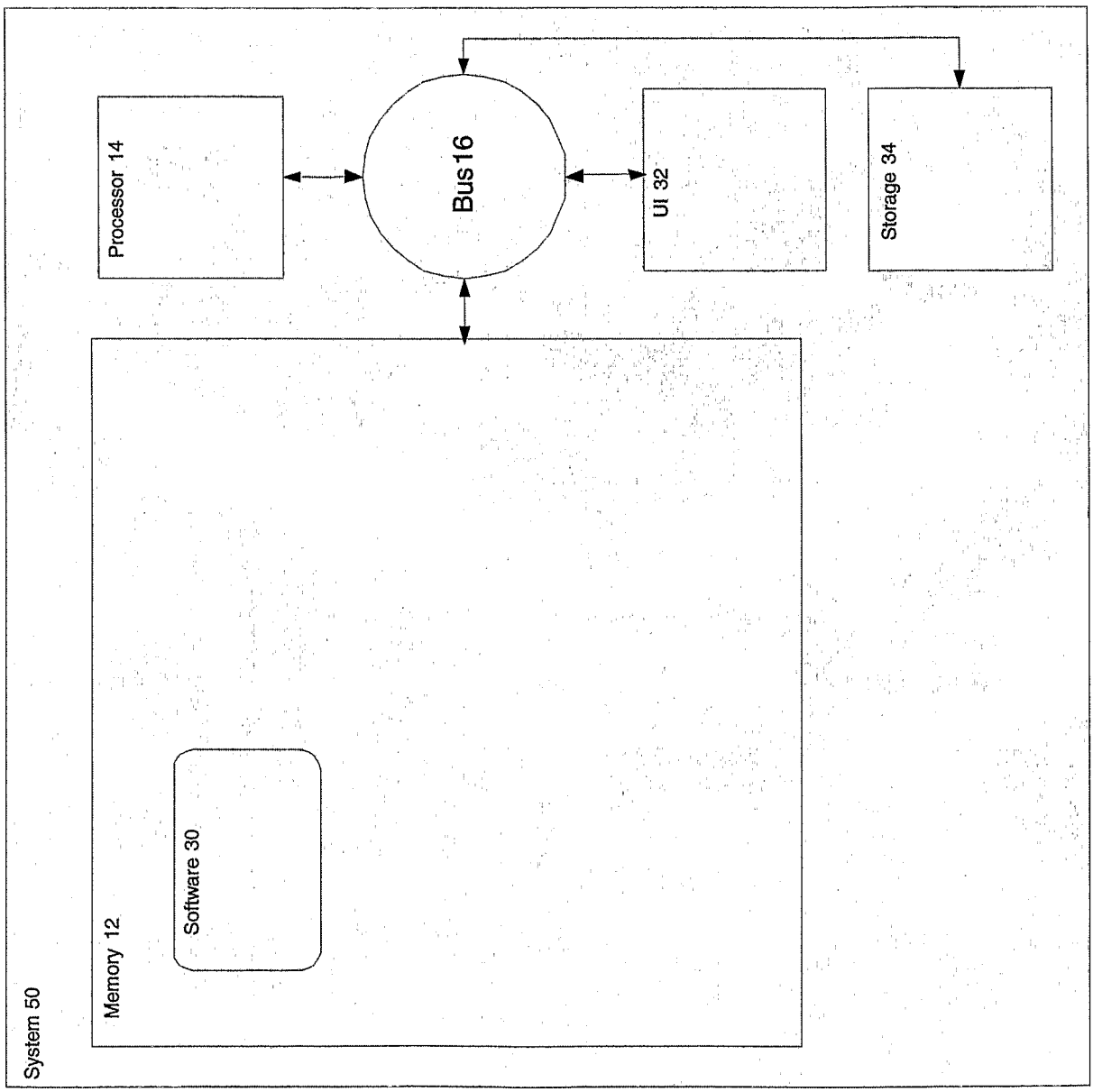

System 50
Memory 12
Software 30
Processor 14
Bus16
UI 32
Storage 34

Figure 2

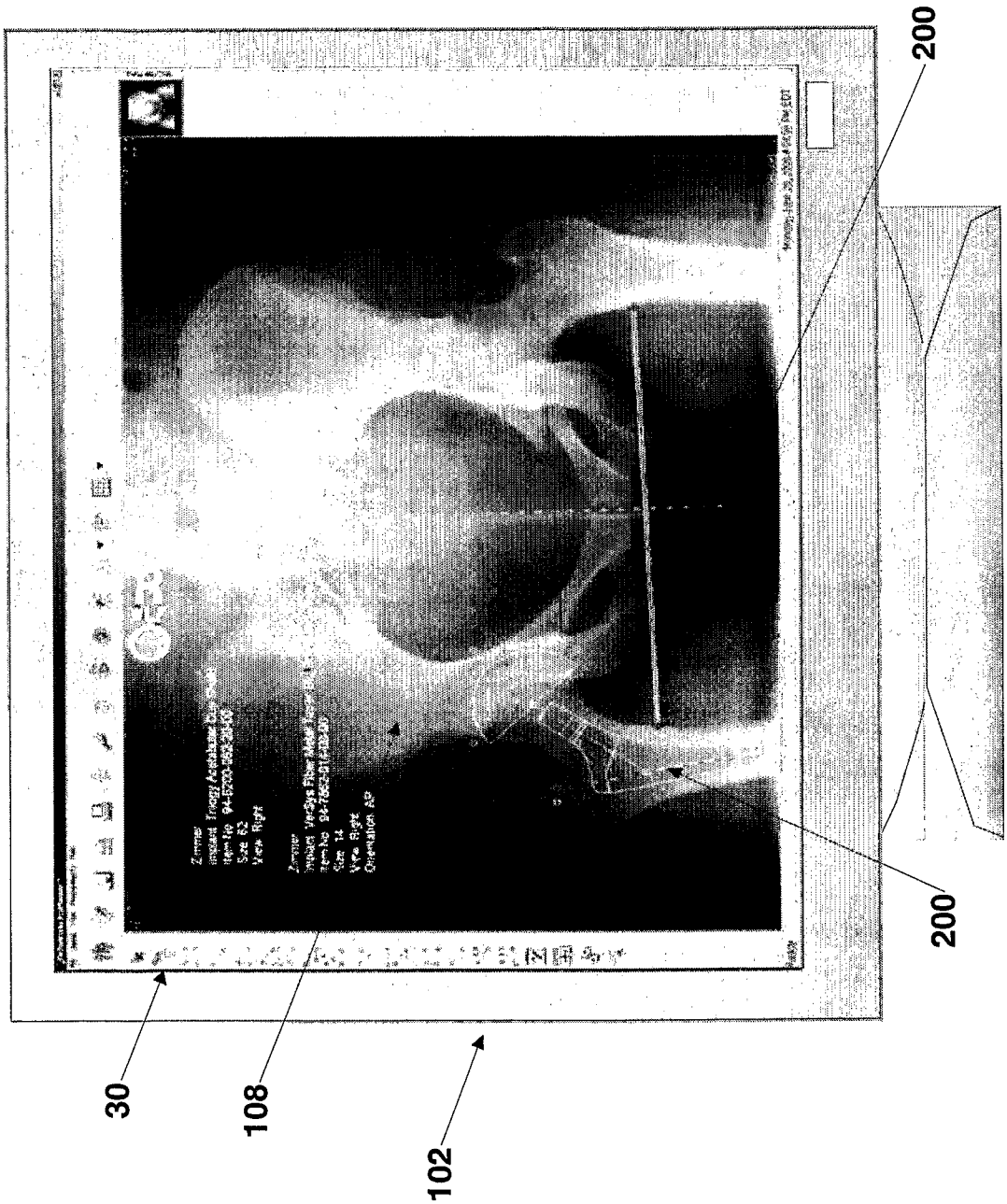


Figure 3a

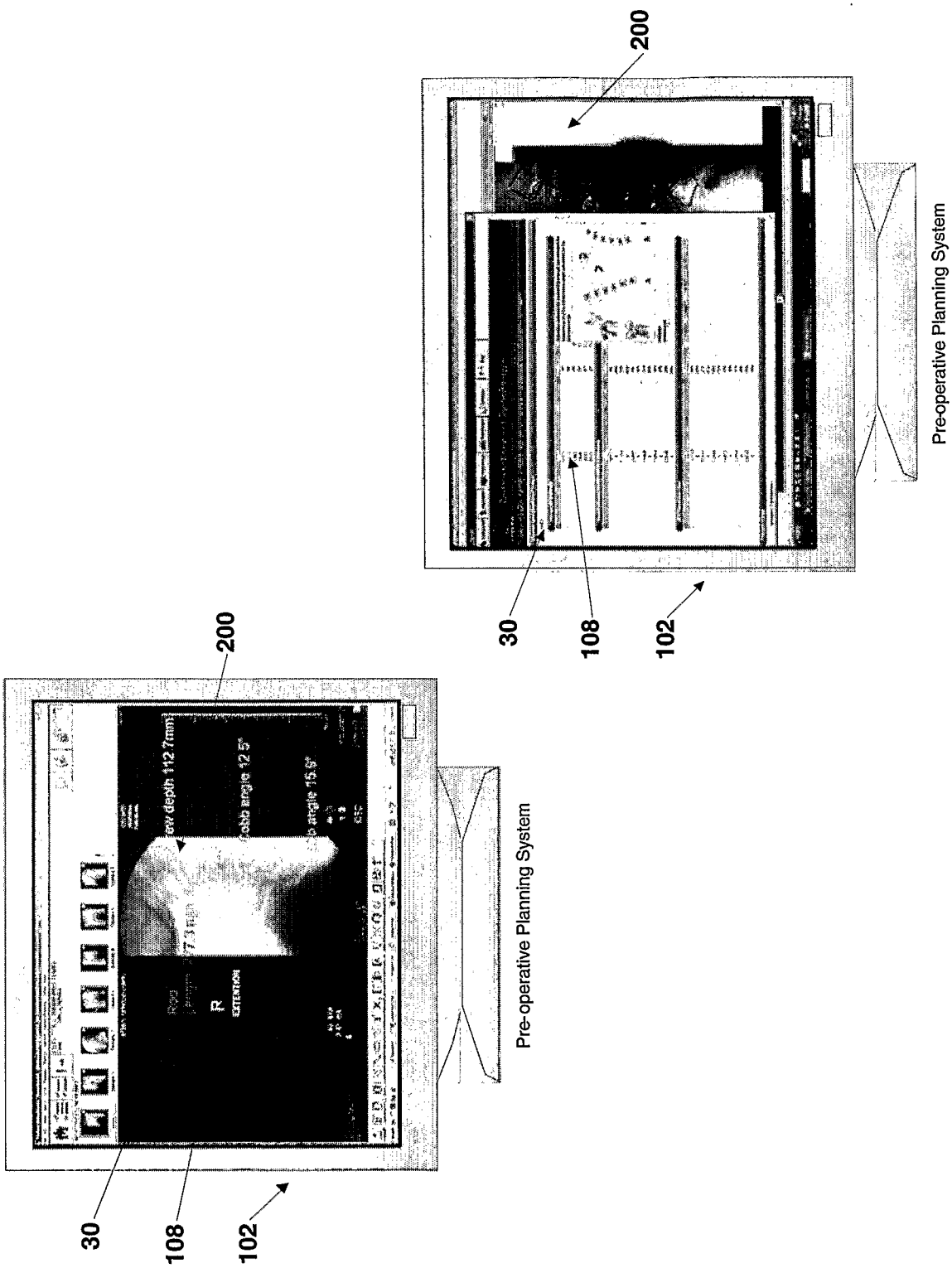

200
30
108
102
Pre-operative Planning System
200
30
108
102
Pre-operative Planning System

