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(54) **ANATOMICAL MODELS AND ASSOCIATED METHODS FOR EVALUATING COMPRESSION**

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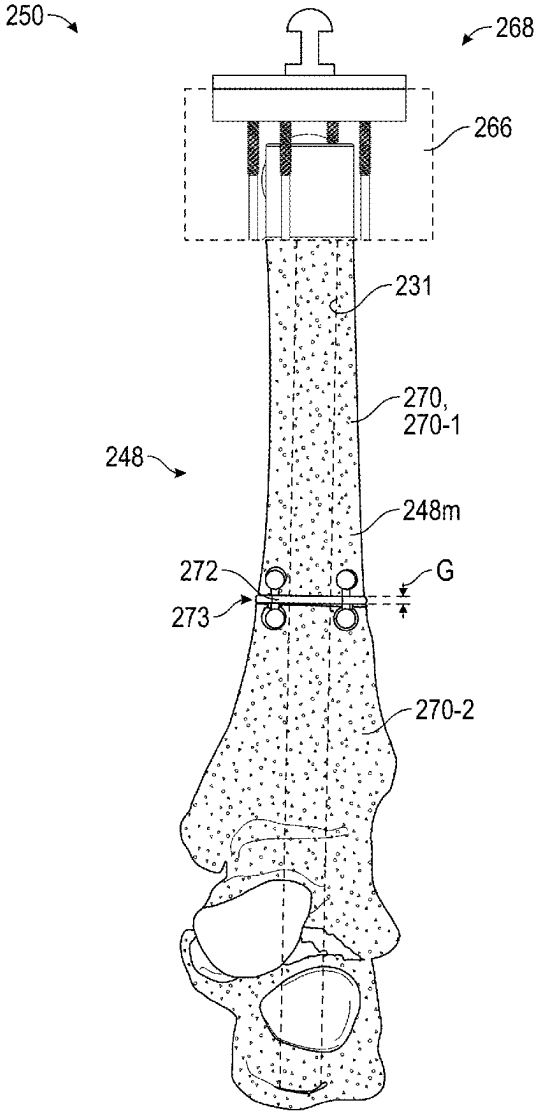
(52) **U.S. Cl.**

CPC ***G09B 23/34*** (2013.01); ***A61B 17/72*** (2013.01); *A61B 2017/00716* (2013.01)

(57) **ABSTRACT**

This disclosure relates to surgical systems, devices and methods for planning and implementing surgical procedures. The systems and methods disclosed herein may be utilized to establish physical anatomical models of anatomy. A compression feature may be utilized to evaluate compression between portions of the physical anatomical model.



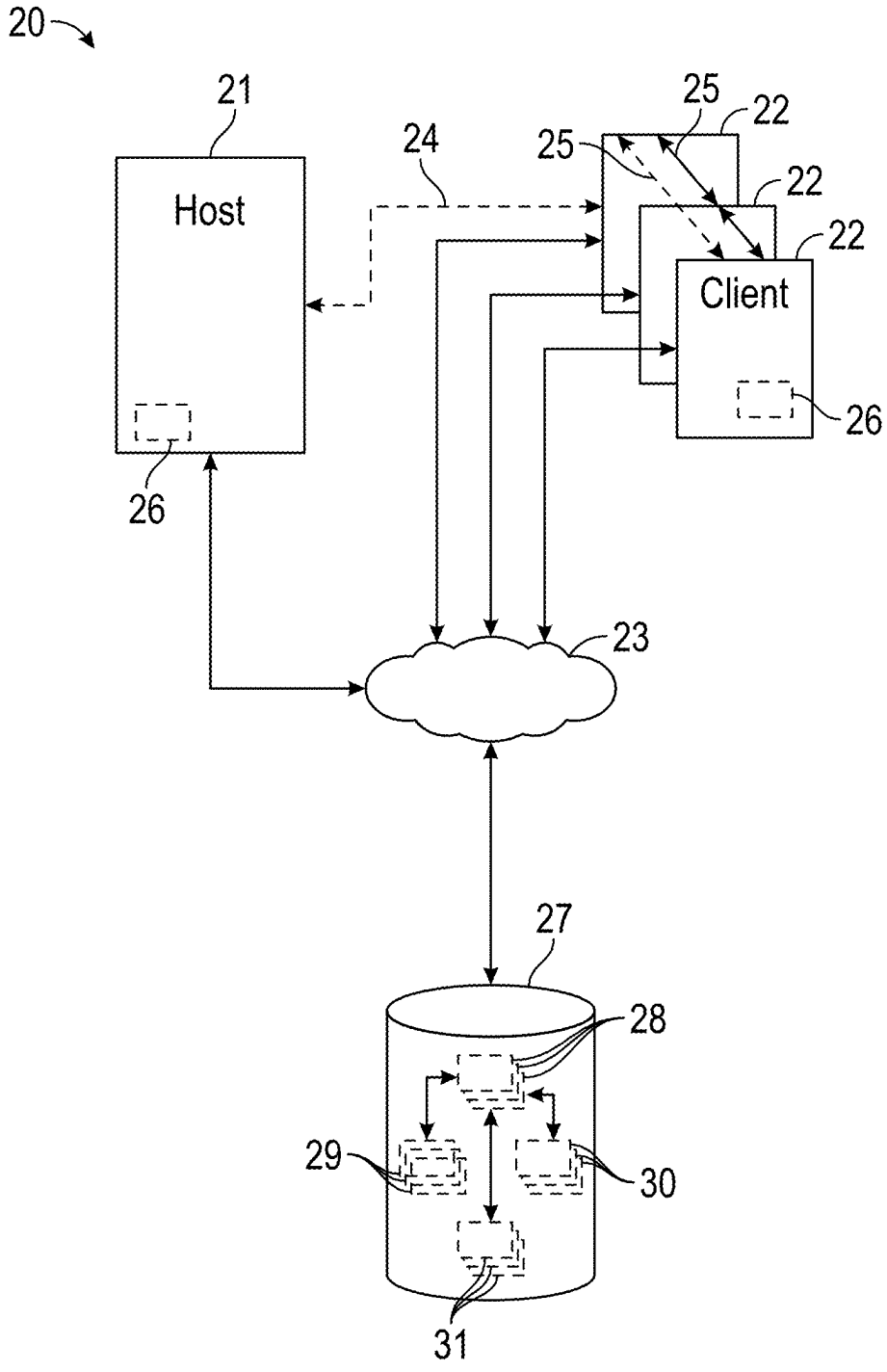
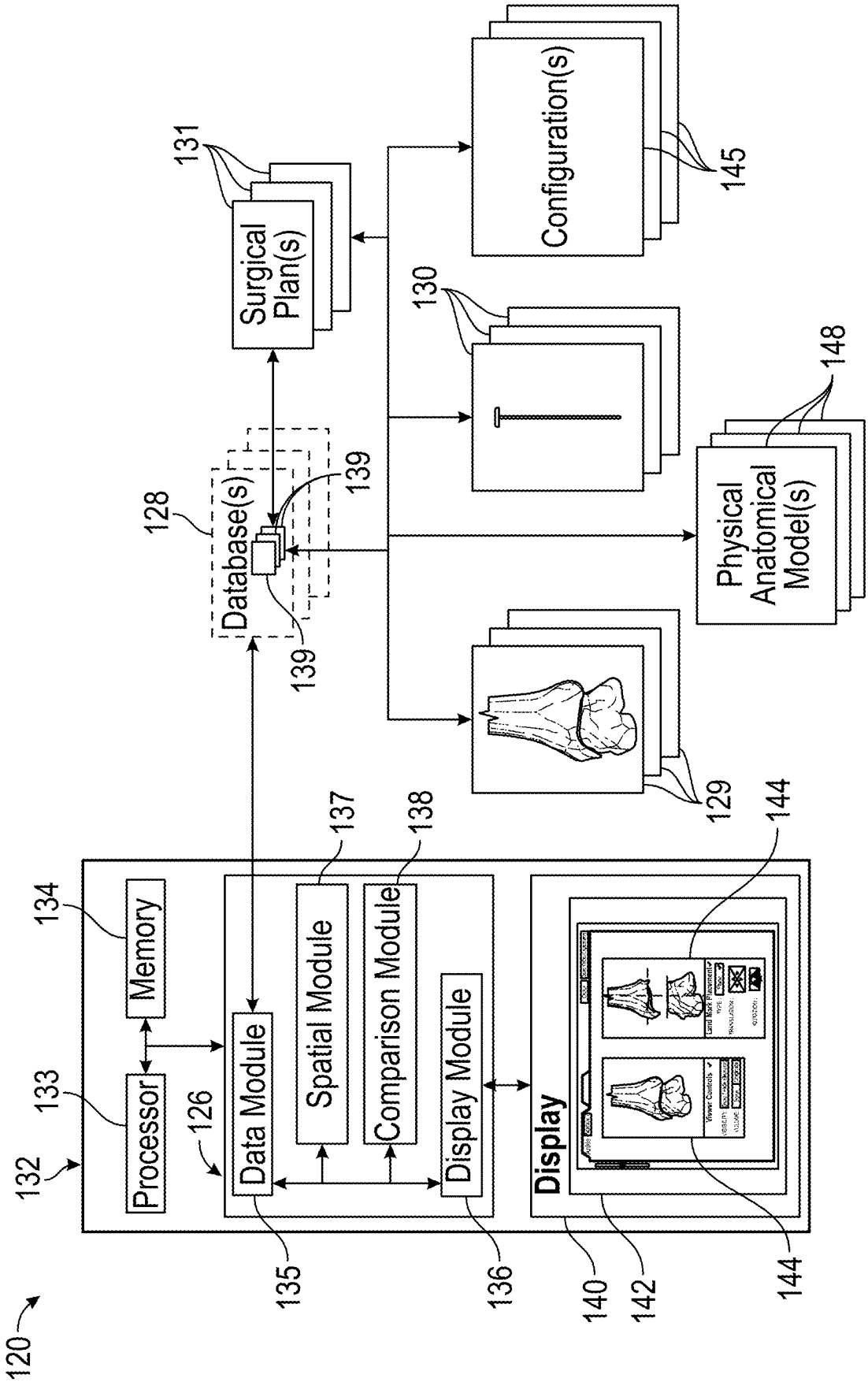


FIG. 1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132
133
134
Memory
Processor
126
Data Module
Spatial Module
Comparison Module
Display Module
135
136
137
138
Display
140
142
144
144
129
130
131
Surgical Plan(s)
Configuration(s)
145
148
Physical Anatomical Model(s)
128
Database(s)
139
139

FIG. 2

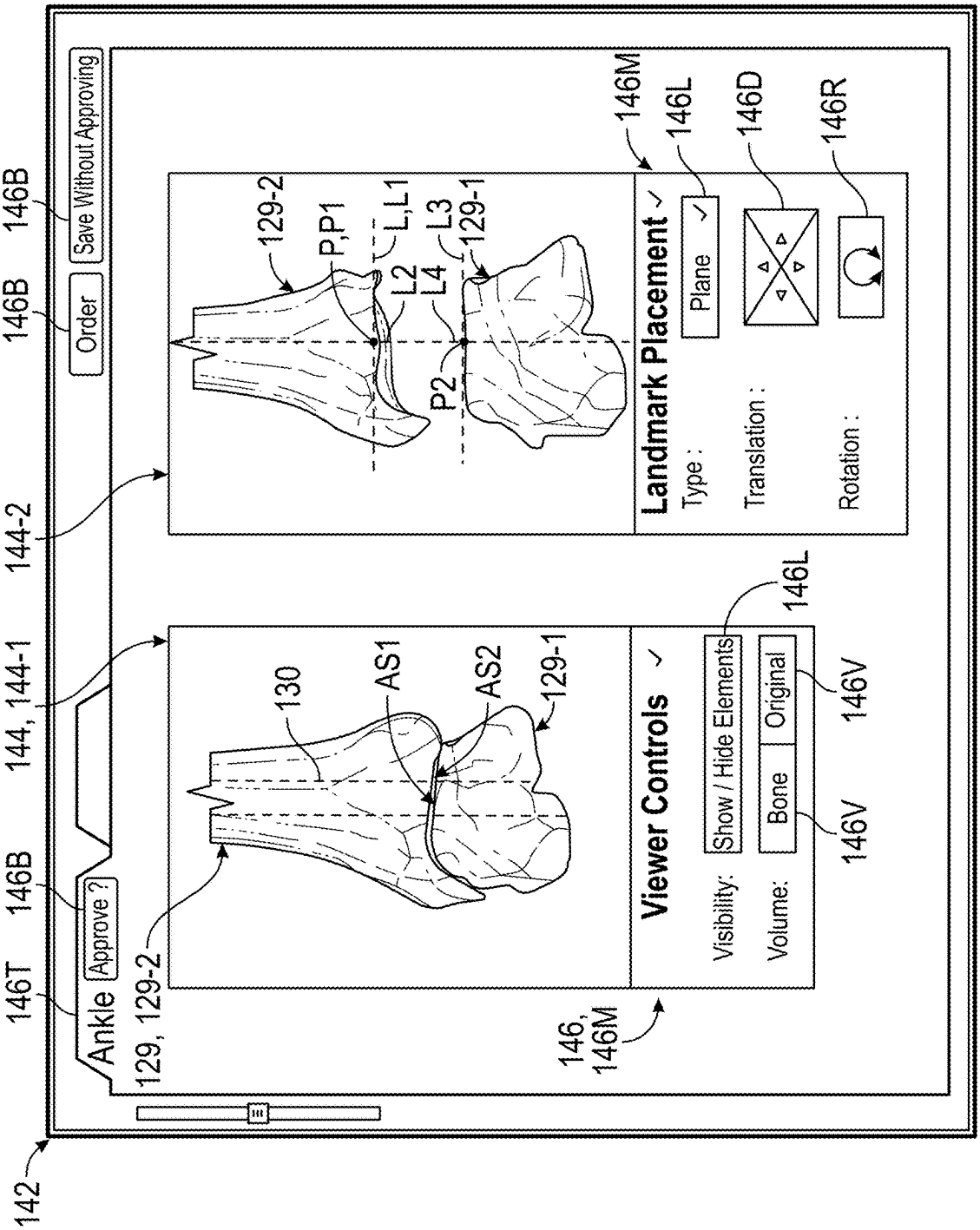

142
146T
Ankle
146B
Approve ?
144, 144-1
129, 129-2
130
AS1
AS2
129-1
146, 146M
Viewer Controls
Visibility:
Show / Hide Elements
146L
Volume:
Bone
Original
146V
146V
144-2
146B
Order
146B
Save Without Approving
129-2
P,P1
L,L1
L2
L4
L3
129-1
P2
146M
Landmark Placement
146L
Type :
Plane
146D
Translation :
146R
Rotation :

