



(51) International Patent Classification:

A61C 8/00 (2006.01) A61C 13/23 (2006.01)
A61C 13/12 (2006.01)

(21) International Application Number:

PCT/US2013/073864

(22) International Filing Date:

9 December 2013 (09.12.2013)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

13/727,750 27 December 2012 (27.12.2012) US

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

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

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(54) Title: JIGS FOR PLACING DENTAL IMPLANT ANALOGS IN MODELS AND METHODS OF DOING THE SAME

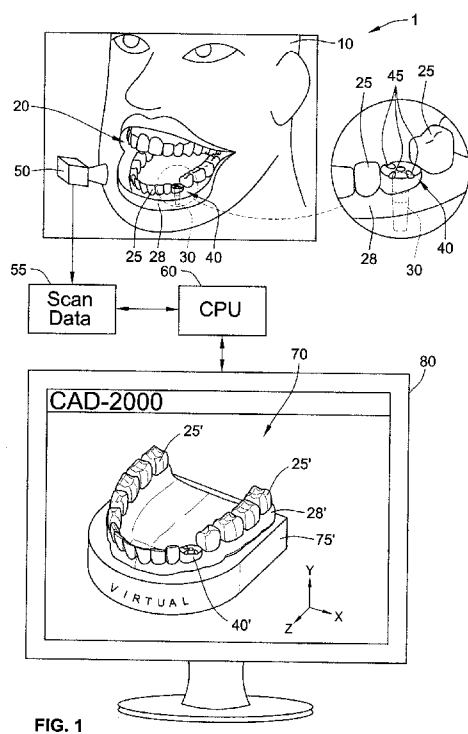


FIG. 1

(57) Abstract: A placement jig for locating a dental implant analog in a physical model of a patient's mouth includes a base, a guide-strut receiving feature, a throughbore, and an angled receiving feature. The guide-strut receiving feature is positioned within the base and is configured to receive a guide-strut of the physical model thereby positioning a lower surface of the placement jig at a desired distance from an opening of a bore in the physical model. The throughbore receives a screw therethrough that engages the dental implant analog such that the dental implant analog is removably coupled to the base. The angled receiving feature is positioned about the throughbore on the lower surface of the base. The angled receiving feature includes a mating surface that is configured to abut a custom abutment positioned between the mating surface and the dental implant analog.

**Declarations under Rule 4.17:**

- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:

- *with international search report (Art. 21(3))*
- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

JIGS FOR PLACING DENTAL IMPLANT ANALOGS IN MODELS AND METHODS OF DOING THE SAME

FIELD OF THE INVENTION

[0001] The present disclosure relates generally to developing a tooth prosthesis. More particularly, the present disclosure relates to using a placement jig to place a dental implant analog in a model of a patient's mouth for use in creating a tooth prosthesis.

BACKGROUND OF THE INVENTION

[0002] The dental restoration of a partially or wholly edentulous patient with artificial dentition is typically done in two stages. In the first stage, an incision is made through the gingiva to expose the underlying bone. An artificial tooth root, in the form of a dental implant, is placed in the jawbone for osseointegration. The dental implant generally includes a threaded bore to receive a retaining screw for holding mating components thereon. During the first stage, the gum tissue overlying the implant is sutured and heals as the osseointegration process continues.

[0003] Once the osseointegration process is complete, the second stage is initiated. Here, the gingival tissue is re-opened to expose an end of the dental implant. A healing component or healing abutment is fastened to the exposed end of the dental implant to allow the gingival tissue to heal therearound. It should be noted that the healing abutment can be placed on the dental implant immediately after the implant has been installed and before osseointegration, thereby, for some situations, combining the osseointegration step and gingival healing step into a one-step process.

[0004] Implant dentistry restorative methods have advanced beyond requiring a fixture-level (e.g., dental implant level) impression as the starting point for developing a final dental prosthesis. In some such cases pre-defined scan bodies (e.g., Encode Healing Abutments available from Biomet 3i, LLC) are assembled to the dental implants prior to and/or during the gingival healing stage. The pre-defined scan bodies include scannable features (e.g., markers) that, when scanned and interpreted, provide information about the location and orientation of the underlying dental implant that is used in developing the final dental prosthesis.

[0005] A model of the patient's mouth is typically created for use in developing the final dental prosthesis. The model of the patient's mouth is modified to include a dental

implant analog that is placed/installed in the model at a position corresponding to the position of the actual underlying dental implant in the patient's mouth. Some prior methods of placing the dental implant analog in the model of the patient's mouth required the use of a robot. Although such methods using robotic placement provide benefits (e.g., accurate placement of the dental implant analog), such methods are reliant on having robotic equipment and accompanying software. Thus, a need exists for other alternative methods for placing dental implant analogs in a model of a patient's mouth for use in developing a final dental prosthesis. The present disclosure is directed to solving these and other needs.