Figure 3b

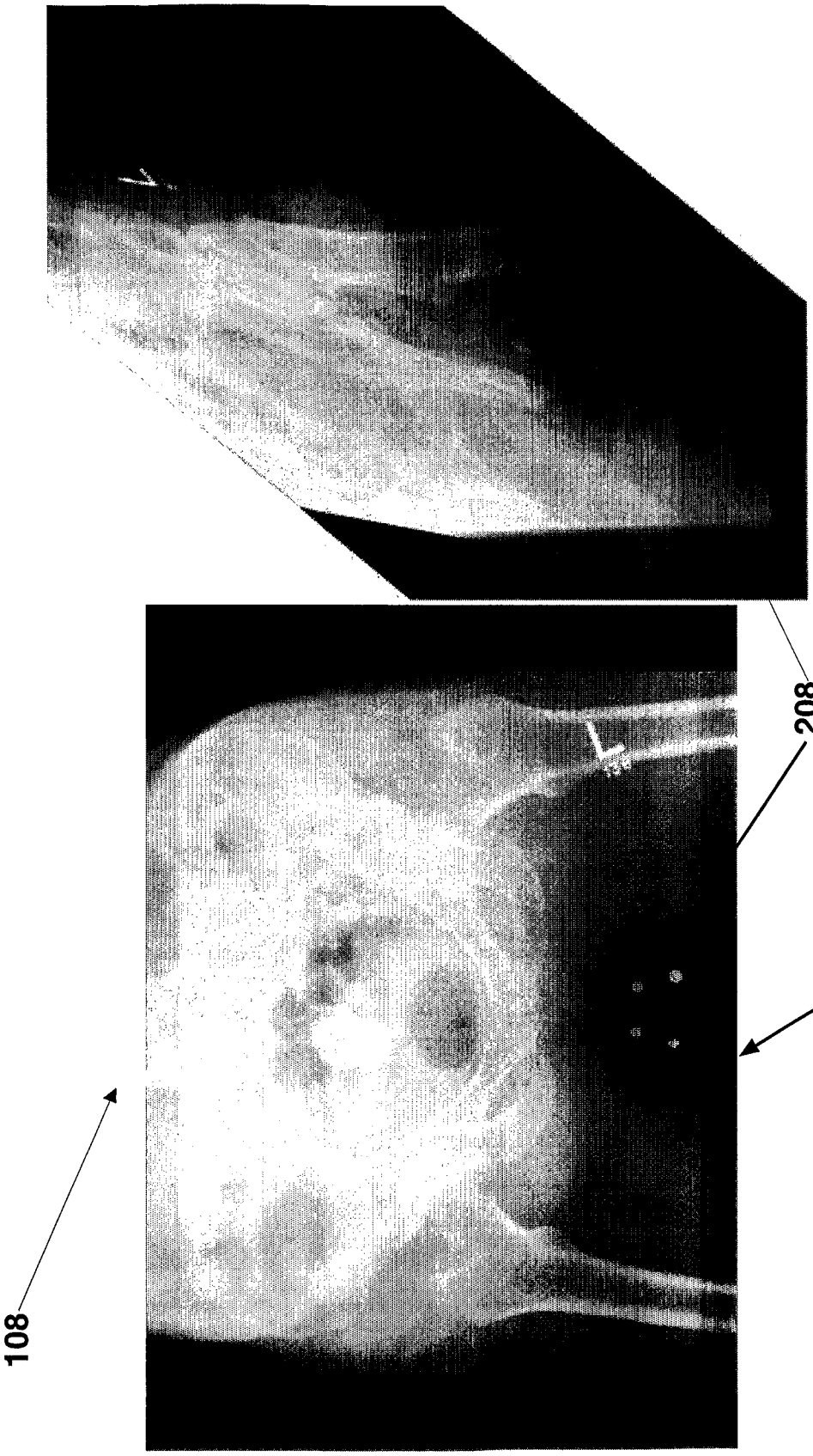
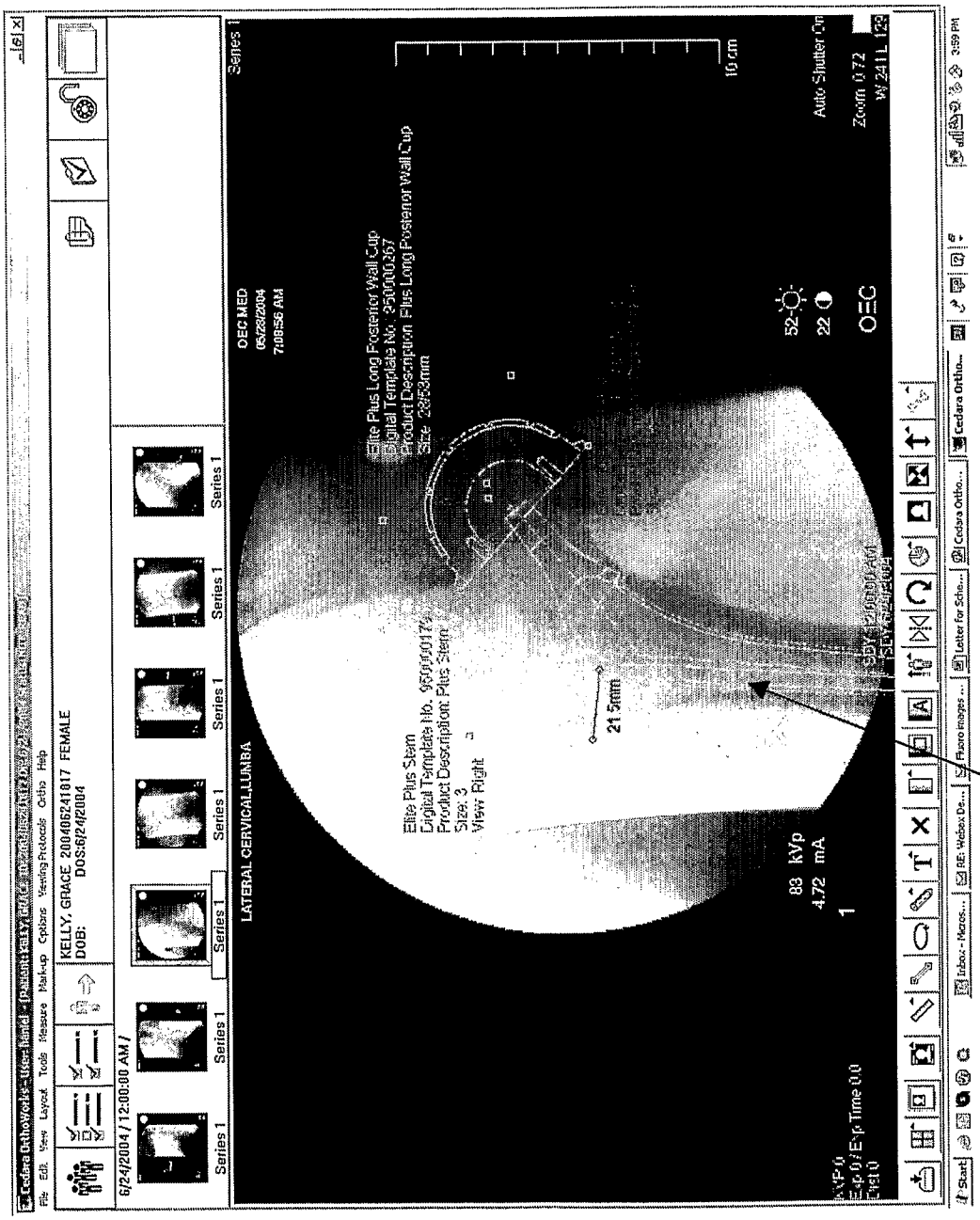