FIG. 3

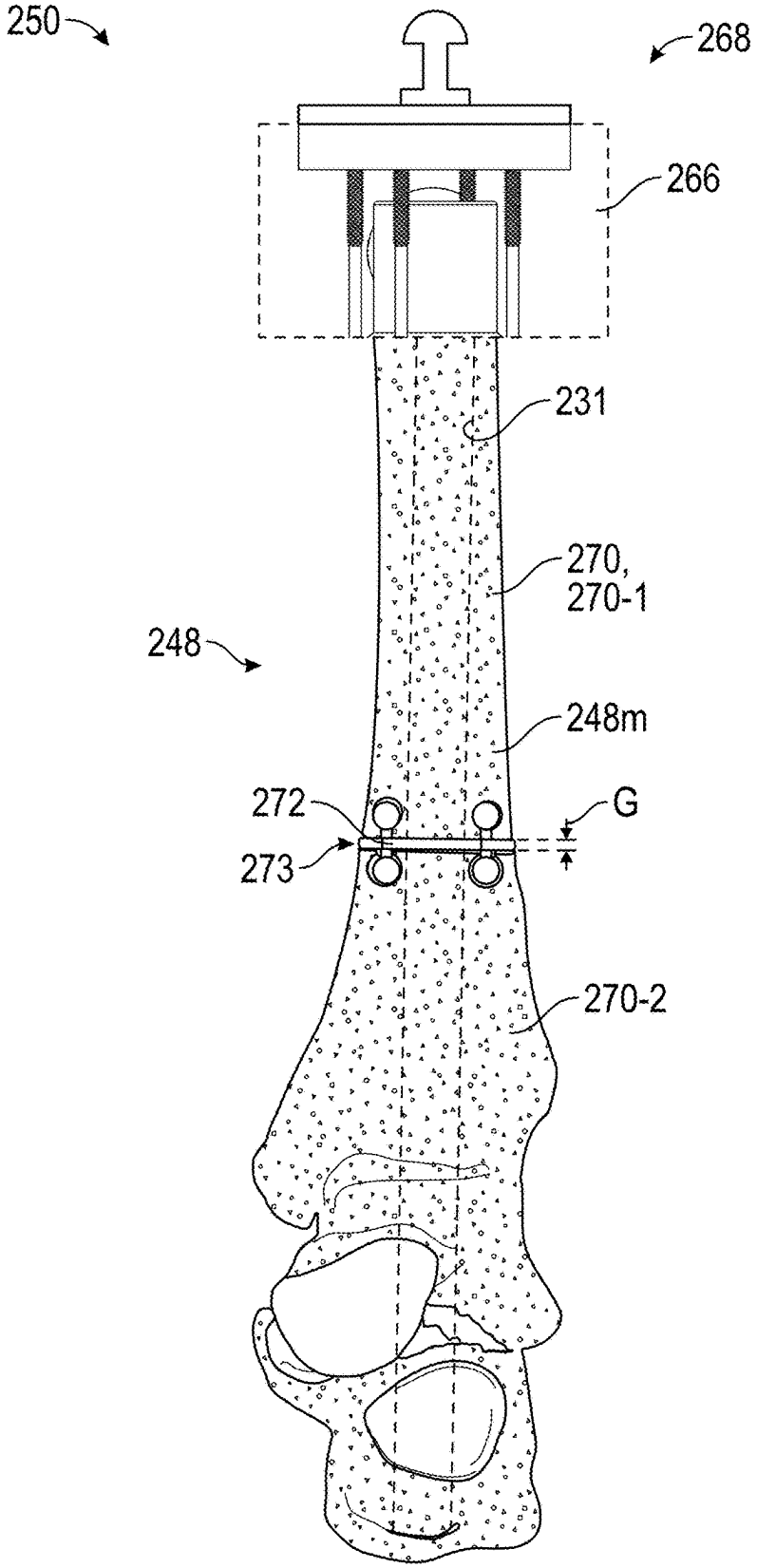


FIG. 4

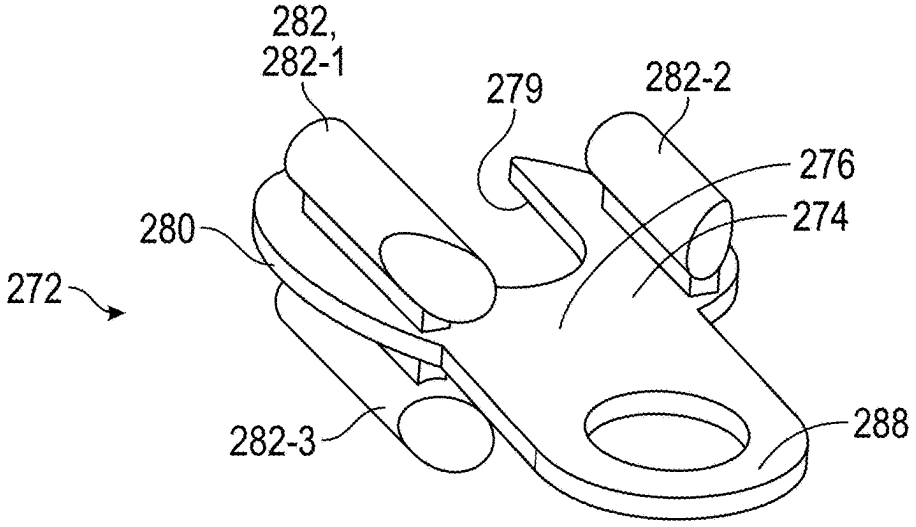


FIG. 5A

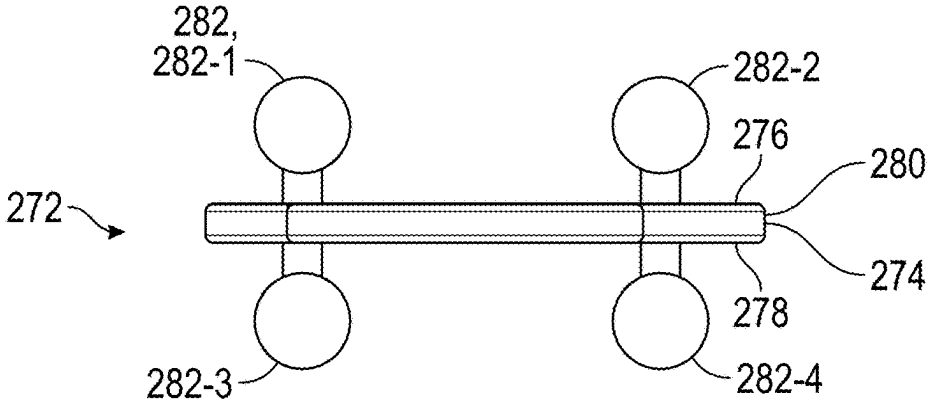


FIG. 5B

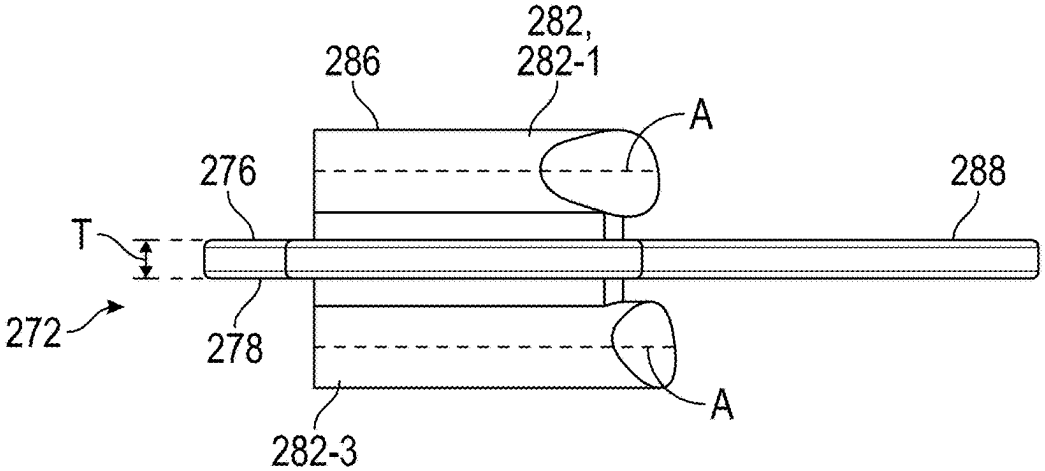


FIG. 5C

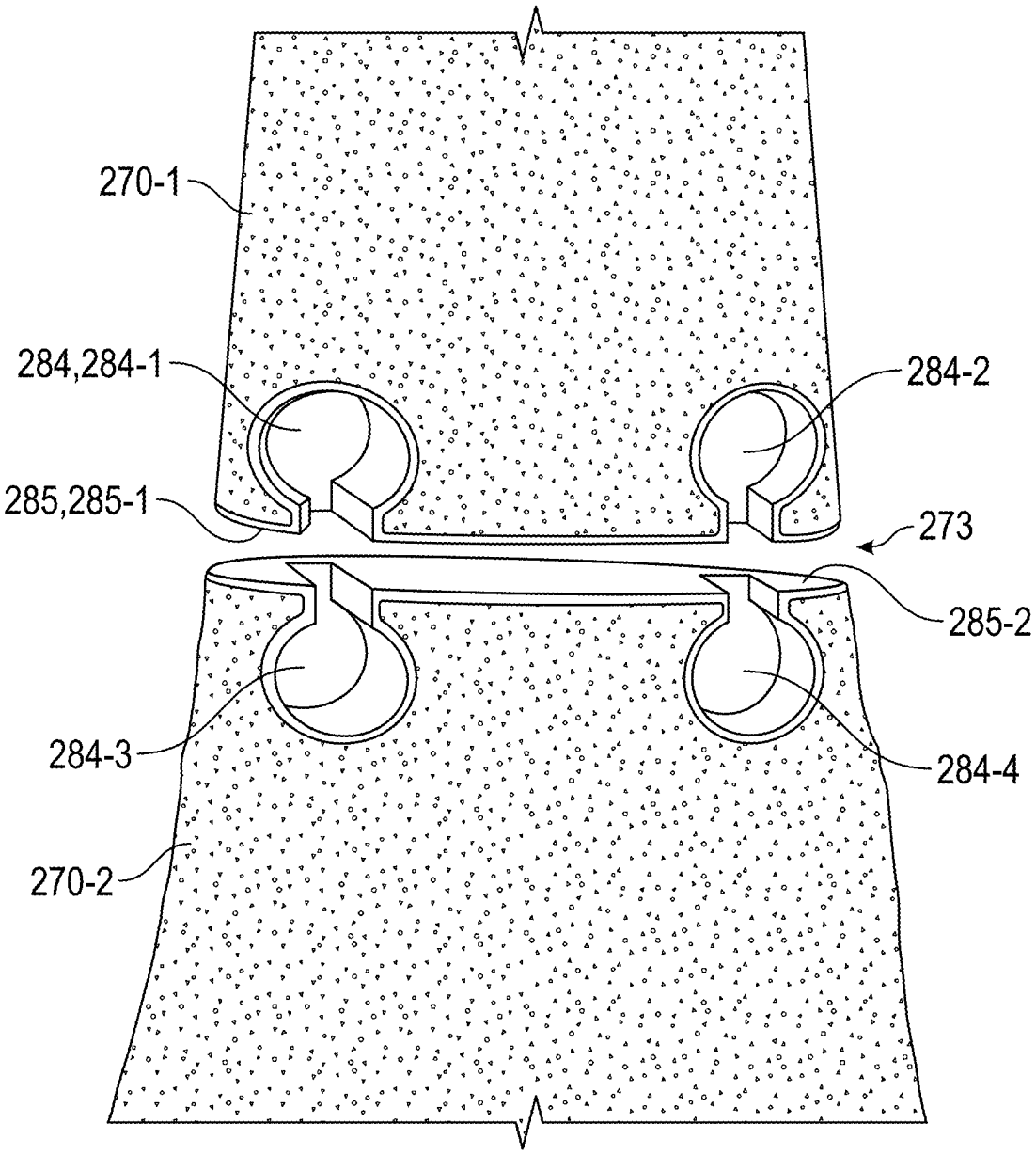


FIG. 6

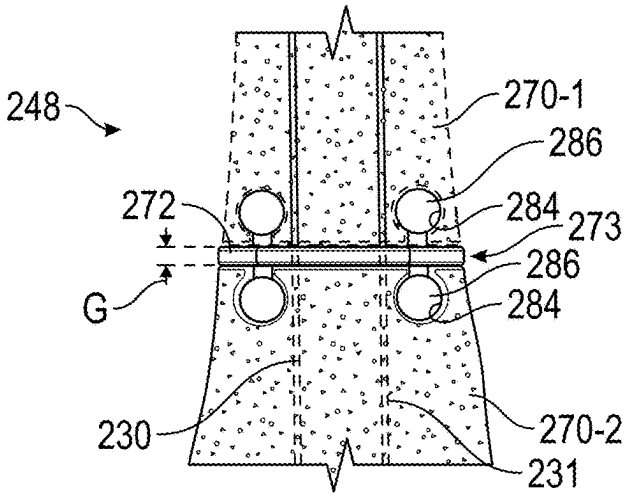


FIG. 7A