SUMMARY OF THE INVENTION

[0006] The present disclosure provides methods for developing and fabricating permanent patient-specific prostheses without needing robotic placement equipment. In particular, the present disclosure provides methods for using dental implant analog placement jigs for placing a dental implant analog in a modified model of a patient's mouth for use in developing a permanent patient-specific prosthesis thereon. The placement jig can be a standard jig or a custom jig. The modified model of the patient's mouth includes a bore for receiving the dental implant analog therein at a position corresponding to the position of a dental implant installed in the patient's mouth. The modified model also includes one or more guide struts protruding from a base of the model. The placement jig is registered on the model by inserting the one or more guide struts into corresponding guide-strut receiving features in the placement jig. As such, the dental implant analog coupled to the placement jig is properly located within the bore at a position and an orientation corresponding to the location and the orientation of the dental implant installed in the patient's mouth. The dental implant analog can then be secured to the model using a securing material (e.g., glue, epoxy, acrylic, etc.). Then the placement jig is detached from the model and the permanent patient-specific prosthesis can be formed thereon.

[0007] A method of locating a dental implant analog in a model of a patient's mouth for use in creating a tooth prosthesis includes scanning at least a portion of the patient's mouth to generate scan data. The scanned portion of the patient's mouth includes teeth and an attachment member. The attachment member includes at least one informational marker indicating the location of a dental implant installed in the patient's mouth. A three-dimensional computer model of at least a portion of the patient's mouth is created using the scan data. The three-dimensional computer model includes (i) virtual teeth that correspond

with the teeth in the patient's mouth, (ii) a virtual bore at a position based on the at least one informational marker, and (iii) at least one virtual guide strut positioned adjacent to the virtual teeth. A physical model of the at least a portion of the patient's mouth is fabricated using a fabrication machine based on the three-dimensional computer model. The physical model includes (i) a bore corresponding to the virtual bore, and (ii) at least one guide strut corresponding to the at least one virtual guide strut. The at least one guide strut is used in positioning the dental implant analog within the bore of the physical model at a position and an orientation corresponding to the location and the orientation of the dental implant in the patient's mouth.

[0008] A method of locating a dental implant analog in a model of a patient's mouth for use in creating a tooth prosthesis includes creating a three-dimensional computer model of at least a portion of the patient's mouth using scan data from a scan of the patient's mouth. The three-dimensional computer model includes (i) virtual teeth that correspond with teeth in the patient's mouth and (ii) a virtual bore at a position based on at least one informational marker on an attachment member in the patient's mouth. The at least one informational marker indicates the location and the orientation of a dental implant installed in the patient's mouth. The three-dimensional computer model further includes (iii) a virtual guide strut positioned adjacent to the virtual teeth. A physical model of the at least a portion of the patient's mouth is fabricated using a fabrication machine based on the three-dimensional computer model. The physical model includes (i) a bore corresponding to the virtual bore, and (ii) a guide strut corresponding to the virtual guide strut. The dental implant analog is coupled to a placement jig. The placement jig includes a guide-strut receiving feature to be used in conjunction with the guide strut of the physical model in positioning the dental implant analog within the bore of the physical model at a position and an orientation corresponding to the location and the orientation of the dental implant in the patient's mouth.

[0009] A method of locating a dental implant analog in a model of a patient's mouth for use in creating a tooth prosthesis includes creating a three-dimensional computer model of at least a portion of the patient's mouth using scan data from a scan of the patient's mouth. The three-dimensional computer model includes (i) virtual teeth that correspond with teeth in the patient's mouth and (ii) a virtual bore at a position based on at least one informational marker on an attachment member in the patient's mouth. The at least one informational marker indicates the location and the orientation of a dental implant installed in the patient's mouth. The three-dimensional computer model further includes (iii) a virtual guide strut

positioned adjacent to the virtual teeth. The method further includes fabricating, using a fabrication machine, a physical model of the at least a portion of the patient's mouth based on the three-dimensional computer model. The physical model includes (i) a bore corresponding to the virtual bore, and (ii) a guide strut corresponding to the virtual guide strut. The dental implant analog is coupled to an adjustable arm of a placement jig. The adjustable arm has at least two degrees of rotational freedom with respect to a base of the placement jig. The base of the placement jig further includes a guide-strut receiving feature to be used in conjunction with the guide strut of the physical model in positioning the dental implant analog within the bore of the physical model at a position and an orientation corresponding to the location and the orientation of the dental implant in the patient's mouth.