Figure 3c



200

108

Figure 4a

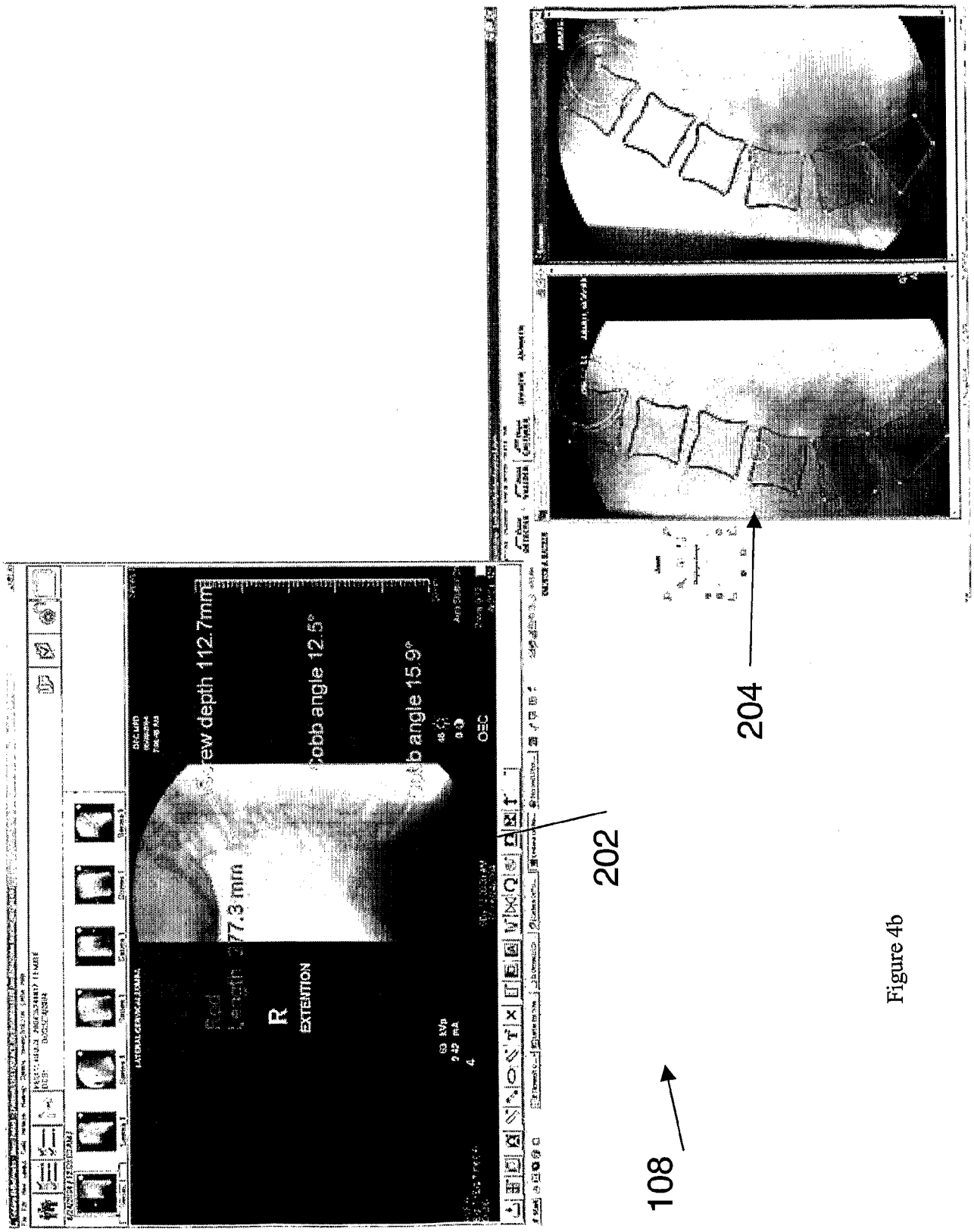

Screw depth 112.7mm
Cobb angle 12.5°
Cobb angle 15.9°
R
EXTENTION
202
204
108

Figure 4b

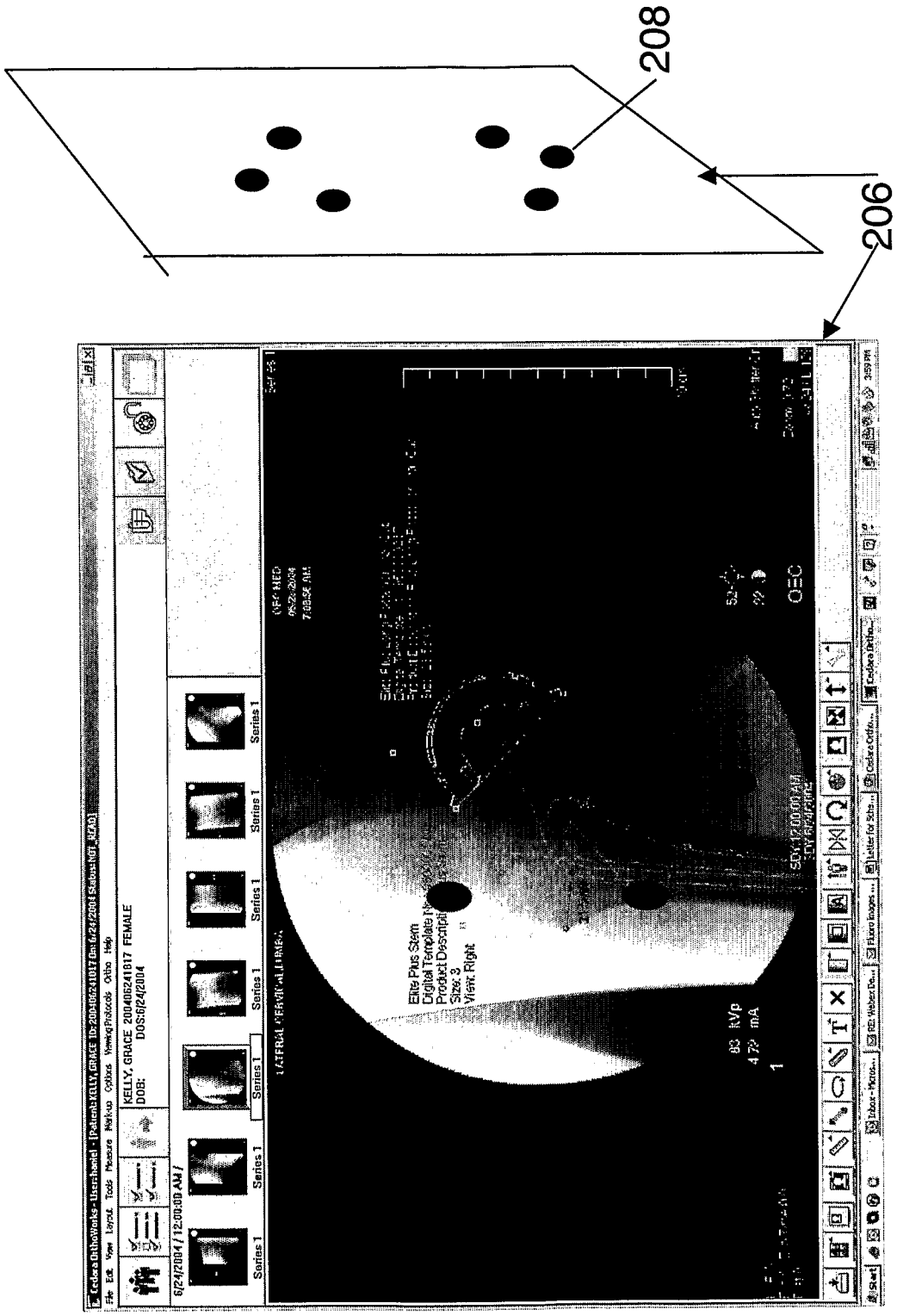


Figure 4c

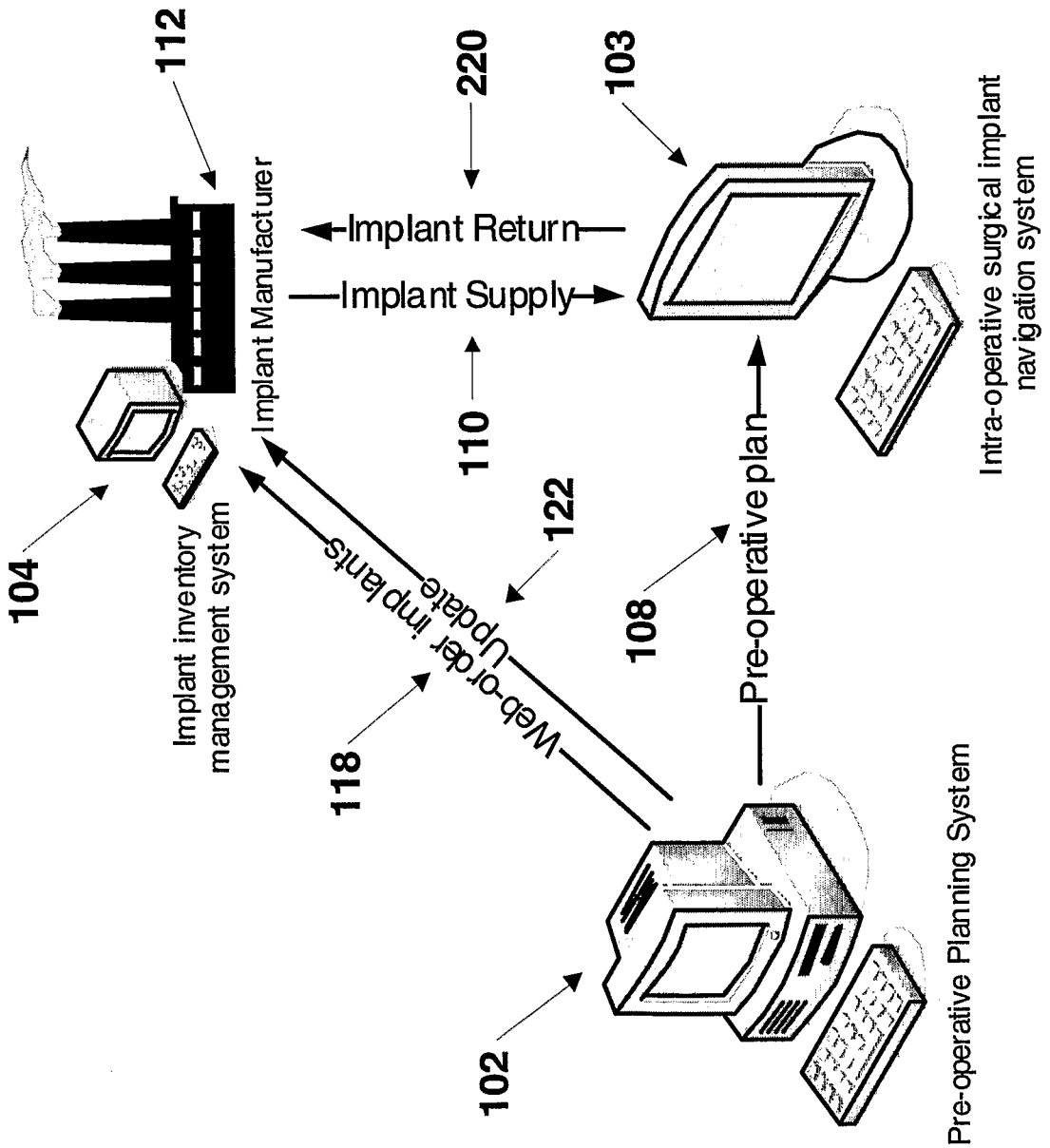

112
220
103
Implant Return
Implant Supply
Implant Manufacturer
Intra-operative surgical implant navigation system
104
110
122
108
Implant inventory management system
Web-order Update
Pre-operative plan
118
102
Pre-operative Planning System