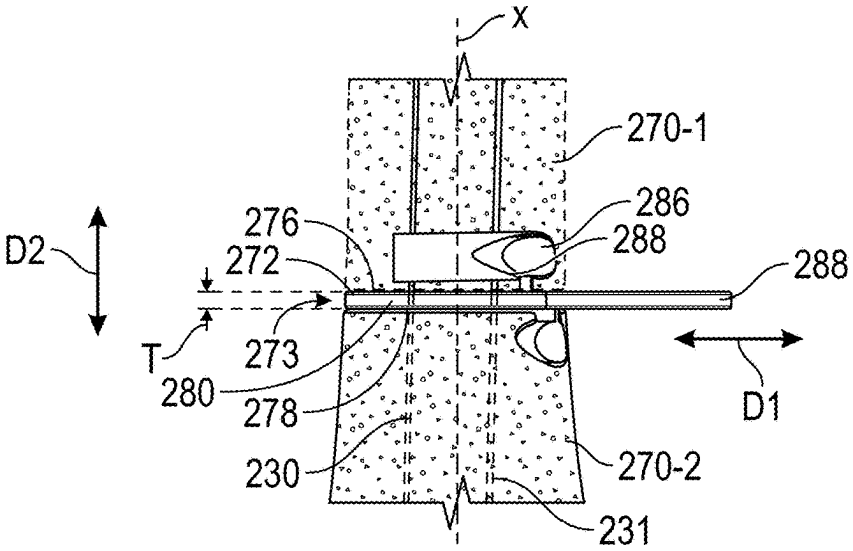


FIG. 7B

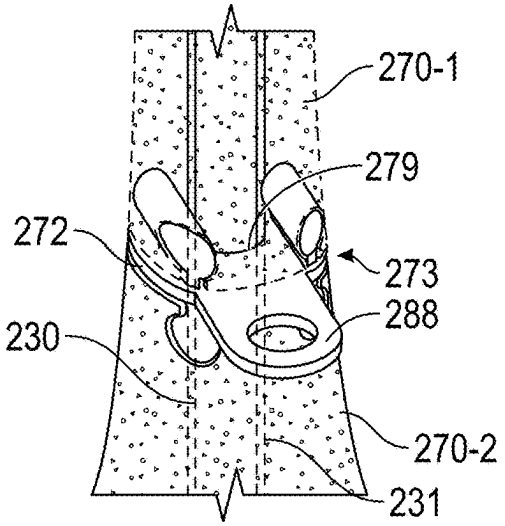


FIG. 7C

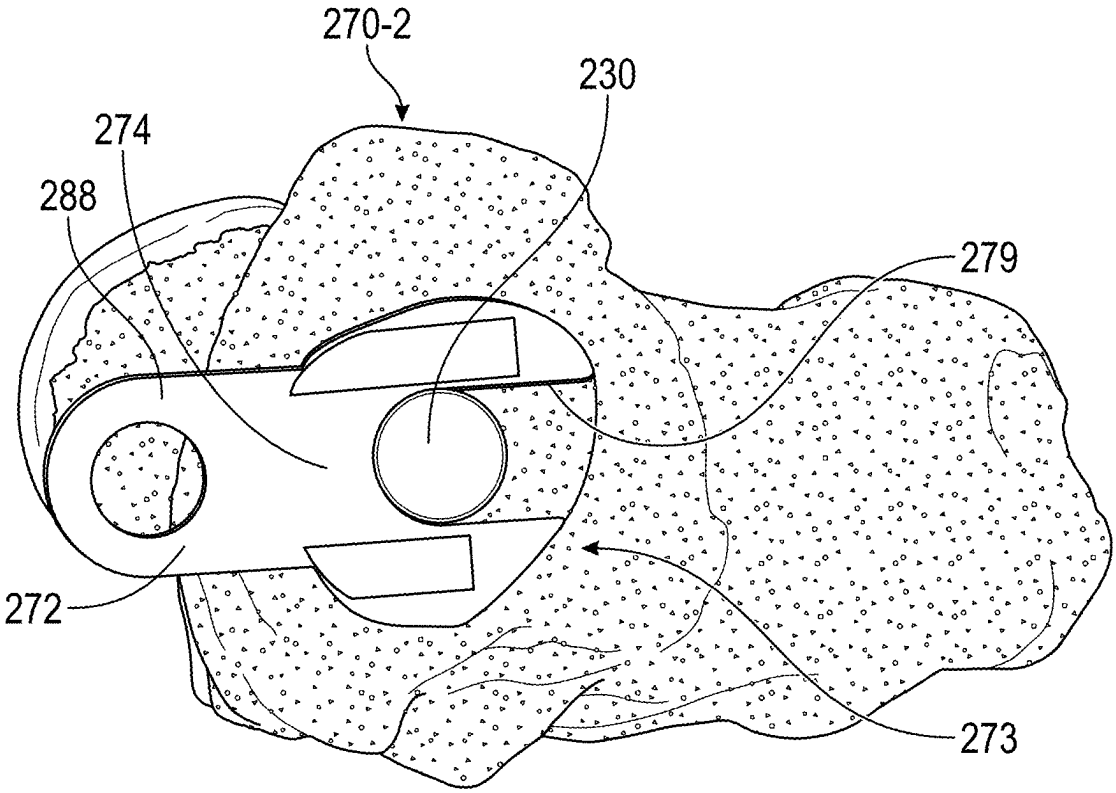


FIG. 8

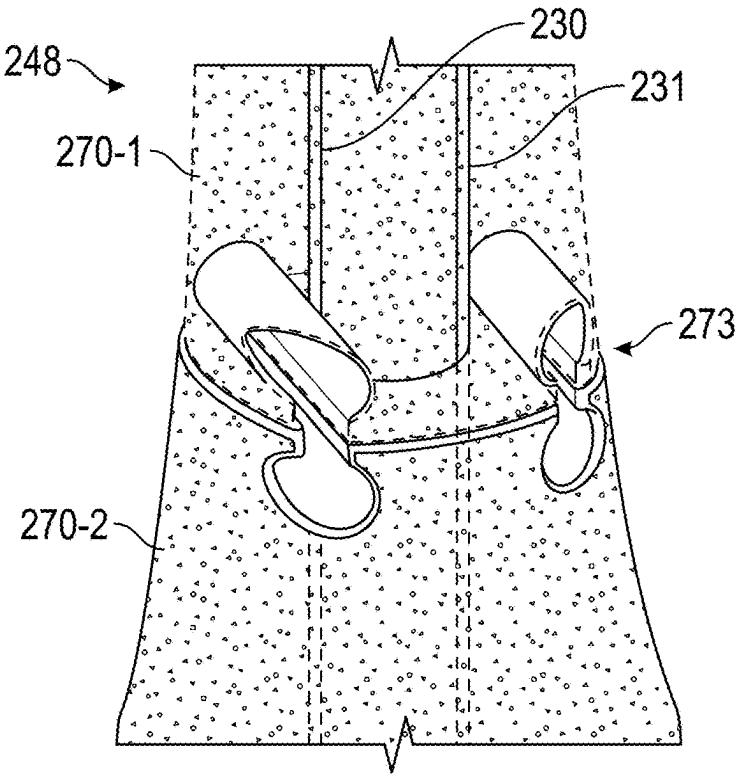


FIG. 9

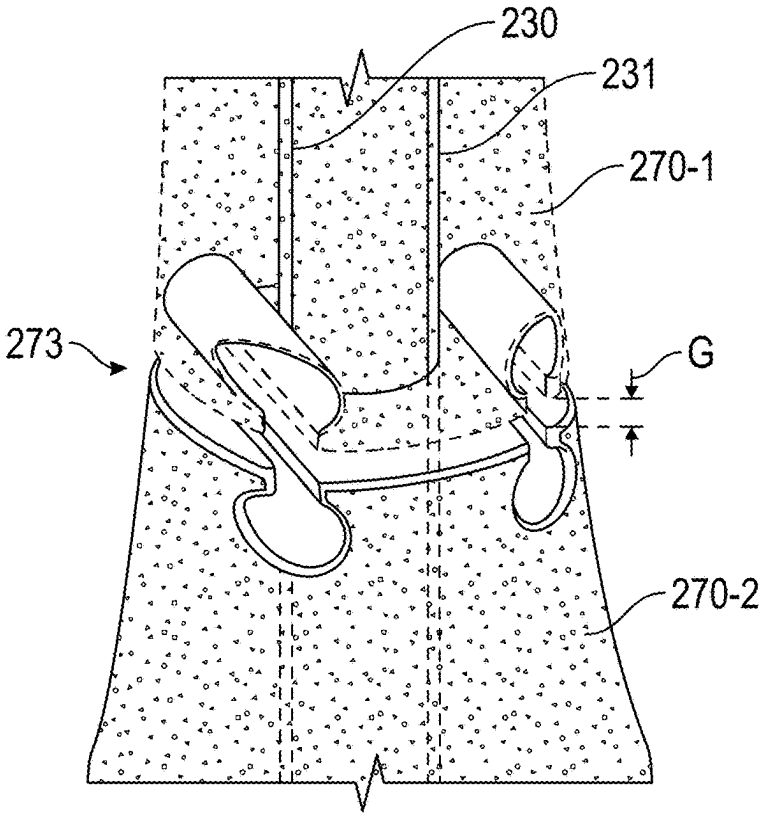


FIG. 10

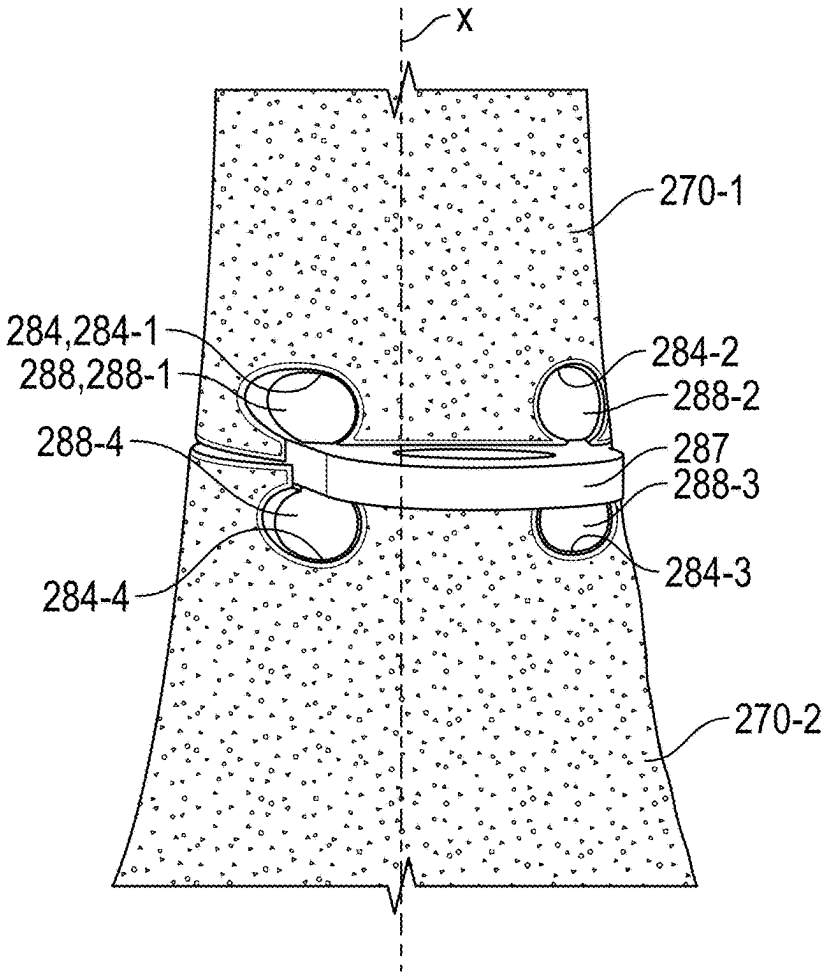
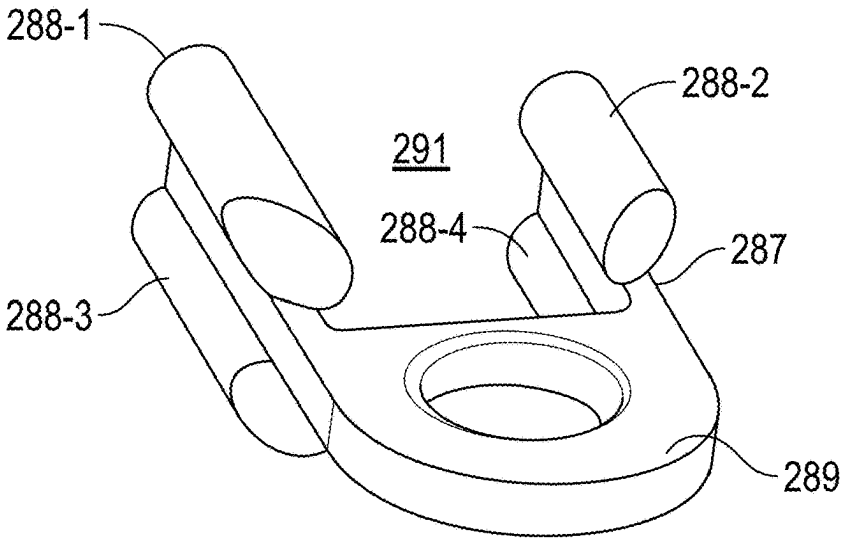