Figure 5

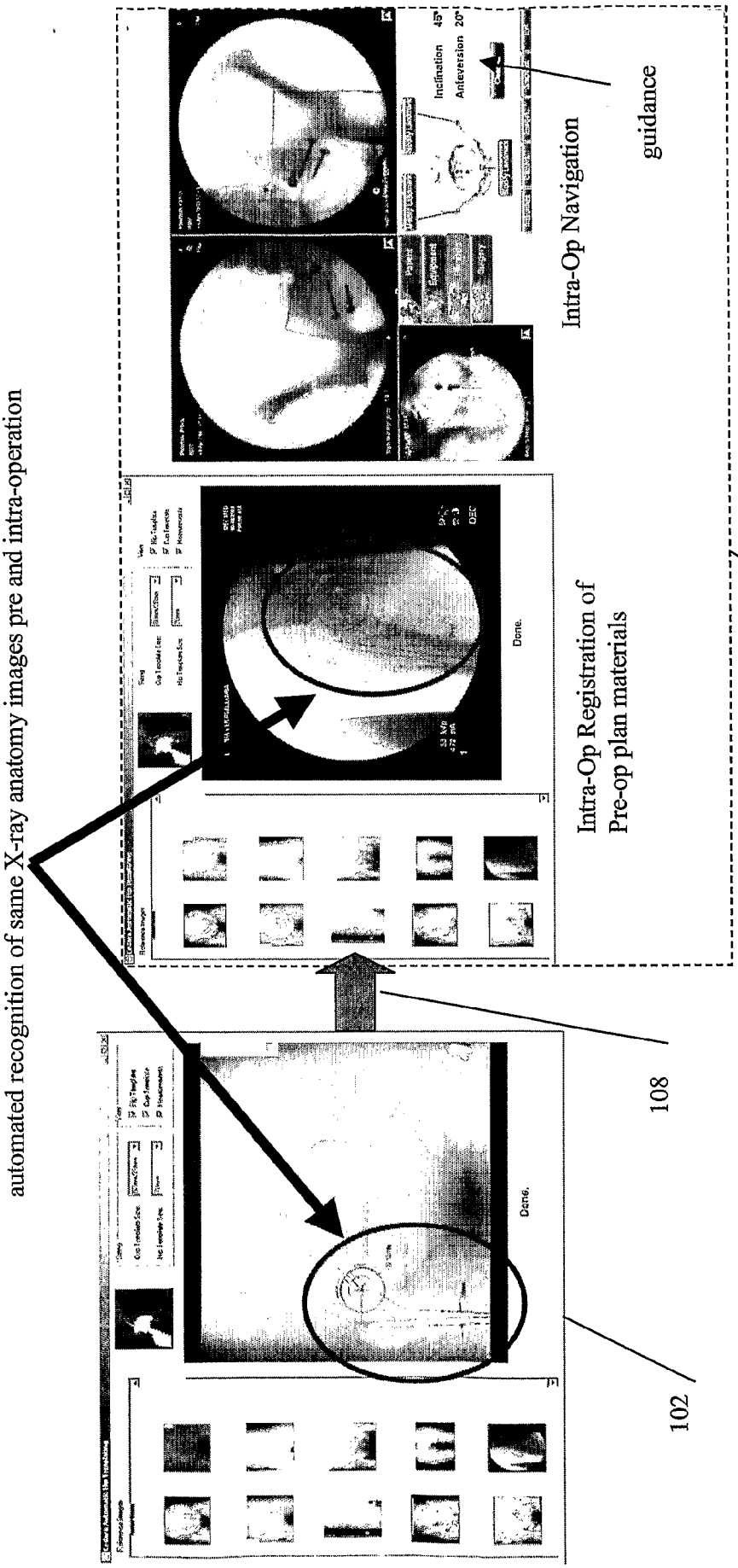

automated recognition of same X-ray anatomy images pre and intra-operation
Intra-Op Registration of
Pre-op plan materials
Intra-Op Navigation
guidance
Done.
Done.
Inclination 45°
Anteversion 20°
102
108
103

Figure 6

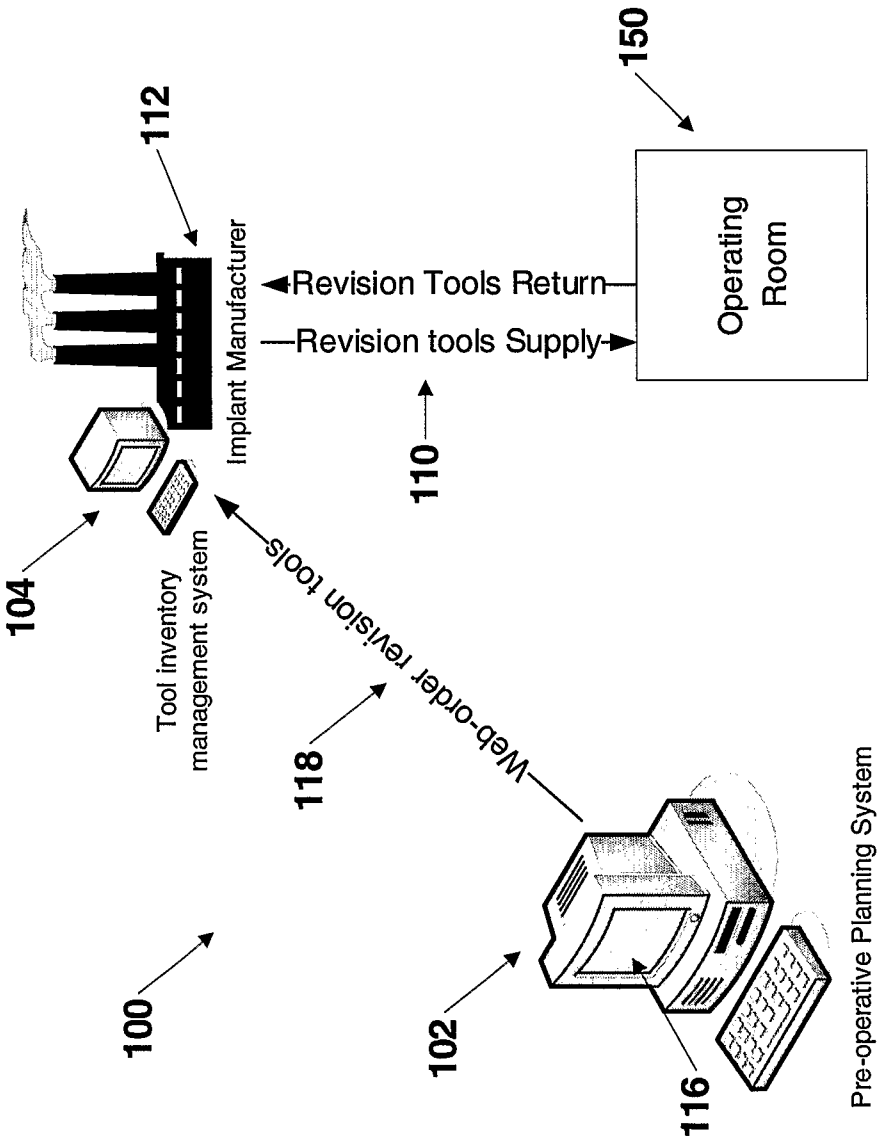

150
112
Implant Manufacturer
Revision Tools Return
Revision tools Supply
Operating Room
110
104
Tool inventory management system
Web-order revision tools
118
100
102
116
Pre-operative Planning System

Figure 7

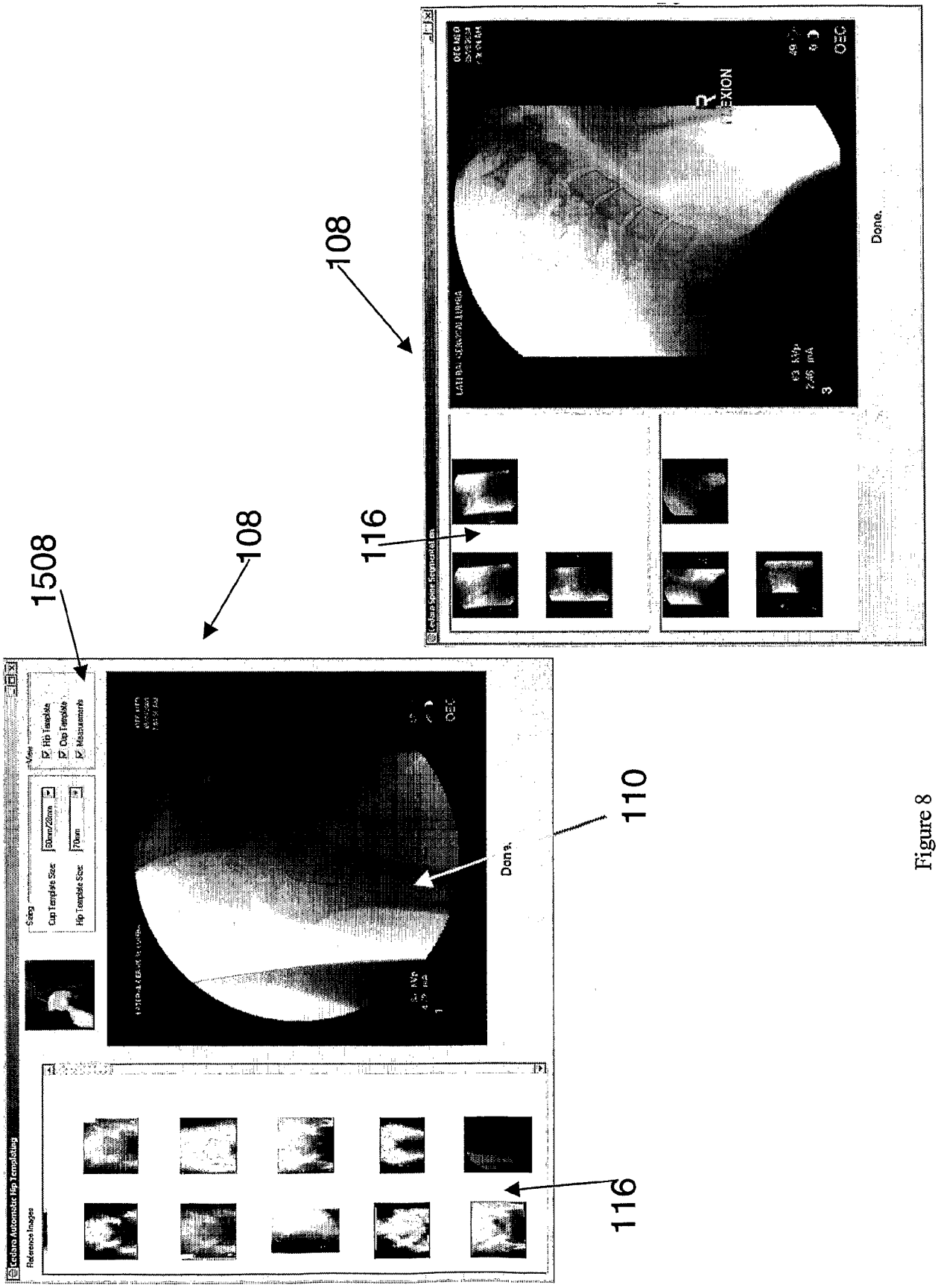


Figure 8

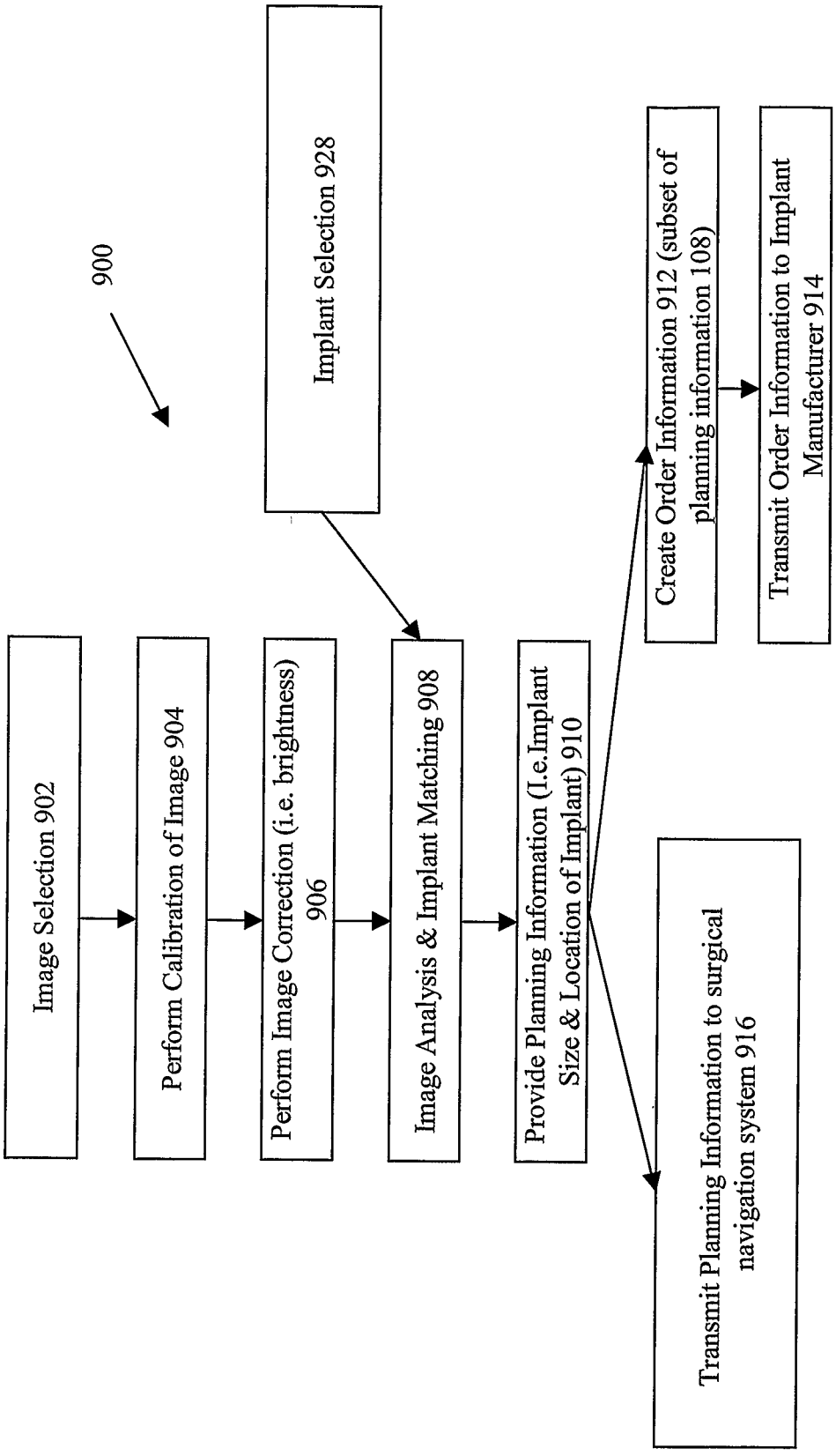

900
Image Selection 902
Perform Calibration of Image 904
Perform Image Correction (i.e. brightness) 906
Image Analysis & Implant Matching 908
Provide Planning Information (I.e.Implant Size & Location of Implant) 910
Implant Selection 928
Create Order Information 912 (subset of planning information 108)
Transmit Order Information to Implant Manufacturer 914
Transmit Planning Information to surgical navigation system 916

Figure 9

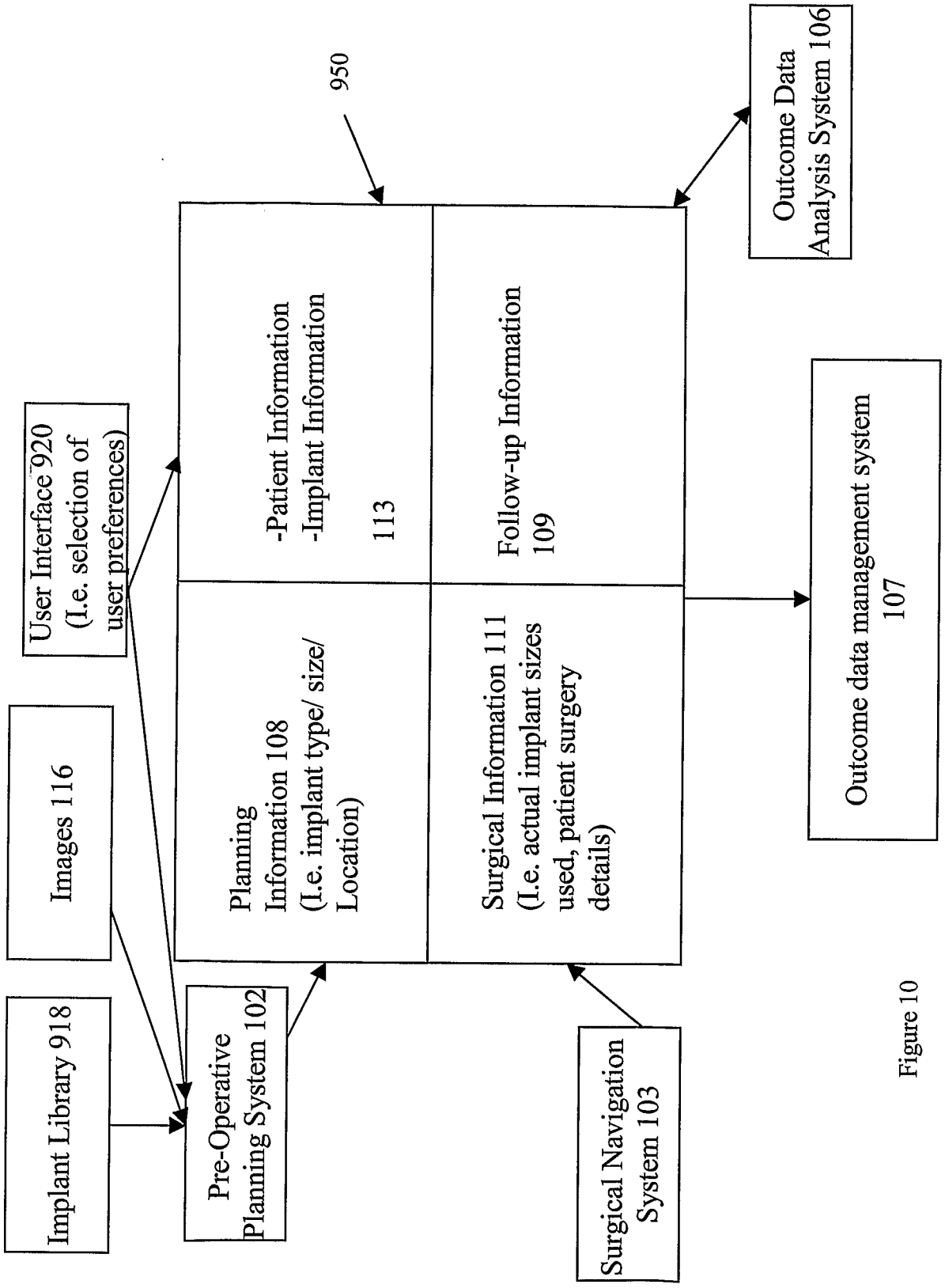
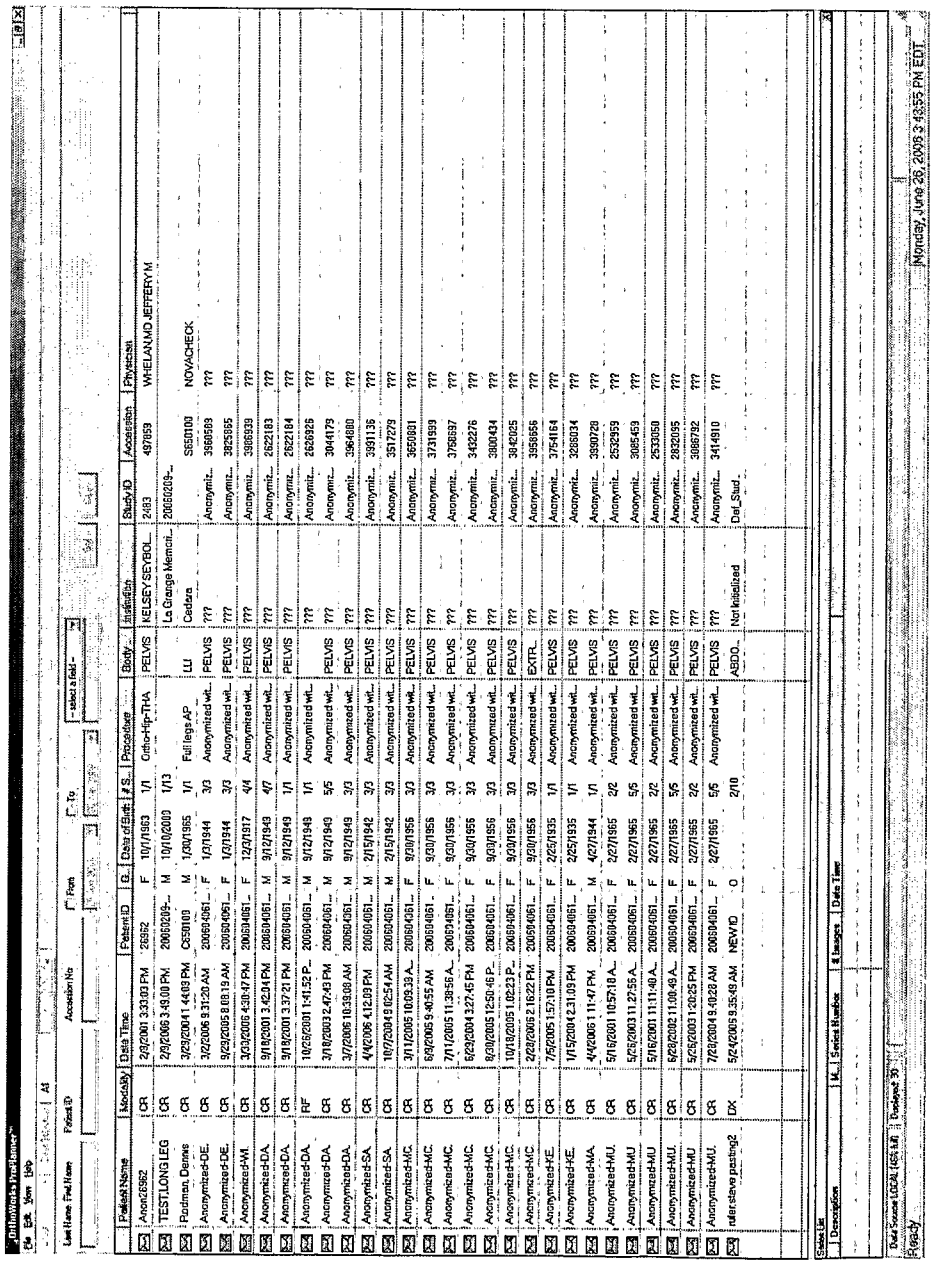
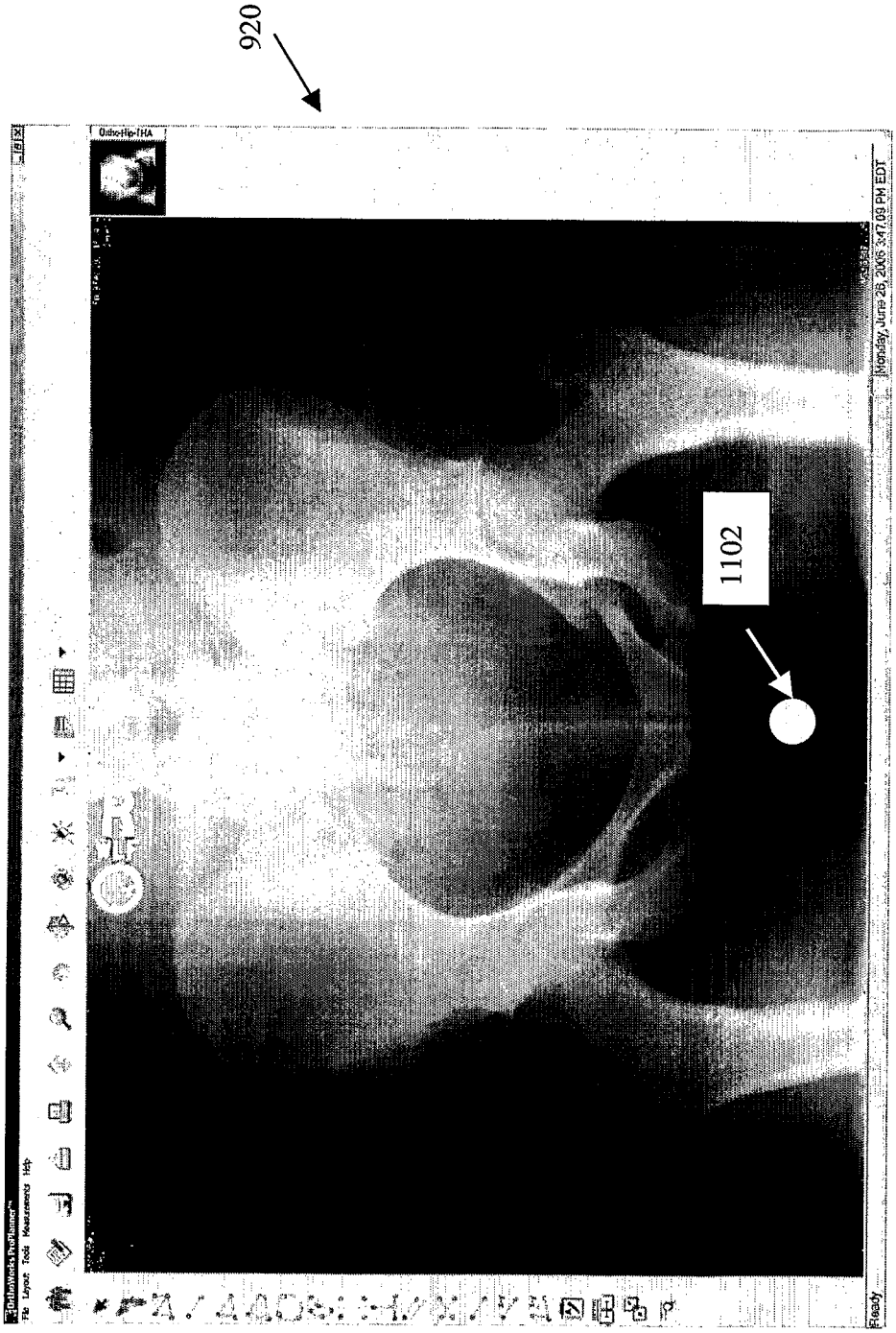