X
270-1
284,284-1
288,288-1
284-2
288-2
288-4
287
288-3
284-3
284-4
270-2

FIG. 11


288-1
288-2
291
288-4
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288-3
289

FIG. 12

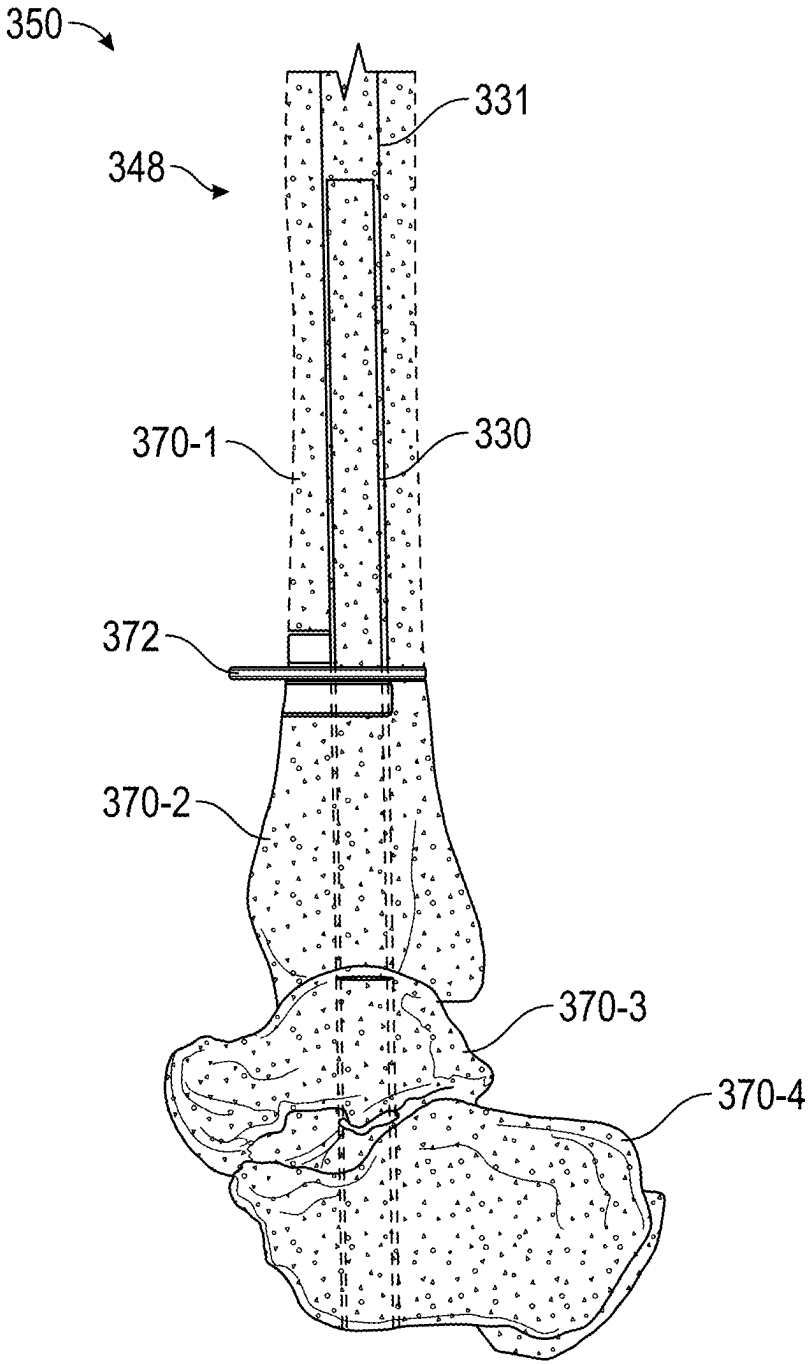

FIG. 13

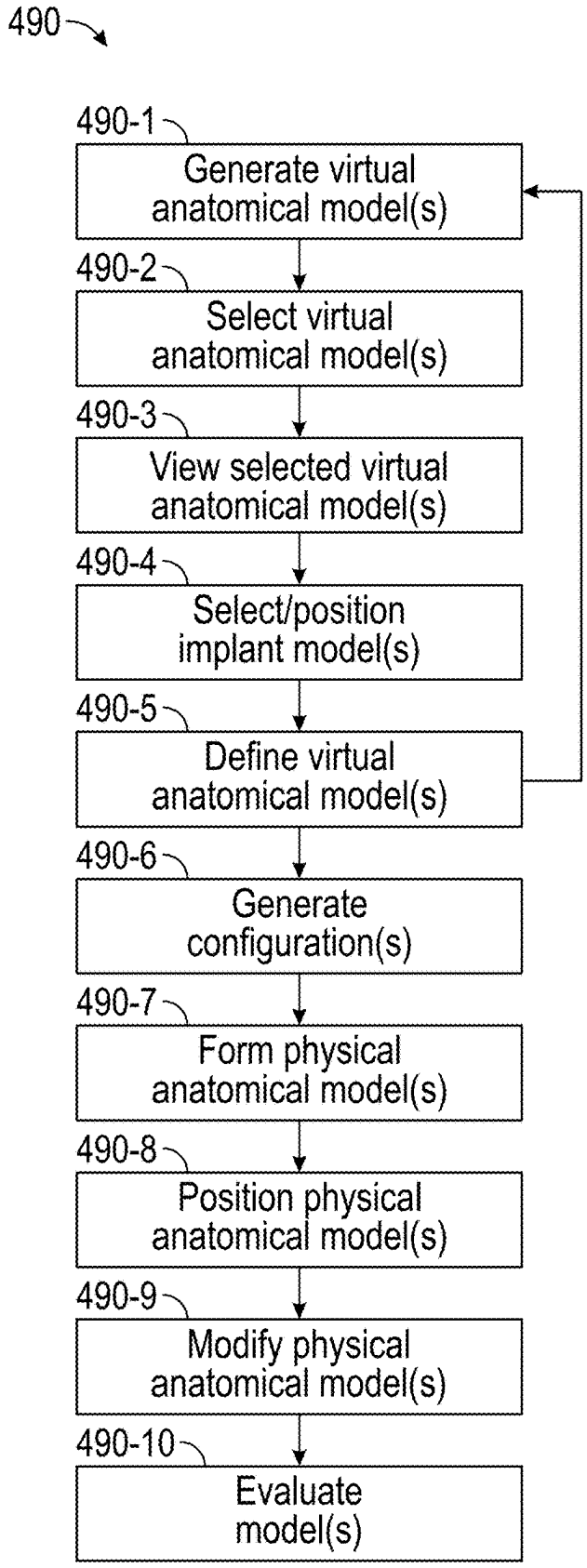
490
490-1
Generate virtual anatomical model(s)
490-2
Select virtual anatomical model(s)
490-3
View selected virtual anatomical model(s)
490-4
Select/position implant model(s)
490-5
Define virtual anatomical model(s)
490-6
Generate configuration(s)
490-7
Form physical anatomical model(s)
490-8
Position physical anatomical model(s)
490-9
Modify physical anatomical model(s)
490-10
Evaluate model(s)

FIG. 14

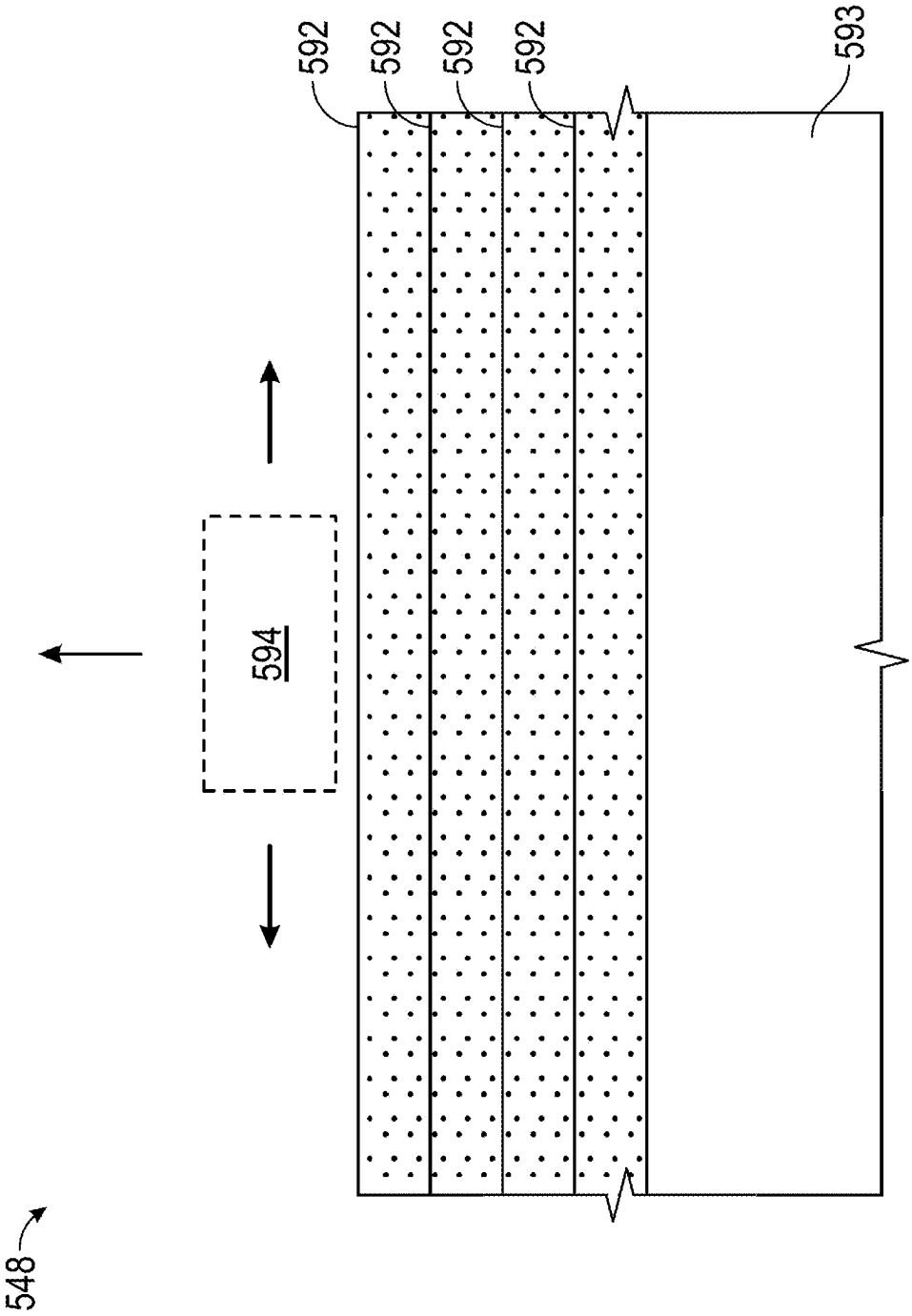

FIG. 15

ANATOMICAL MODELS AND ASSOCIATED METHODS FOR EVALUATING COMPRESSION

CROSS-REFERENCED TO RELATED APPLICATION

[0001] This application claims priority to U.S. Provisional Application No. 63/551,574, which was filed on Feb. 9, 2024.

BACKGROUND

[0002] This disclosure relates to surgical systems, devices and methods for planning and implementing surgical procedures utilizing physical models of anatomy.

[0003] Deformities may form along various bones and joints of the human musculoskeletal system. Surgeons may prepare for surgery by performing a procedure on a cadaveric or saw bone specimen.

SUMMARY

[0004] The systems and methods disclosed herein may be utilized to establish physical anatomical models of anatomy. A compression feature (e.g., spacer) may be utilized to evaluate compression between portions of the physical anatomical model.

[0005] A system for an orthopaedic procedure according to an implementation may include a physical anatomical model including a main body representative of anatomy. The main body may include a first bone portion and a second bone portion. A compression spacer may be positionable to establish a gap at an interface between the first bone portion and the second bone portion. The compression spacer may be associated with a preselected compressive force relating to the gap.

[0006] A system for an orthopaedic procedure according to an implementation may include a physical anatomical model representative of anatomy. The physical anatomical model may include a first bone portion and a second bone portion. A compression spacer may be dimensioned to separate the first bone portion and the second bone portion under a compressive load, such that removal of the compression spacer may cause movement between the first bone portion and the second bone portion.

[0007] A method of rehearsing for a surgical procedure according to an implementation may include accessing a virtual anatomical model associated with an anatomy of a patient. The method may include generating a configuration associated with a physical anatomical model that may be representative of the virtual anatomical model. The method may include forming the physical anatomical model. The physical anatomical model may include a body that may be associated with an anatomical profile of a bone. The body may include a first bone portion and a second bone portion. The method may include forming a compression spacer that may be insertable between the first bone portion and the second bone portion.

[0008] A compression spacer for a surgical procedure according to an implementation may include a spacer body configured to be received between first and second bone portions of a physical anatomical model. The spacer body may be dimensioned to have a thickness associated with a compressive force of an implant associated with abutment of the first and second bone portions.

[0009] These and other features may be best understood from the following specification and drawings, the following of which is a brief description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. **1** discloses a planning system according to an implementation.

[0011] FIG. **2** discloses another implementation of a planning system including a user interface.

[0012] FIG. **3** discloses the user interface of FIG. **2** including display windows depicting adjacent bone models.

[0013] FIG. **4** discloses a system for a surgical procedure according to an implementation.

[0014] FIGS. **5**A-**5**C disclose a compression spacer relative to the system of FIG. **4**.

[0015] FIG. **6** discloses a view of the system of FIG. **4** with the compression spacer removed.

[0016] FIGS. **7**A-**7**C disclose views of the system of FIG. **4** at different orientations.

[0017] FIG. **8** discloses a cross-sectional view of the system of FIG. **4**.

[0018] FIG. **9** discloses an implementation of the system in FIG. **4**, in which the compression spacer is removed and sufficient compressive force may be achieved.

[0019] FIG. **10** discloses an implementation of the system in FIG. **4**, in which the compression spacer is removed and insufficient compressive force may be achieved.

[0020] FIG. **11** discloses an implementation of the system in FIG. **4**, in which a locking key is provided within the first and second bone portions.

[0021] FIG. **12** discloses an example locking key.

[0022] FIG. **13** discloses a system for a surgical procedure according to another implementation.

[0023] FIG. **14** discloses a method of planning and implementing a surgical procedure utilizing physical anatomical model(s).

[0024] FIG. **15** discloses a technique for forming a physical anatomical model.

[0025] Like reference numbers and designations in the various drawings indicate like elements.

DETAILED DESCRIPTION

[0026] This disclosure relates to surgical systems, devices and methods for planning and implementing surgical procedures utilizing physical models of anatomy. Physical anatomical models may be utilized to rehearse and train for various surgical procedures.

[0027] The disclosed techniques may be utilized to provide the surgeon a preoperative planning and/or training experience that may be targeted or tailored to the surgeon based on procedure, skill set, experience, etc. The surgeon may select a particular configuration of a virtual anatomical model that may be fabricated or otherwise formed to establish a physical anatomical model based on the anatomy or pathology that the surgeon may intend to treat. The surgeon may utilize the physical anatomical model to train with particular instrumentation, implants and other devices that may be intended for a planned surgery to treat a patient.

[0028] The surgeon, assistant or other user may interact with a graphical user interface (GUI) to select various parameters or characteristics of the physical anatomical model. The parameters may include anatomy, patient, fracture classification, case, etc., to establish a desired configu-

ration of the physical anatomical model. The specified parameters may be represented in the physical anatomical model.

[0029] Various techniques may be utilized to establish the physical anatomical models, including any of the techniques disclosed herein. A compression feature may be utilized to evaluate compression between portions of the physical anatomical model. In implementations, the compression feature may include a compression spacer. The compression spacer may be dimensioned and formed to evaluate the compression associated with an implant. The compression spacer may be dimensioned to be situated between two (e.g., adjacent) bone portions of the physical anatomical model. The spacer may then be removed to evaluate compression between the two bone portions, such as the compressive force established by an implant that may extend between the two portions. In implementations, a set of compression spacers of various dimensions (e.g., thicknesses) may be provided with the physical anatomical model as a kit. The surgeon or clinical user may select one or more compression spacers from the kit to evaluate the compression associated with a selected implant that may be utilized to secure the two portions to each other.

[0030] The repaired physical anatomical model may serve as an artifact for the surgeon. The surgeon may leave a training facility with a revised physical anatomical model once training is completed. The surgeon may refer to the revised physical anatomical model prior to and/or during a surgical procedure on a respective patient.

[0031] A system for an orthopaedic procedure according to an implementation may include a physical anatomical model including a main body representative of anatomy. The main body may include a first bone portion and a second bone portion. A compression spacer may be positionable to establish a gap at an interface between the first bone portion and the second bone portion. The compression spacer may be associated with a preselected compressive force relating to the gap.

[0032] In any implementations, the compression spacer may include a spacer body extending between a first surface and a second surface. The first surface may be dimensioned to abut the first bone portion. The second surface may be dimensioned to abut the second bone portion.

[0033] In any implementations, the spacer body may include a periphery adjoining the first surface and the second surface.

[0034] In any implementations, the periphery of the spacer body may have a contour dimensioned to substantially match a bone contour of at least one of the first bone portion and the second bone portion.

[0035] In any implementations, the compression spacer may include a slot dimensioned to allow passage of an implant through the interface.

[0036] In any implementations, the compression spacer may include a first protrusion receivable in a first opening in the first bone portion to limit relative movement between the compression spacer and the first bone portion.

[0037] In any implementations, the first protrusion may include a cylinder having a longitudinal axis that may be substantially parallel with the first surface.

[0038] In any implementations, the compression spacer may include a second protrusion receivable in a second opening in the first bone portion.

[0039] In any implementations, the first protrusion may be opposite the slot from the second protrusion.

[0040] In any implementations, the first protrusion may extend from the first surface, the first opening may be established in the first bone portion, the second protrusion may extend from the second surface, and the second opening may be established in the second bone portion such that the compression spacer may limit relative movement between the first and second bone portions at the interface in an assembled position.

[0041] In any implementations, the compression spacer may include a first protrusion receivable in a first opening in the first bone portion to limit relative movement between the compression spacer and the first bone portion.

[0042] In any implementations, the compression spacer may include a second protrusion receivable in a second opening in the second bone portion to limit relative movement between the compression spacer and the second bone portion.

[0043] In any implementations, the compression spacer may include an aperture dimensioned to receive an implant extending through the first bone portion and the second bone portion.

[0044] In any implementations, the implant may include an intramedullary nail.

[0045] In any implementations, the preselected force may be selected such that removal of the compression spacer may cause the first and second bone portions to abut each other at the interface. The compression spacer may be removable to evaluate compression between the first and second bone portions at the interface in response to a compressive force established by the implant.

[0046] In any implementations, the aperture may be a slot.

[0047] In any implementations, the compression spacer may be metallic.

[0048] In any implementations, the compression spacer may include a handle for removing the compression spacer from the gap.

[0049] In any implementations, the compression spacer may include a first set of protrusions receivable in a first set of openings in the first bone portion and a second set of protrusions receivable in a second set of openings in the second bone portion to limit relative movement between the first and second bone portions.

[0050] A system for an orthopaedic procedure according to an implementation may include a physical anatomical model representative of anatomy. The physical anatomical model may include a first bone portion and a second bone portion. A compression spacer may be dimensioned to separate the first bone portion and the second bone portion under a compressive load, such that removal of the compression spacer may cause movement between the first bone portion and the second bone portion.

[0051] In any implementations, a thickness of the compression spacer may be associated with a preselected compressive force such that removal of the compression spacer may cause abutment between the first bone portion and the second bone portion in response to the compressive load being equal to or exceeding the preselected compressive force.

[0052] In any implementations, the compression spacer may include an aperture dimensioned to receive an implant that may extend through the first bone portion and the second bone portion.

[0053] In any implementations, the first bone portion and the second bone portion may be associated with a common bone of the anatomy.

[0054] In any implementations, the first bone portion and the second bone portion may be associated with adjacent bones that establish a joint of the anatomy.

[0055] In any implementations, a periphery of the compression spacer may be dimensioned to substantially match a contour of the anatomy.

[0056] A method of rehearsing for a surgical procedure according to an implementation may include accessing a virtual anatomical model associated with an anatomy of a patient. The method may include generating a configuration associated with a physical anatomical model that may be representative of the virtual anatomical model. The method may include forming the physical anatomical model. The physical anatomical model may include a body that may be associated with an anatomical profile of a bone. The body may include a first bone portion and a second bone portion. The method may include forming a compression spacer that may be insertable between the first bone portion and the second bone portion.

[0057] In any implementations, the method may include inserting an orthopaedic implant through the first bone portion and the second bone portion.

[0058] In any implementations, the method may include, after inserting the orthopaedic implant, removing the compression spacer from a gap between the first bone portion and the second bone portion.

[0059] In any implementations, the method may include evaluating compression of the orthopaedic implant by determining whether the first bone portion abuts the second bone portion after removing the compression spacer.

[0060] In any implementations, the forming step may include printing layers of material on each other to establish the physical anatomical model.

[0061] In any implementations, the method may include forming an internal cavity in the first bone portion and the second bone portion. The method may include inserting an orthopaedic implant through the internal cavity to secure the first and second bone portions to each other.

[0062] In any implementations, the method may include inserting an orthopaedic implant through an aperture in the compression spacer to secure the first and second bone portions to each other.

[0063] In any implementations, the forming step may include printing layers of material on each other to establish the physical anatomical model.

[0064] In any implementations, the first bone portion and the second bone portion may be associated with a common bone of the anatomy.

[0065] In any implementations, the first bone portion and the second bone portion may be associated with adjacent bones that establish a joint of the anatomy.

[0066] In any implementations, the first bone portion may be associated with a long bone of the anatomy.

[0067] In any implementations, the method may include inserting an orthopaedic implant through the first bone portion, the second bone portion, and a third bone portion. The first and second bone portions may be associated with a tibia of the anatomy. The third bone portion may be associated with a talus of the anatomy.

[0068] A compression spacer for a surgical procedure according to an implementation may include a spacer body configured to be received between first and second bone portions of a physical anatomical model. The spacer body may be dimensioned to have a thickness associated with a compressive force of an implant associated with abutment of the first and second bone portions.

[0069] In any implementations, the spacer body may include an aperture dimensioned to receive an implant extending through the first and second bone portions.

[0070] In any implementations, the spacer body may include a U-shaped profile.

[0071] In any implementations, one or more protrusions may extend from the spacer body and may be dimensioned to be received in one or more openings of one or more of the first and second bone portions.

[0072] In any implementations, a handle may extend from the spacer body for manipulation of the compression spacer.

[0073] FIG. **1** discloses a planning system **20** that may be utilized for planning surgical procedures. The system **20** may be used for planning orthopaedic procedures, including pre-operatively, intra-operatively and/or post-operatively to create, edit, execute and/or review surgical plans.

[0074] The system **20** may include a host computer **21** and one or more client computers **22**. The host computer **21** may be configured to execute one or more software programs. In some implementations, the host computer **21** is more than one computer jointly configured to process software instructions serially or in parallel.

[0075] The host computer **21** may be in communication with one or more networks such as a network **23** comprised of one or more computing devices. The network **23** may be a private local area network (LAN), a private wide area network (WAN), the Internet, or a mesh network, for example.

[0076] The host computer **21** and each client computer **22** may include one or more of a computer processor, memory, storage means, network device and input and/or output devices and/or interfaces. The input devices may include a keyboard, mouse, etc. The output device may include a monitor, speakers, printers, etc. The memory may, for example, include UVPROM, EEPROM, FLASH, RAM, ROM, DVD, CD, a hard drive, or other computer readable medium which may store data and/or other information relating to the planning techniques disclosed herein. The host computer **21** and each client computer **22** may be a desktop computer, laptop computer, smart phone, tablet, or any other computing device. The interface may facilitate communication with the other systems and/or components of the network **23**.

[0077] Each client computer **22** may be configured to communicate with the host computer **21** directly via a direct client interface **24** or over the network **23**. The client computers **22** may be configured to execute one or more software programs, such as a various surgical tools. The planning package may be configured to communicate with the host computer **21** either over the network **23** or directly through the direct client interface **24**. In another implementation, the client computers **22** are configured to communicate with each other directly via a peer-to-peer interface **25**.