Implant Library 918
Images 116
User Interface 920 (I.e. selection of user preferences)
Pre-Operative Planning System 102
950
-Patient Information
-Implant Information
113
Planning Information 108 (I.e. implant type/ size/ Location)
Surgical Information 111 (I.e. actual implant sizes used, patient surgery details)
Follow-up Information 109
Surgical Navigation System 103
Outcome Data Analysis System 106
Outcome data management system 107

Figure 10



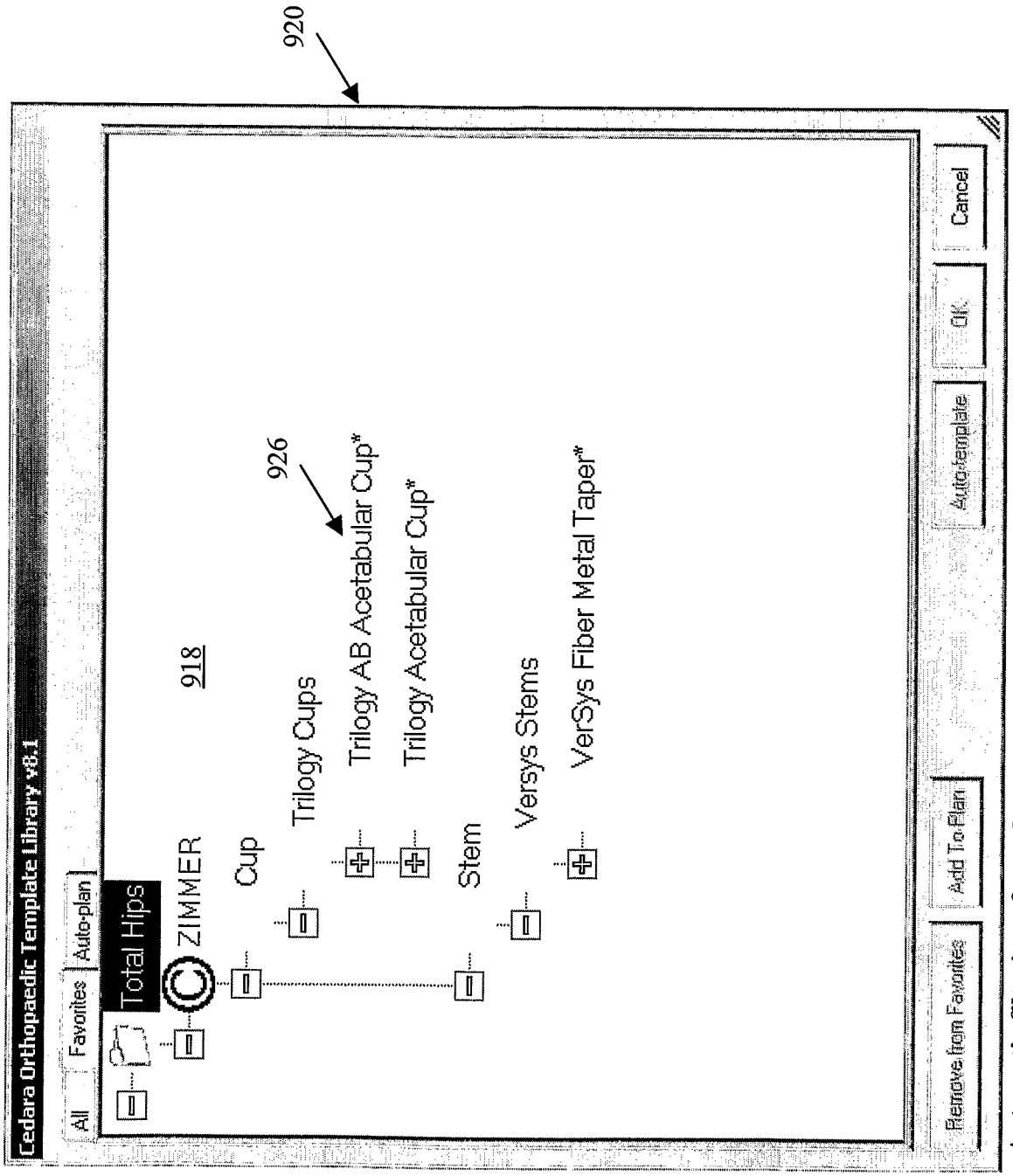
Patient and Study selection

Figure 11a



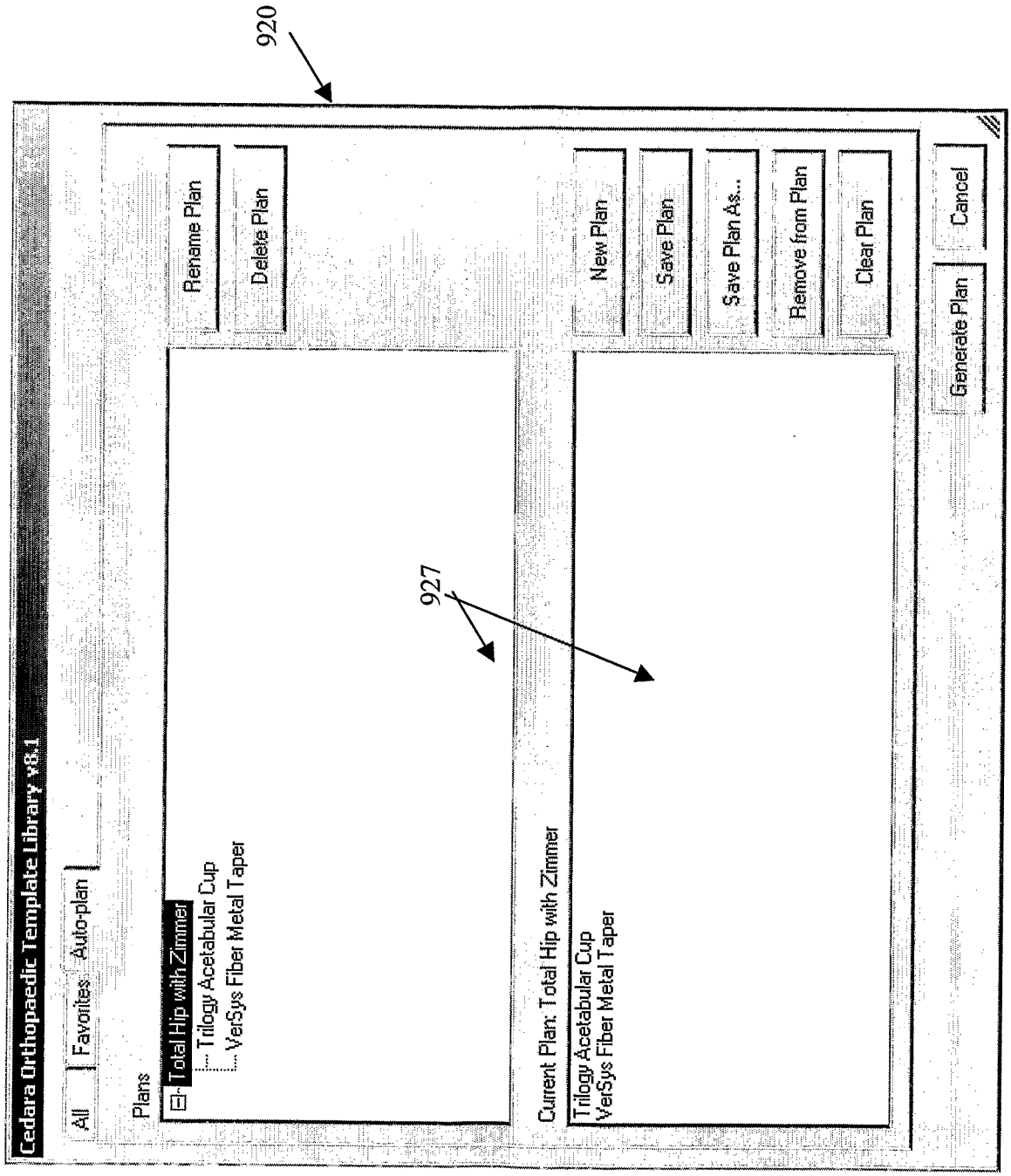
Images loaded when study is selected.

Figure 11b



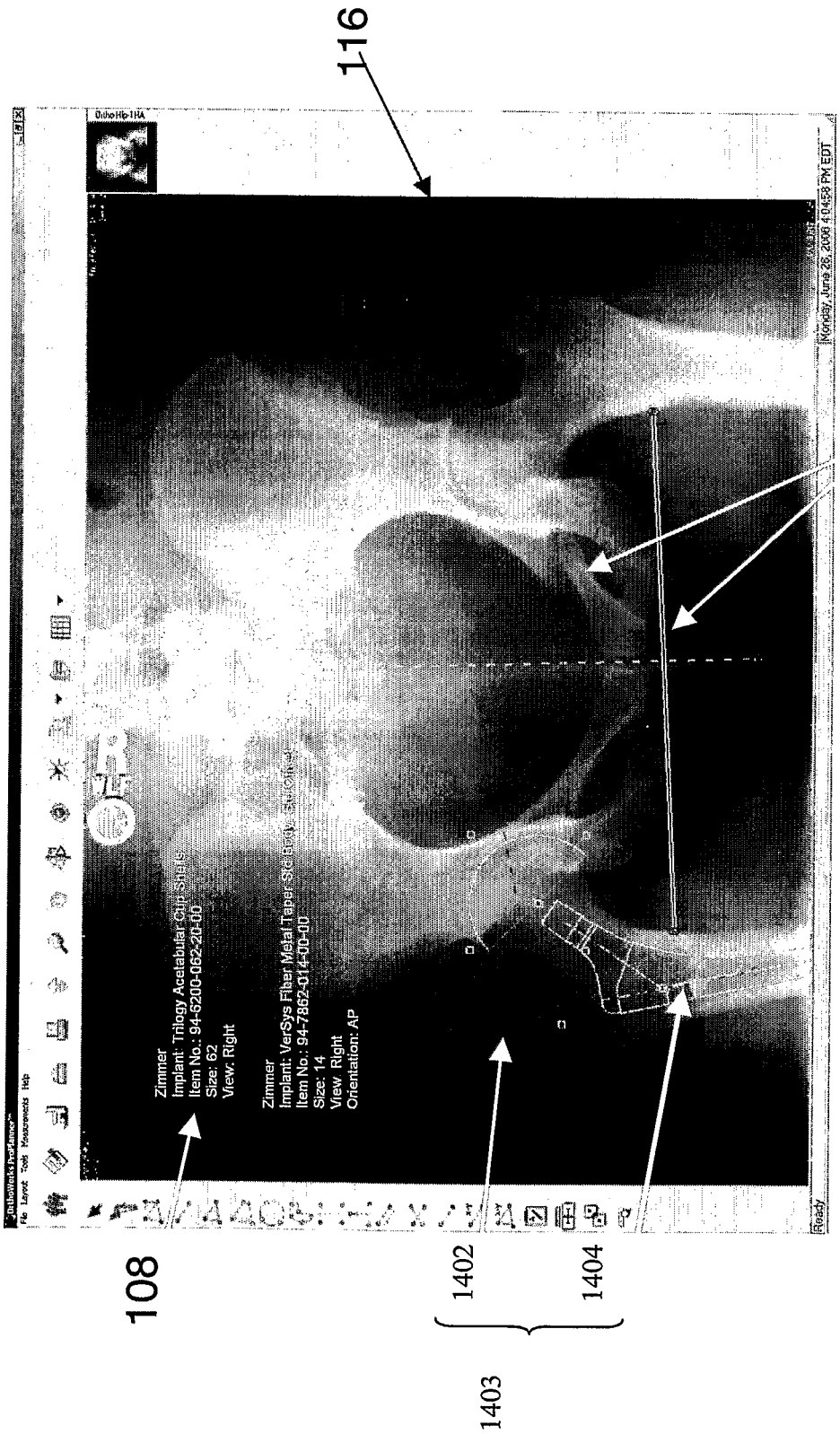
Automatic filtering of templates according to user preferences

Figure 12



Automatic Plans save time in creating a preoperative plan

Figure 13



Automatic templating performed on a pelvic image 108

Figure 14

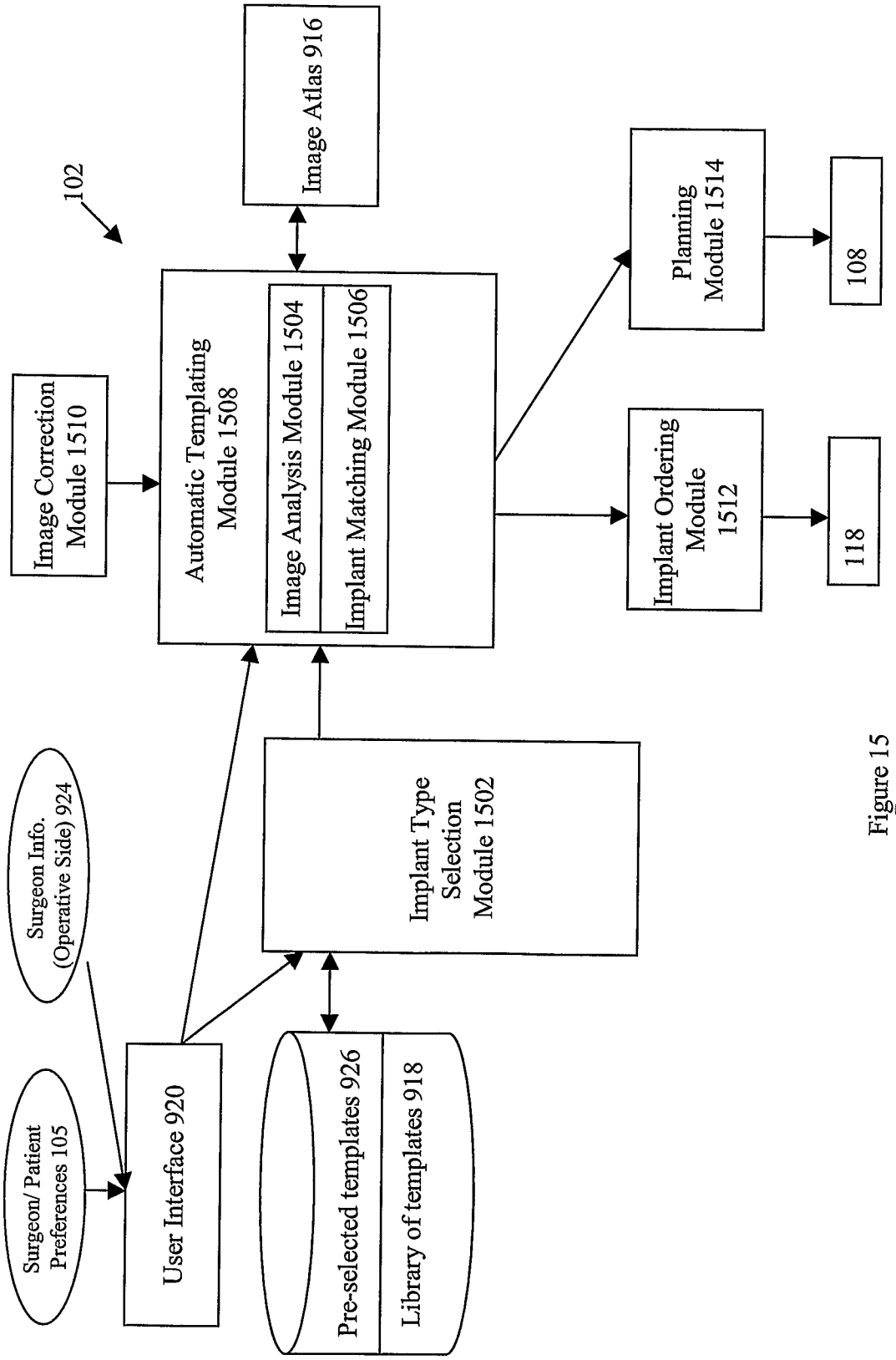

102
Image Atlas 916
Image Correction Module 1510
Automatic Templating Module 1508
Image Analysis Module 1504
Implant Matching Module 1506
Planning Module 1514
108
Implant Ordering Module 1512
118
Surgeon Info. (Operative Side) 924
Implant Type Selection Module 1502
Surgeon/ Patient Preferences 105
User Interface 920
Pre-selected templates 926
Library of templates 918

Figure 15

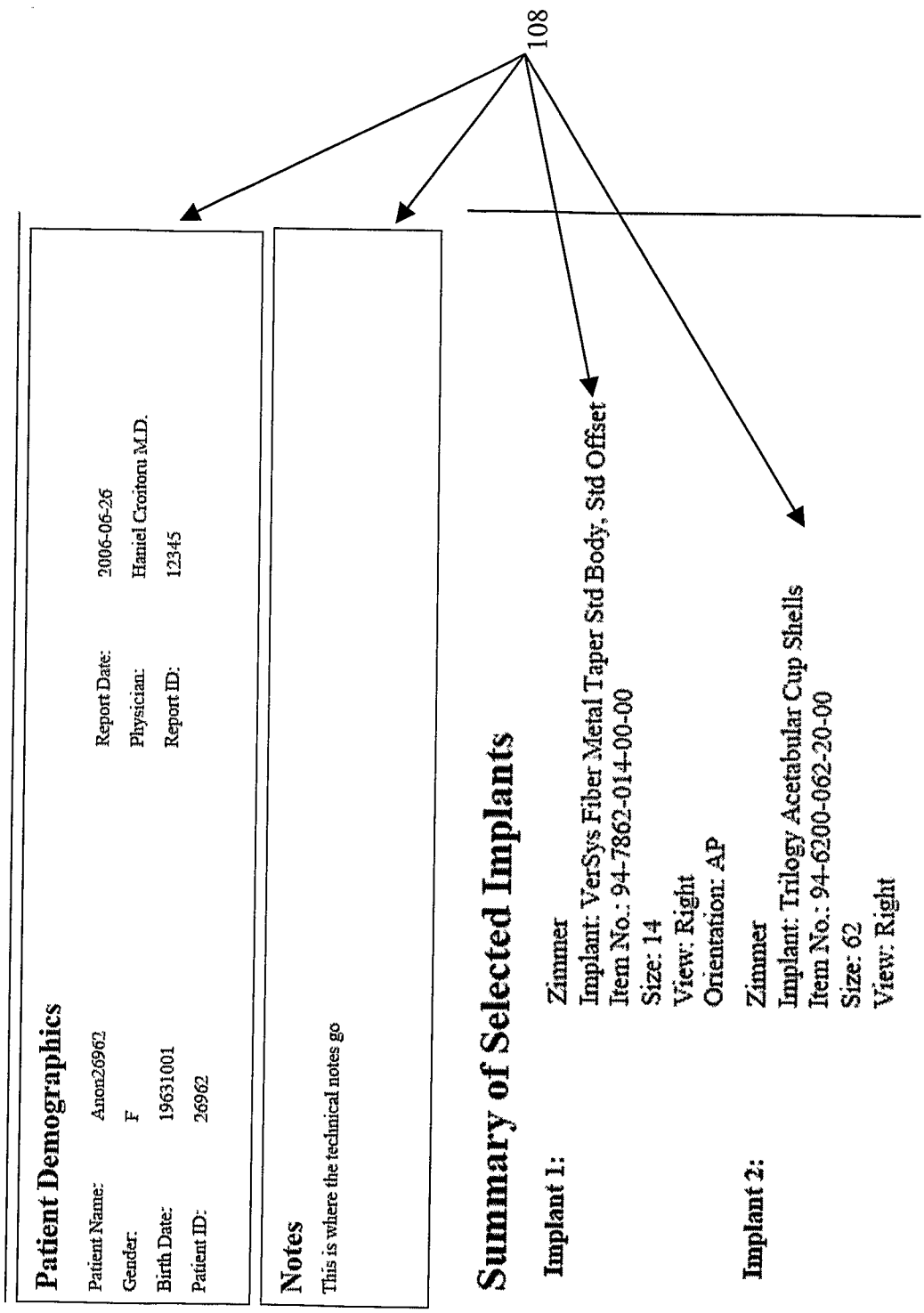

108
Patient Demographics
Patient Name: Anon26962
Gender: F
Birth Date: 19631001
Patient ID: 26962
Report Date: 2006-06-26
Physician: Haniel Croitoru M.D.
Report ID: 12345
Notes
This is where the technical notes go
Summary of Selected Implants
Implant 1:
Zimmer
Implant: VerSys Fiber Metal Taper Std Body, Std Offset
Item No.: 94-7862-014-00-00
Size: 14
View: Right
Orientation: AP
Implant 2:
Zimmer
Implant: Trilogy Acetabular Cup Shells
Item No.: 94-6200-062-20-00
Size: 62
View: Right