[0078] Each client computer **22** may be operable to access and locally and/or remotely execute a planning environment **26**. The planning environment **26** may be a standalone software package or may be incorporated into another surgical tool. The planning environment **26** may provide a display or visualization of one or more bone models and

related images and one or more implant models via one or more graphical user interfaces (GUI). Each bone model, implant model, and related images and other information may be stored in one or more files or records according to a specified data structure.

[0079] The system **20** may include at least one storage system **27**, which may be operable to store or otherwise provide data to other computing devices. The storage system **27** may be a storage area network device (SAN) configured to communicate with the host computer **21** and/or the client computers **22** over the network **23**. In implementations, the storage system **27** may be incorporated within or directly coupled to the host computer **21** and/or client computers **22**. The storage system **27** may be configured to store one or more of computer software instructions, data, database files, configuration information, etc.

[0080] In implementations, the system **20** may be a client-server architecture configured to execute computer software on the host computer **21**, which may be accessible by the client computers **22** using either a thin client application or a web browser executing on the client computers **22**. The host computer **21** may load the computer software instructions from local storage, or from the storage system **27**, into memory and may execute the computer software using the one or more computer processors.

[0081] The system **20** may include one or more databases **28**. The databases **28** may be stored at a central location, such as the storage system **27**. In another implementation, one or more databases **28** may be stored at the host computer **21** and/or may be a distributed database provided by one or more of the client computers **22**. Each database **28** may be a relational database configured to associate one or more bone models **29** and one or more implant models **30** to each other and/or a surgical plan **31**. Each surgical plan **31** may be associated with a respective patient. Each bone model **29**, implant model **30** and surgical plan **31** may be assigned a unique identifier or database entry. The database **28** may be configured to store data corresponding to the bone models **29**, implant models **30** and surgical plans **31** in one or more database records or entries, and/or may be configured to link or otherwise associate one or more files corresponding to each respective bone model **29**, implant model **30** and surgical plan **31**. Bone models **29** stored in the database(s) **28** may correspond to respective patient anatomies from prior surgical cases, and may be arranged into one or more predefined categories such as sex, age, ethnicity, defect category, procedure type, etc.

[0082] Each bone model **29** may include information obtained from one or more medical devices or tools, such as a computerized tomography (CT), magnetic resonance imaging (MRI) machine and/or X-ray machine, that may obtain one or more images of a patient. The bone model **29** may include one or more digital images and/or coordinate information relating to an anatomy of the patient obtained or derived from the medical device(s). Each implant model **30** may include coordinate information associated with a predefined design. The planning environment **26** may incorporate and/or interface with one or more modeling packages, such as a computer aided design (CAD) package, to render the models **29**, **30** as two-dimensional (2D) and/or three-dimensional (3D) volumes or constructs.

[0083] The predefined design may correspond to one or more components. The implant models **30** may correspond to implants and components of various shapes and sizes. Each implant may include one or more components that may be situated at a surgical site including plates, screws, anchors, and/or grafts. Each implant model **30** may correspond to a single component or may include two or more components that may be configured to establish an assembly. Each bone model **29** and implant model **30** may correspond to 2D and/or 3D geometry, and may be utilized to utilized to generate a wireframe, mesh and/or solid construct in a display.

[0084] Each surgical plan **31** may be associated with one or more of the bone models **29** and implant models **30**. The surgical plan **31** may include one or more revisions to a bone model **29** and information relating to a position of an implant model **30** relative to the original and/or revised bone model **29**. The surgical plan **31** may include coordinate information relating to the revised bone model and a relative position of the implant model **30** in predefined data structure(s). Revisions to each bone model **29** and surgical plan **31** may be stored in the database **28** automatically and/or in response to user interaction with the system **20**.

[0085] One or more surgeons and other clinical users may be provided with a planning environment **26** via the client computers **22** and may simultaneously access each bone model **29**, implant model **30** and surgical plan **31** stored in the database(s) **28**. Each user may interact with the planning environment **26** to create, view and/or modify various aspects of the surgical plan **31**. Each client computer **22** may be configured to store local instances of the bone models **29**, implant models **30** and/or surgical plans **31**, which may be synchronized in real-time or periodically with the database (s) **28**. The planning environment **26** may be a standalone software package executed on a client computer **22** or may be provided as one or more services executed on the host computer **21**

[0086] FIG. **2** illustrates a planning system **120** for planning a surgical procedure according to an implementation. The system **120** may be utilized to plan and implement various orthopaedic and other surgical procedures, such as an arthroplasty to repair a joint. The system **120** may be utilized in planning placement of an implant, which may be utilized for securing adjacent bones such as a tibia and talus in an ankle repair. Although the planning systems and methods disclosed herein primarily refer to repair of an ankle joint, it should be understood that the planning system **120** may be utilized in the repair of other locations of the patient and other surgical procedures including repair of other joints such as a shoulder, wrist, hand, hip or knee, and including repair of fractures.

[0087] The system **120** may include a computing device **132** including at least one processor **133** coupled to memory **134**. The computing device **132** can include any of the computing devices disclosed herein, including the host computer **21** and/or client computer **22** of FIG. **1**. The processor **133** may be configured to execute a planning environment **126** for creating, editing, executing and/or reviewing one or more surgical (e.g., pre-operative) plans **131** during pre-operative, intra-operative and/or post-operative phases of a surgery.

[0088] The planning environment **126** may include at least a data module **135**, a display module **136**, a spatial module **137** and a comparison module **138**. Although four modules are shown, it should be understood that fewer or more than

four modules may be utilized and/or one or more of the modules may be combined to provide the disclosed functionality.

[0089] The data module **135** may be configured to access, retrieve and/or store data and other information in the database(s) **128** corresponding to one or more bone model(s) **129**, implant model(s) **130** and/or surgical plan(s) **131**. The data and other information may be stored in one or more databases **128** as one or more records or entries **139**. In implementations, the data and other information may be stored in one or more files that may be accessible by referencing one or more objects or memory locations references by the records or entries **139**.

[0090] The memory **134** may be configured to access, load, edit and/or store instances of one or more bone models **129**, implant models **130** and/or surgical plans **131** in response to one or more commands from the data module **135**. The data module **135** may be configured to cause the memory **134** to store a local instance of the bone model(s) **129**, implant model(s) **130** and/or surgical plan(s) **131** which may be synchronized with records **139** in the database(s) **128**.

[0091] The display module **136** may be configured to display data and other information relating to one or more surgical plans **131** in at least one graphical user interface (GUI) **142**. The computing device **132** may be coupled to a display device **140**. The display module **136** may be configured to cause the display device **140** to display information in the user interface **142**. A surgeon or other user may interact with the user interface **142** via the planning environment **126** to create, edit, execute and/or review one or more surgical plans **131**.

[0092] The system **120** may be configured to generate one or more physical anatomical models **148**, including any of the physical anatomical models disclosed herein. The physical anatomical models **148** may be representative of various anatomy and tissue, including any of the bones and joints disclosed herein. The surgeon may perform one or more modifications to the physical anatomical model **148** to rehearse or train for a surgical procedure. The system **120** may be configured to generate configuration(s) **145** associated with respective physical anatomical model(s) **148**. The configuration **145** may be utilized in the formation of a physical anatomical model **148**. Each physical anatomical model **148** may be representative of, or may otherwise be associated with, a virtual anatomical model **129**, including a substantially or generally corresponding geometry, texture, density, porosity, color, etc. as the virtual anatomical model **129**. The virtual anatomical model **129** may be associated with an anatomy, such as the anatomy of a patient and/or a hypothetical anatomy. The anatomical models **129** may include one or more anatomical features. The anatomical features may be representative of anatomy, including one or more bones including cartilage, cortical and/or cancellous bone tissue, soft tissue including muscle, ligaments and/or tendons, etc., and/or other tissue. For the purposes of this disclosure, the term "substantially" means±10 percent of the stated value or relationship unless otherwise indicated.

[0093] Referring to FIG. **3**, with continuing reference to FIG. **2**, the user interface **142** may include one or more display windows **144** and one or more objects **146**. The objects **146** may include graphics such as menus, tabs and buttons accessible by user interaction. Geometric objects including selected bone model(s) **129** and implant model(s) **130** and other information relating to the surgical plan **131** may be displayed in one or more of the display windows **144**.

[0094] The implant model **130** may include one or more components associated with an implant. The implant model **130** may be representative of various implants including one or more components that may be situated at a surgical site including plates, anchors, screws, nails, suture, grafts, etc. In implementations, the implant model **130** may be an intramedullary nail or rod, which may be used in a tibio-talo-calcaneal (TTC) fusion procedure. In implementations, the implant model **130** may be associated with an implant suitable to establish a compressive force at an interface between two or more bone portions, such as between a tibia and talus and/or between the talus and calcaneus of a patient.

[0095] The display module **136** may be configured to display one or more selected bone models **129** and/or one or more selected implant models **130** in the display windows **144**. The display module **136** may be configured such that the selected bone model **129** and/or selected implant model **130** may be selectively displayed and hidden (e.g., toggled) in one or more of the display windows **144** in response to user interaction with the user interface **142**, which may provide the surgeon with enhanced flexibility in reviewing aspects of the surgical plan **131**.

[0096] The data module **135** may be configured to access a first bone model **129-1** and a second bone model **129-2** from the database **128**, which may occur automatically or in response to user interaction with the user interface **142**. The data module **135** may be configured to store an instance of the first bone model **129-1** and second bone model **129-2** in the memory **134**. The first bone model **129-1** and second bone model **129-2** may be associated with a joint. In implementations, one of the bone models **129** may be associated with a long bone such as a tibia, and another one of the bone models **129** may be associated with an adjacent bone such as a talus that may cooperate to establish an ankle or another joint of a patient. In the implementation of FIG. **3**, the first bone model **129-1** may be associated with a talus, and the second bone model **129-2** may be associated with a tibia. The display module **136** may be configured to display the first bone model **129-1** and second bone model **129-2** in at least one of the display windows **144** of the user interface **142**.

[0097] The display windows **144** may include first and second display windows **144-1**, **144-2**. Although a particular number of display windows **144** are disclosed, the user interface **142** may be configured with any number of display windows **144** in accordance with the teachings disclosed herein. The display windows **144-1**, **144-2** may be configured to display a two-dimensional (2D) and/or three-dimensional (3D) representation of the selected bone models **129**.

[0098] The first display window **144-1** may be configured to display the first bone model **129-1** and second bone model **129-2** relative to each other. The spatial module **137** may be configured to position the bone models **129-1**, **129-2** into contact with each other at a specified or defined position and orientation, which may be according to user interaction with the window **144-1**, menu **146**M, and/or other objects **146** of the user interface **142**.

[0099] The surgeon or assistant may interact with the display window **144-1** or another portion of the user interface **142** to move the selected bone model **129** and/or selected implant model **130** in 2D space (e.g., up, down, left,

right) and/or 3D space (e.g., rotation, tilt, zoom, etc.), which may occur in response to interaction with the directional indicators **146**D, **146**R.

[0100] The second display window **144-2** may be configured to display the first bone model **129-1** and second bone model **129-2** in spaced relationship relative to each other. The surgeon or assistant may interact with the second display window **144-2** or another portion of the user interface **142** to associate one or more landmarks L with the selected bone models **129**. The landmarks L may include one or more points P along the anatomy (e.g., P**1**-P**2**) and one or more planes (e.g., L**1**-L**4**). Exemplary landmarks include a tibial axis, sagittal plane, coronal plane and transverse plane. In implementations, the spatial module **137** may be configured to determine one or more landmarks L based on evaluating a profile of the selected bone model **129**. The profile can be compared to one or more profiles of representative bones in the database **128**.

[0101] The display module **136** may be configured to display one or more implant models **130** in one or more of the display window(s) **144** of the user interface **142**. The spatial module **137** may be configured to position the implant model(s) **130** relative to the first and second bone models **129-1**, **129-2** automatically and/or in response to user interaction with the user interface **142**. The surgeon or other user may select an implant model **130** and a placement of an implant model **130** within the first and second bone models **129-1**, **129-2**. The surgeon or other user may determine a desired compressive force associated with placement of the implant model **130** relative to the bone models **129-1**, **129-2**.

[0102] FIG. **4** discloses a system **250** for a surgical procedure according to an implementation. The system **250** may incorporate any of the features disclosed herein. The system **250** may include a physical anatomical model **248**. The physical anatomical model **248** may be established based on a configuration **145** (FIG. **2**). The physical anatomical model **248** may be secured to at least one fixture **266** to establish an assembly **268**. The fixture **266** may be securable to a static structure. The physical anatomical model **248** may include a main body **248**M representative of anatomy, including the anatomy of a patient or a hypothetical anatomy. In implementations, the main body **248**M may be associated with an anatomical profile of one or more bones and/or joints, including any of the bones and/or joints disclosed herein. In implementations, the bone may be a long bone, such as a fibula, tibia, femur or humerus.