Figure 16a

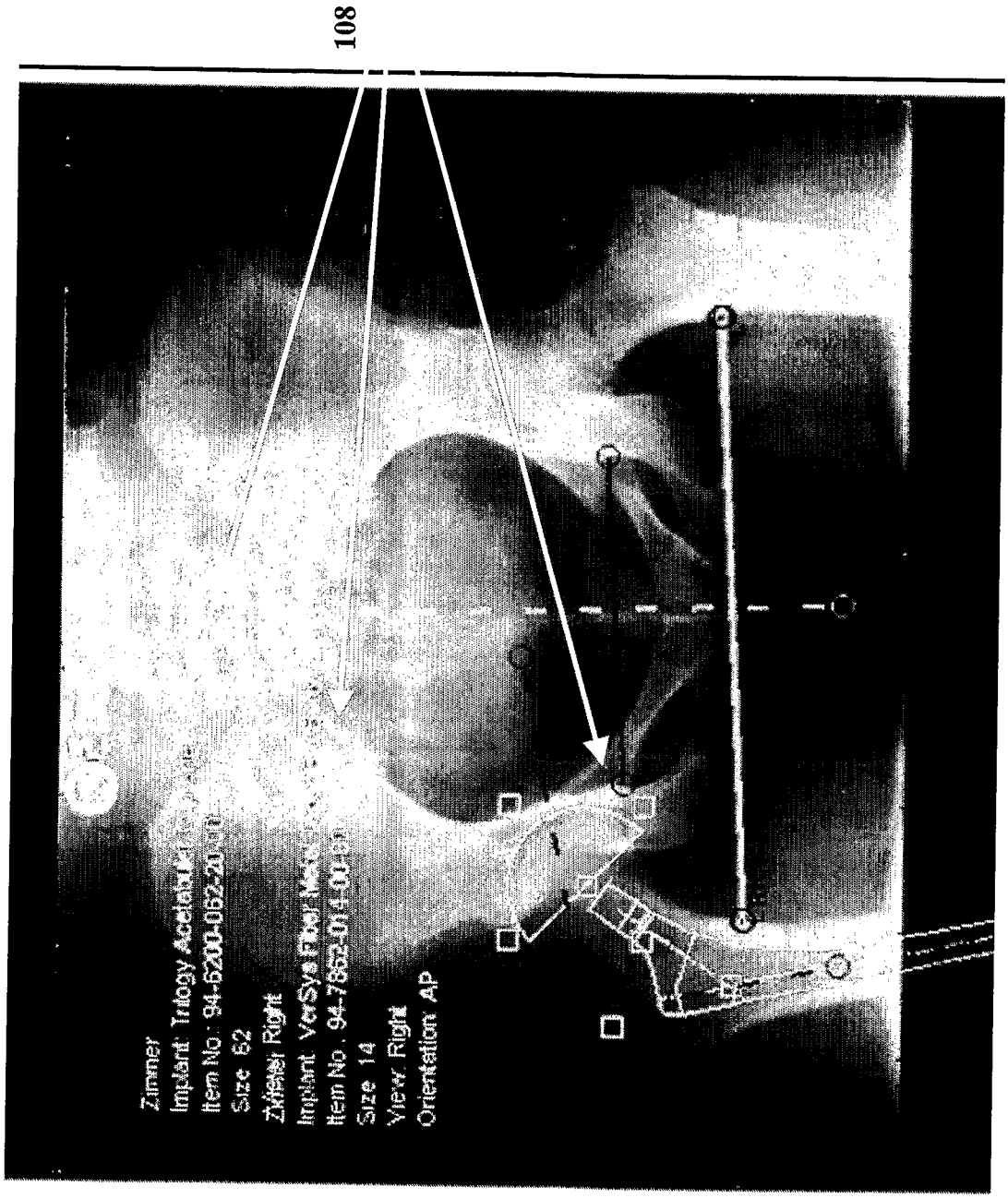

108
Zimmer
Implant: Trilogy Acetabul
Item No.: 94-6200-062-20
Size: 62
Zimmer Right
Implant: VerSys Fiber Met
Item No.: 94-7852-014-00
Size: 14
View: Right
Orientation: AP

Figure 16b

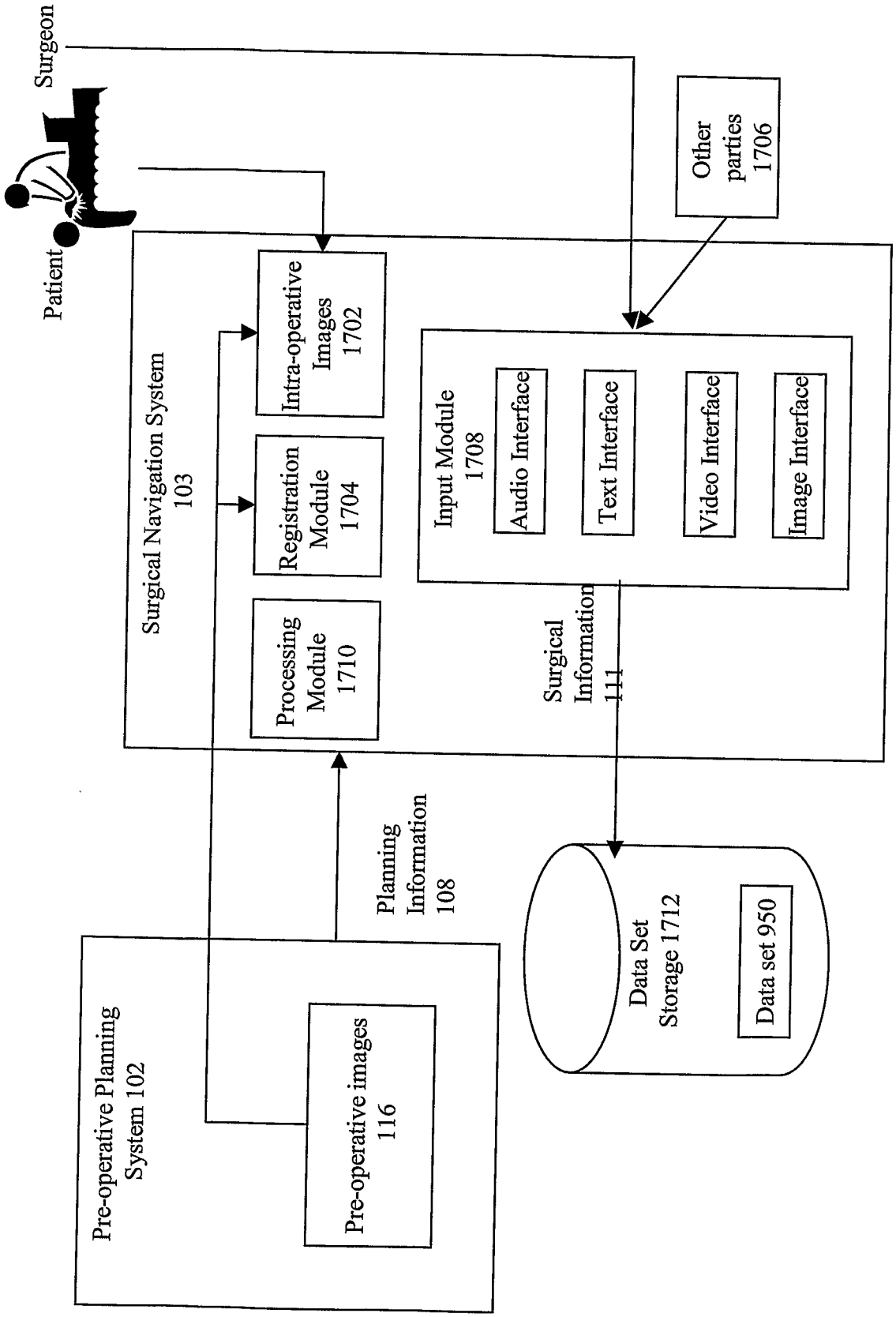

Surgeon
Patient
Other parties 1706
Surgical Navigation System 103
Intra-operative Images 1702
Registration Module 1704
Processing Module 1710
Input Module 1708
Audio Interface
Text Interface
Video Interface
Image Interface
Surgical Information 111
Planning Information 108
Pre-operative Planning System 102
Pre-operative images 116
Data Set Storage 1712
Data set 950

Figure 17

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2006/001215

A. CLASSIFICATION OF SUBJECT MATTER
IPC: ***A61B 19/00*** (2006.01) , ***A61B 6/00*** (2006.01) , ***A61G 99/00*** (2006.01) , ***G06Q 10/00*** (2006.01) , ***G06Q 50/00*** (2006.01) , *A61F 2/02* (2006.01)
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)
IPC: A61B*; A61B 19/00; A61B 6/00; A61G 99/00; G06Q 10/00; G06Q 8/00; A61F 2/02
US Classifications: 600/473; 600/*

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

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
CPD: A61B 19/00; data
Delphion: classifications (as above); implant, plan*, data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	US 2002/0115934 A1 (TUKE, M.) 22 Aug 2002 (22-08-2002) -whole document	21-29 1-20
A	US 6370418 B1 (BERNOSKI, F.) 9 Apr 2002 (09-04-2002) -whole document	1-29
A	US 6711432 B1 (KRAUSE, N. et al) 23 Mar 2004 (23-03-2004) -abstract; columns 4-11, 18	1-29

[ ] Further documents are listed in the continuation of Box C.

[X] 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 application or patent 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	Date of mailing of the international search report
13 October 2006 (13-10-2006)	17 November 2006 (17-11-2006)

Name and mailing address of the ISA/CA	Authorized officer
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	Elizabeth Matthes 819-934-3468

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CA2006/001215

Patent Document Cited in Search Report	Publication Date	Patent Family Member(s)	Publication Date
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		NL1005565C C2	24-09-1998
		WO9841152 A1	24-09-1998
US6711432	23-03-2004	AU3086402 A	21-05-2002
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		JP2003530177T T	14-10-2003
		US6701174 B1	02-03-2004
		US2004039259 A1	26-02-2004
		US2004068187 A1	08-04-2004
		WO0178015 A2	18-10-2001
		WO0237935 A2	16-05-2002