[0103] The main body **248**M may include two or more (e.g., adjacent) bone portions **270**. The bone portions **270** may include a first bone portion **270-1** and a second bone portion **270-2**. The first bone portion **270-1** and the second bone portion **270-2** may be associated with a common bone of the anatomy or may be associated with adjacent bones that may establish a joint of the anatomy. In implementations, one or both of the first bone portion **270-1** and the second bone portion **270-2** may be associated with a long bone of the anatomy, such as a tibia.

[0104] The system **250** may include at least one compression spacer **272**. The compression spacer **272** may be positioned to establish a gap G at an interface **273** between the first bone portion **270-1** and the second bone portion **270-2**. The compression spacer **272** may be associated with a preselected compressive force relating to the gap G such that removal of the compression spacer **272** may cause abutment between the first bone portion **270-1** and the second bone portion **270-2** at the interface **273**. The compression spacer **272** may be formed from various metallic and/or non-metallic materials, such as stainless steel or titanium. In implementations, the compression spacer **272** may be a different material from one, or both, of the first bone portion **270-1** and the second bone portion **270-2**.

[0105] Referring to FIGS. **5**A-**5**C, with continuing reference to FIG. **4**, the compression spacer **272** may include a spacer body **274** extending between a first surface **276** and a second surface **278**. The first surface **276** may be dimensioned to abut the first bone portion **270-1** (FIG. **4**). The second surface **278** may be dimensioned to abut the second bone portion **270-2** (FIG. **4**). The spacer body **274** may include a periphery **280** adjoining the first surface **276** and the second surface **278**. The periphery **280** of the spacer body **274** may have a contour dimensioned to substantially match a bone contour of one, or both, of the first bone portion **270-1** and the second bone portion **270-2**. The spacer body **274** may include a generally U-shaped profile (e.g., FIGS. **5**A and **8**). The spacer body **274** may define an aperture **279**. In implementations, the aperture **279** may be a slot. The aperture **279** may be dimensioned to allow passage of an implant **230** through the interface **273** (e.g., FIG. **8**).

[0106] The compression spacer **272** may cooperate with the first and second bone portions **270-1**, **270-2** to selectively establish a lock mechanism for limiting relative movement. The compression spacer **272** may include one or more protrusions (e.g., keys) **282** (indicated at **282-1**, **282-2**, **282-3**, **282-4**) receivable in corresponding openings (e.g., keyways) **284** (indicated at **284-1**, **284-2**, **284-3**, **284-4** in FIG. **6**) in the first bone portion **270-1** and second bone portion **270-2** to limit relative movement between the compression spacer **272** and at least one, or both, of the first bone portion **270-1** and second bone portion **270-2** when in an assembled position. Although four protrusions **282-1**, **282-2**, **282-3**, **282-4** are shown, fewer or more than four protrusions and associated openings may be utilized in accordance with the teachings disclosed herein.

[0107] In implementations, the protrusions **282-1**, **282-2** may be on an opposite side of the spacer body **274** as the protrusions **282-3**, **282-4**. The protrusion **282-1** may be opposite the aperture **279** from the protrusion **282-2**. The protrusion **282-3** may be opposite the aperture **279** from the protrusion **282-4**. The protrusions **282-1**, **282-2** may extend from the surface **276**. The protrusions **282-3**, **282-4** may extend from the surface **278**. One or more of the protrusions **282-1**, **282-2**, **282-3**, **282-4** may include a cylindrical body **286** having a longitudinal axis A. The longitudinal axis A may be substantially parallel (±10 degrees) to one or both of the surfaces **276**, **278**.

[0108] Referring to FIG. **6**, with continuing reference to FIGS. **4** and **5**A-**5**C, the openings **284-1**, **284-2** may be provided in the first bone portion **270-1**. The openings **284-3**, **284-4** may be provided in the second bone portion **270-2**. The cylindrical body **286** may be dimensioned to mate with the respective opening **284** to limit relative movement (e.g., FIG. **7**A).

[0109] One, or both, of the first bone portion **270-1** and the second bone portion **270-2** may include a reinforcement member **285** (indicated at **285-1** and **285-2**) at the interface **273**. A first reinforcement member **285-1** may be provided on the first bone portion **270-1**. A second reinforcement

member **285-2** may be provided on the second bone portion **270-2**. In implementations, the reinforcement members **285** may a material that may be the same or may differ from a material of the first bone portion **270-1** and/or the second bone portion **270-2**. In implementations, the reinforcement members **285** include a metallic material, including any of the materials disclosed herein. The reinforcement members **285** may include a material that may be the same or may different from a material of the compression spacer **272**. The reinforcement members **285** may be dimensioned to abut the compression spacer **272** when the compression spacer **272** is received at the interface **273**. The reinforcement members **285** may establish the openings **284**. In implementations, the reinforcement members **285-1**, **285-2** may abut one another after removal of the compression spacer **272** if a sufficient (e.g., preselected) compressive force is achieved. The reinforcement members **285** may serve to reinforce the first and/or second bone portions **270-1**, **270-2** adjacent to the interface **273**. The reinforcement members **285** may also serve to more uniformly spread compressive loads applied to the first and/or second bone portions **270-1**, **270-2**, which may include a relatively softer (e.g., non-metallic) material than a (e.g., metallic) material of the reinforcement members **285** and/or compression spacer **272**. In other implementations, the reinforcement members **285** may be omitted.

[0110] Referring to FIGS. **7**A-**7**C, with continuing reference to FIGS. **4**, **5**A-**5**C and **6**, the compression spacer **272** may be received at the interface **273** between the first bone portion **270-1** and the second bone portion **270-2**. An implant **230** may be at least partially received in the model **248** (shown in dashed lines). The implant **230** may extend at least partially through the first bone portion **270-1** and/or the second bone portion **270-2**. The implant **230** may be adapted to establish a compressive force between the first bone portion **270-1** and the second bone portion **270-2**. The implant **230** may be any of the implementations discussed herein, such as an intramedullary nail. The intramedullary nail may be positionable in an intramedullary canal of the model **248**. The compression spacer **272** may be removable to evaluate compression between the first bone portion **270-1** and the second bone portion **270-2** at the interface **273** in response to a compressive force established by the implant **230**. The compression may be associated with a compressive force specified in a surgical plan **131** (FIG. **2**). The implant **230** may extend through the aperture **279** (e.g., FIGS. **5**A and **8**). A (e.g., reaming or drill) path **231** may be established in one, or both, of the first bone portion **270-1** and the second bone portion **270-2**. The reaming path **231** may be dimensioned to at least partially receive the implant **230**. The reaming path **231** may be formed with the physical anatomical model **248** utilizing any of the techniques disclosed herein, such as through rapid prototyping (e.g., printing) and other additive manufacturing techniques. In other implementations, the reaming path **231** may be established subsequent to forming the physical anatomical model **248**. The reaming path **231** may be established using a machining or other material removal technique. The surgeon or other clinical user may utilize a surgical instrument such as a drill to establish the reaming path **231**.

[0111] The compression spacer **272** may include a (e.g., pull-out) handle **288** for manipulating the compression spacer **272** by the surgeon or clinical user. The handle **288** may be useful for moving the compression spacer **272** into and/or out of the gap G at the interface **283** (e.g., FIG. **7**A). With reference to FIGS. **5**A, **7**B and **8**, the handle **288** may extend from the spacer body **274**. The aperture **279** may be open to the periphery **280** to allow the compression spacer **272** to be removed from the interface **283** while the implant **230** is received through the interface **273**. In the implementation of FIG. **7**B, the protrusions **282** and openings **284** may be dimensioned such that the compression spacer **272** may be moveable in a first direction D**1**. The first direction D**1** may be substantially perpendicular relative to a (e.g., longitudinal) axis X of the model **248** at the interface **273**. The protrusions **282** and openings **284** may be dimensioned to limit movement in a second direction D**2** between the compression spacer **272** and the first and/or second bone portions **270-1**, **270-2**. The second direction D**2** may be substantially perpendicular or otherwise transverse to the first direction D**1**. In implementations, the second direction D**2** may be substantially parallel to the axis X.

[0112] The compression spacer **272** may be dimensioned to separate the first bone portion **270-1** and the second bone portion **270-2** under a compressive load, which may be established by the implant **230**, such that removal of the compression spacer **272** may cause movement between the first bone portion **270-1** and the second bone portion **270-2**. In implementations, a thickness T of the compression spacer **272** (FIG. **7**B) may be associated with a preselected compressive force, such as a (e.g., preselected) compressive force of the implant **230**, such that removal of the compression spacer **272** may cause abutment between the first bone portion **270-1** and the second bone portion **270-2** in response to the compressive load being equal to or exceeding the preselected compressive force. The preselected compressive force may be specified in a surgical plan **131** (FIG. **2**). A thickness T of the spacer body **274** may be the distance between the surfaces **276**, **278** (e.g., FIGS. **5**C and **7**B). As the thickness T increases, a greater compressive force may be needed to cause abutment between the first bone portion **270-1** and the second bone portion **270-2** when the compressive spacer **272** is removed. In implementations, the thickness T may therefore be preselected in order to evaluate the compressive force of an implant **230** selection and/or configuration. In implementations, a set of compression spacers **272** of various dimensions (e.g., thicknesses) may be provided with the physical anatomical model **248** as a kit. The surgeon or clinical user may select one or more compression spacers **272** from the kit to evaluate the compression associated with a selected implant **230** that may secure the two portions **270-1**, **270-2** to each other. The set of compression spacers **272** may include incremental thicknesses and/or a preselected thickness associated with a surgical plan **131** (FIG. **2**).

[0113] FIG. **8** discloses a cross sectional view through the interface **273**. The aperture **279** may be dimensioned to allow the implant **230** to extend through the compression spacer **272**. The implant **230** may be dimensioned to pass through the aperture **279** for securing the first and second bone portions **270-1**, **270-2** each other (e.g., FIGS. **7**A-**7**C). The compression spacer **272** may be removable from the physical anatomical model **248** when the first and second bone portions **270-1**, **270-2** are secured together.

[0114] FIG. **9** discloses the physical anatomical model **248** after the compression spacer **272** (not shown) is removed and sufficient compressive force is achieved. The implant **230** has achieved sufficient compressive force, such that the

first bone portion **270-1** and the second bone portion **270-2** are in abutment at the interface **273**.

[0115] FIG. **10** discloses the physical anatomical model **248** after the compression spacer **272** (not shown) is removed and insufficient compressive force is achieved. The implant **230** has not achieved sufficient compressive force, such that the first bone portion **270-1** and the second bone portion **270-2** are spaced from one another and not in abutment. There remains a gap G after removal of the compression spacer **272**. The gap G may be equal to or less than the thickness T of the compression spacer **272** (FIG. **7**B).

[0116] Referring to FIGS. **11** and **12**, after the compression spacer **272** (not shown) is removed and sufficient compressive force is achieved, a locking key **287** may be inserted into the openings **284** to limit relative rotation, such as rotation about the axis x, of the first bone portion **270-1** and the second bone portion **270-2**. The locking key **287** may limit relative axial movement of the first bone portion **270-1** and the second bone portion **270-2** along the axis x. A number of locking protrusions **288** (indicated at **288-1**, **288-2**, **288-3**, **288-4**) are dimensioned to be received within the openings **284**. The locking protrusion **288-1** may be received within the opening **284-1**, the locking protrusion **288-2** may be received within the opening **284-2**, the locking protrusion **288-3** may be received within the opening **284-3**, and locking protrusion **288-4** may be received within the opening **284-4**. The locking protrusions **288** may be shaped similarly to the protrusions **286** of the compression spacer **272**. The locking protrusions may include cylindrical bodies dimensioned to mate with the respective opening **284**. In implementations, there may be one locking protrusion **288** per opening **284**. The locking protrusions **288** may be spaced from a handle **289** for insertion and removal of the locking key **287**. In implementations, the locking key **287** may be configured substantially similarly to an associated compression spacer **272**, but the locking key **287** does not have a spacer body **274** (see FIGS. **5**A-**5**C).

[0117] FIG. **13** discloses a system **350** including physical anatomical model **348** and a compression spacer **372**. In implementations, the compression spacer **372** may act as a spacer to hold the proximal and distal portions **370-1**, **370-2** of a model tibia together for an implant **330** installation for a TTC fusion procedure. The implant **330** may be a hindfoot nail for a TTC fusion procedure. In implementations, the compression spacer **372** may be dimensioned to allow the implant **330** to compress a distance (e.g., 2 mm) after removal of the compression spacer **372** from the physical anatomical model **348**. The implant **330** may extend through a third bone portion **370-3**. The third bone portion **370-3** may be representative of a talus. The implant **330** may extend through a fourth bone portion **370-4**. The fourth bone portion **370-4** may be representative of a calcaneus.

[0118] FIG. **14** discloses a method of planning and performing a surgical procedure in a flowchart **490** according to an implementation. The method **490** may be utilized to pre-operatively plan, rehearse and/or train for various surgical procedures. The method **490** may be utilized with any of the planning systems and virtual and physical anatomical models disclosed herein. The method **490** may be utilized to evaluate the accuracy in which a surgeon implements a surgical procedure on a physical anatomical model associated with an anatomy of a patient. The method **490** may be utilized to evaluate compression between two or more portions of a physical anatomical model, which may be representative of portions of the same bone or two or more different (e.g., adjacent) bones. The method **490** may utilize one or more compression spacers to evaluate the compression, which may be established by a respective orthopaedic implant. Fewer or additional steps than are recited below could be performed within the scope of this disclosure, and the recited order of steps is not intended to limit this disclosure.

[0119] Referring to FIG. **2**, with continuing reference to FIG. **14**, at step **490-1**, one or more virtual anatomical models **129** may be generated or otherwise defined. Each virtual anatomical model **129** may be associated with an anatomy of a patient and may be generated utilizing any of the techniques disclosed herein.

[0120] At step **490-2**, one or more virtual anatomical models **129** may be selected from a set of virtual anatomical models **129**. The virtual anatomical models **129** may be stored in memory of a computing device, such as in the database **128** or the memory **134** of the computing device **132**. Selecting the virtual anatomical model **129** may include selecting from various parameters associated with the set of virtual anatomical models **129**. The parameters may include any of the parameters disclosed herein, including patient classification, anatomy and/or defect. The parameters may be selected in response to user interaction with the graphical user interface **142**. The virtual anatomical models **129** may include any of the anatomies and tissue types disclosed herein, including bone, ligament, tendon, cartilage, etc. At step **490-3**, the selected virtual anatomical model(s) **129** may be viewed in the graphical user interface **142**.

[0121] At step **490-4**, one or more implant models **130** may be selected and/or positioned relative to the selected virtual anatomical model(s) **129**. Each implant model **130** may be selected from a set of implant models **130**. The implant models **130** may be stored in memory of a computing device, such as in the database **128** or the memory **134** of the computing device **132**. The implant models **130** may be associated with any of the implants disclosed herein.

[0122] At step **490-5**, aspects of one or more of the virtual anatomical models **129** may be defined. Each virtual anatomical model **129** may be defined prior, during and/or subsequent to generating the virtual anatomical model **129** at step **490-1** and/or selecting the virtual anatomical model **129** at step **490-2**. Defining the virtual anatomical model **129** may include setting one or more parameters of the virtual anatomical model **129**, including any of the parameters disclosed herein. The parameters may be selected in response to user interaction with the graphical user interface **142**. The parameters may be associated with one or more indicators.

[0123] At step **490-6**, one or more configurations (e.g., definitions) **145** may be generated. Each configuration **145** may be associated with a physical anatomical model **148** and may be generated utilizing any of the techniques disclosed herein. The configuration **145** may be representative of the selected virtual anatomical model **129**. Each configuration may be generated in response to selecting the respective virtual anatomical model **129** at step **490-2** and/or defining the selected virtual anatomical model **129** at step **490-5**. The configuration **145** may be established according to the selection or specification of any parameters associated with the selected virtual anatomical model **129**. The configuration **145** may include data and other information sufficient to

establish a physical anatomical model **148** based on the parameters of the selected virtual anatomical model **129**, including coordinate information, moduli of elasticity and color schemes of the associated tissues, etc.

[0124] Referring to FIGS. **4** and **5**A-**5**C, with continuing reference to FIGS. **2** and **14**, step **490-6** may include generating a configuration for a compression spacer **272**. Dimensions of the spacer **272** may be established based on a (e.g., preselected) compressive force of an implant **230**. With reference to FIGS. **5**C and **7**B, a thickness T of the spacer **272** may be selected based on a (e.g., preselected) compressive force of the implant **230**. The spacer **272** may be dimensioned to evaluate compression between two or more adjacent bones, which may establish a joint through which the implant **230** may pass.

[0125] At step **490-7**, one or more physical anatomical models **248** may be fabricated or otherwise formed based on the generated configuration **145**. Each physical anatomical model **248** may be formed utilizing any of the techniques disclosed herein. The physical anatomical model **248** may be a monolithic structure or may have one or more portions releasably secured to each other. The spacer **272** may be fabricated or otherwise formed based on the generated configuration **145**.

[0126] Various techniques may be utilized to form the physical anatomical models. Each physical anatomical model may be formed utilizing any of the techniques disclosed herein, such as rapid prototyping (e.g., printing) and other additive manufacturing techniques, casting, machining, etc. The physical anatomical model may have a unitary construction or may have two or more components fixedly attached or otherwise secured to each other to establish a unit.

[0127] In the implementation of FIG. **15**, one or more layers **592** of material may be printed or otherwise formed on a substrate **593** to establish a physical anatomical model **548**. The physical anatomical model **548** may be representative of a virtual anatomical model, including any of the virtual anatomical models disclosed herein. A device **594** such as a three-dimensional printer may be configured to form the layers **592** according to data and other information associated with the respective configuration **145**. The layers **592** of material may include any of the constructions, materials, color schemes, textures, porosities, etc. disclosed herein. The layers **592** may have respective moduli of elasticity that may substantially correspond to moduli of elasticity of respective biomaterial of the anatomy. The porosities of the material forming the physical anatomical model **548** may substantially approximate the porosity or density of the respective tissue. The physical anatomical model **548** may be formed with materials having different transparencies, translucence, opacity, etc., utilizing any of the techniques disclosed herein.

[0128] Step **490-7** may include forming the layers **592** of material to establish the physical anatomical model **548**. The layers **592** may be formed concurrently and/or sequentially. Each layer L may be homogenous or heterogenous. Heterogenous layers may incorporate different regions associated with respective tissue types, densities, porosities, colors, etc. Step **490-7** may include printing the layers **592** of material on each other to establish one or more components of the physical anatomical model **548**, including any of the components disclosed herein.

[0129] Referring to FIG. **4**, with continuing reference to FIGS. **2** and **14**, at step **490-8** the physical anatomical model **248** may be positioned or otherwise prepared. The physical anatomical model **248** may be secured to one or more fixtures **266** to establish an assembly **268**.

[0130] At step **490-9**, one or more modifications to the physical anatomical model(s) **248** may be performed. Step **490-9** may include removing a portion of the physical anatomical model **248** to establish a revised physical anatomical model **248**. Various modifications may be performed to simulate surgical operations performed on an anatomy, including any of the modifications disclosed herein such as one or more incision, cutting, drilling, reaming, resection and implantation operations. Each modification may result in permanently altering a geometry of the physical anatomical model **248**.

[0131] Referring to FIGS. **4** and **9-10**, with continuing reference to FIG. **14**, at step **490-10** the physical anatomical model(s) **248** may be evaluated utilizing any of the techniques disclosed herein. Step **490-10** may include position a compression spacer **272** between the first bone portion **270-1** and the second bone portion **270-2** to establish a gap G. The first and/or second bone portions **270-1**, **270-2** and compression spacer **272** may be under a compressive load at an interface **273**. The compressive load may be established by an orthopaedic implant **230**. The compression spacer **272** may be dimensioned to separate the first and second bone portions **270-1**. The compression spacer **272** may be selected from a set of compression spacers **272** having various thicknesses, which may be incremental and/or specified in a surgical plan **131** (FIG. **2**). Step **490-10** may include removing the compression spacer **272** from the gap G between the first bone portion **270-1** and the second bone portion **270-2**, including when the first and/or second bone portions **270-1**, **270-2** are under a compressive load. Step **490-10** may include evaluating compression of the implant **230** by determining whether the first bone portion **270-1** abuts the second bone portion **270-2** after removing the compression spacer **272** from between the first and second bone portions **270-1**, **270-2**. With reference to FIGS. **11** and **12**, after removal of the compressor spacer **272**, a locking key **287** may be positioned to prevent relative rotation and or axial movement of the first and second bone portions **270-1**, **270-2**.

[0132] The novel devices and methods of this disclosure provide versatility in planning, rehearsing and training for surgical procedures utilizing physical anatomical models. The physical anatomical models may be representative of various anatomy. The surgeon may interact with the disclosed system to gain familiarity with the selected anatomy and various surgical procedures that may be utilized to implement a surgical plan, including testing and evaluating the compression of implants in various orthopaedic procedures.

[0133] Although the different examples are illustrated as having specific components, the examples of this disclosure are not limited to those particular combinations. It is possible to use some of the components or features from any of the embodiments in combination with features or components from any of the other embodiments.

[0134] The foregoing description shall be interpreted as illustrative and not in any limiting sense. A worker of ordinary skill in the art would understand that certain modifications could come within the scope of this disclo-

sure. For these reasons, the following claims should be studied to determine the true scope and content of this disclosure.

1. A system for an orthopaedic procedure comprising:

a physical anatomical model including a main body representative of anatomy, wherein the main body includes a first bone portion and a second bone portion; and

a compression spacer positionable to establish a gap at an interface between the first bone portion and the second bone portion, wherein the compression spacer is associated with a preselected compressive force relating to the gap.

2. The system of claim **1**, wherein the compression spacer includes a spacer body extending between a first surface and a second surface, the first surface dimensioned to abut the first bone portion, and the second surface dimensioned to abut the second bone portion.

3. The system of claim **2**, wherein the spacer body includes a periphery adjoining the first surface and the second surface.

4. The system of claim **3**, wherein the periphery of the spacer body has a contour dimensioned to substantially match a bone contour of at least one of the first bone portion and the second bone portion.

5. The system of claim **3**, wherein the compression spacer includes a slot dimensioned to allow passage of an implant through the interface.

6. The system of claim **5**, wherein the compression spacer includes a first protrusion receivable in a first opening in the first bone portion to limit relative movement between the compression spacer and the first bone portion.

7. The system of claim **6**, wherein the first protrusion includes a cylinder having a longitudinal axis substantially parallel with the first surface.

8. (canceled)

9. The system of claim **6**, wherein the compression spacer includes a second protrusion receivable in a second opening in the first bone portion, and the first protrusion is opposite the slot from the second protrusion.

10. The system of claim **6**, wherein the compression spacer includes a second protrusion receivable in a second opening in the first bone portion, and the first protrusion extends from the first surface, the first opening is established in the first bone portion, the second protrusion extends from the second surface, and the second opening is established in the second bone portion such that the compression spacer limits relative movement between the first and second bone portions at the interface in an assembled position.

11. The system of claim **1**, wherein the compression spacer includes a first protrusion receivable in a first opening in the first bone portion to limit relative movement between the compression spacer and the first bone portion.

12. The system of claim **11**, wherein the compression spacer includes a second protrusion receivable in a second opening in the second bone portion to limit relative movement between the compression spacer and the second bone portion.

13. The system of claim **1**, wherein the compression spacer includes an aperture dimensioned to receive an implant extending through the first bone portion and the second bone portion.

14. The system of claim **13**, wherein the implant includes an intramedullary nail.

15. The system of claim **13**, wherein the preselected force is selected such that removal of the compression spacer causes the first and second bone portions to abut each other at the interface, and the compression spacer is removable to evaluate compression between the first and second bone portions at the interface in response to a compressive force established by the implant.

16. (canceled)

17. (canceled)

18. The system of claim **1**, wherein the compression spacer includes a handle for removing the compression spacer from the gap.

19. The system of claim **1**, wherein the compression spacer includes a first set of protrusions receivable in a first set of openings in the first bone portion and a second set of protrusions receivable in a second set of openings in the second bone portion to limit relative movement between the first and second bone portions.

20. A system for an orthopaedic procedure comprising:

a physical anatomical model representative of anatomy, wherein the physical anatomical model includes a first bone portion and a second bone portion; and

a compression spacer dimensioned to separate the first bone portion and the second bone portion under a compressive load such that removal of the compression spacer causes movement between the first bone portion and the second bone portion, and including an aperture dimensioned to receive an implant extending through the first bone portion and the second bone portion, wherein a periphery of the compression spacer is dimensioned to substantially match a contour of the anatomy, and a thickness of the compression spacer is associated with a preselected compressive force such that removal of the compression spacer causes abutment between the first bone portion and the second bone portion in response to the compressive load being equal to or exceeding the preselected compressive force.

21. (canceled)

22. (canceled)

23. (canceled)

24. (canceled)

25. (canceled)

26. A method of rehearsing for a surgical procedure comprising:

accessing a virtual anatomical model associated with an anatomy of a patient;

generating a configuration associated with a physical anatomical model that is representative of the virtual anatomical model;

forming the physical anatomical model, the physical anatomical model including a body associated with an anatomical profile of a bone, the body including a first bone portion and a second bone portion; and

forming a compression spacer insertable between the first bone portion and the second bone portion.

27. The method of claim **26**, the method comprising:

inserting an orthopaedic implant through the first bone portion and the second bone portion;

after inserting the orthopaedic implant, removing the compression spacer from a gap between the first bone portion and the second bone portion; and

evaluating compression of the orthopaedic implant by determining whether the first bone portion abuts the second bone portion after removing the compression spacer.

28. (canceled)

29. (canceled)

30. (canceled)

31. (canceled)

32. (canceled)

33. (canceled)

34. (canceled)

35. (canceled)

36. (canceled)

37. (canceled)

38. (canceled)

39. (canceled)

40. (canceled)

41. (canceled)

42. (canceled)

43. The system of claim **20**, wherein the compression spacer includes a first protrusion receivable in a first opening in the first bone portion to limit relative movement between the compression spacer and the first bone portion, the compression spacer includes a second protrusion receivable in a second opening in the first bone portion, and the first protrusion is opposite the aperture from the second protrusion.

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