[0010] A placement jig for locating a dental implant analog in a physical model of at least a portion of a patient's mouth for use in creating a tooth prosthesis includes a base, a guide-strut receiving feature, a throughbore, and an angled receiving feature. The base has an upper surface and a lower surface. The guide-strut receiving feature is positioned within the base and is configured to receive a guide-strut of the physical model thereby positioning the lower surface of the placement jig at a desired distance from an opening of a bore in the physical model. The throughbore is for receiving a screw therethrough. The screw is configured to be coupled with the dental implant analog such that the dental implant analog is removably coupled to the base. The throughbore has a central axis oriented at an angle relative to the lower surface of the base. The angled receiving feature is positioned about the throughbore on the lower surface of the base. The angled receiving feature includes a mating surface that is configured to abut a custom abutment positioned between the mating surface and the dental implant analog. The central axis of the throughbore is perpendicular to the angled receiving feature.

[0011] A placement jig for locating a dental implant analog in a physical model of at least a portion of a patient's mouth for use in creating a tooth prosthesis includes a base, a guide-strut receiving feature, and an adjustable arm. The base has an upper surface spaced from a lower surface. The guide-strut receiving feature is positioned within the base and is configured to receive a guide-strut of the physical model to position the lower surface of the placement jig a desired distance from an opening of a bore in the physical model. The adjustable arm extends from the lower surface of the base and is configured to be removably coupled to the dental implant analog. The adjustable arm has at least two degrees of rotational freedom with respect to the base.

[0012] A physical model of a patient's mouth for use in creating a tooth prosthesis includes a model base, model teeth, a bore, and a first guide strut. The model teeth protrude from the model base. The model teeth correspond with teeth in the patient's mouth. The bore is in the model base and is configured to receive a dental implant analog therein. The bore is also positioned adjacent to at least one of the model teeth. The first guide strut protrudes from the model base and is configured to mate with a positioning jig to position the dental implant analog within the bore at a position and an orientation corresponding to the location and the orientation of a dental implant in the patient's mouth.

[0013] Additional aspects and implementations of the present disclosure will be apparent to those of ordinary skill in the art in view of the detailed description of various implementations, which is made with reference to the drawings, a brief description of which is provided below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The foregoing and other advantages of the disclosure will become apparent upon reading the following detailed description and upon reference to the drawings.

[0015] FIG. 1 is an illustrative flow diagram of a patient's mouth including an abutment installed therein being scanned and processed by a CPU to create an unmodified three-dimensional computer model of the patient's mouth according to some implementations of the present disclosure;

[0016] FIG. 2 is an illustrative flow diagram of a modified version of the three-dimensional computer model of the patient's mouth of FIG. 1 being processed by a CPU and sent to a fabrication machine;

[0017] FIG. 3 is an illustrative flow diagram of the fabrication machine of FIG. 2 creating a physical model of the patient's mouth including a bore and a guide struts according to some implementations of the present disclosure;

[0018] FIGS. 4A and 4B are an exploded perspective views of a dental implant analog placement jig assembly according to some implementations of the present disclosure;

[0019] FIGS. 4C and 4D are assembled perspective views of the dental implant analog placement jig assembly of FIGS. 4A and 4B;

[0020] FIGS. 4E and 4F are cross-sectional views of the assembled dental implant analog placement jig assembly of FIG. 4D;

[0021] FIG. 5 is a perspective view of the assembled dental implant analog placement jig assembly of FIGS. 4C-4F registered on the physical model of the patient's mouth of FIG. 3;

[0022] FIG. 6 is a perspective view of FIG. 5 with the dental implant analog placement jig removed from the dental implant analog placement jig assembly;

[0023] FIG. 7 is a perspective view of FIG. 6 with the abutment removed from the dental implant analog placement jig assembly revealing the installed dental implant analog;

[0024] FIG. 8A is a perspective view of a dental implant analog placement jig including an adjustable arm according to some implementations of the present disclosure; and

[0025] FIGS. 8B and 8C are cross-sectional views of the dental implant analog placement jig of FIG. 8A.

[0026] While the present disclosure is susceptible to various modifications and alternative forms, specific embodiments have been shown by way of example in the drawings and will be described in detail herein. It should be understood, however, that the present disclosure is not intended to be limited to the particular forms disclosed. Rather, the present disclosure is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the present disclosure as defined by the appended claims.

DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[0027] When developing a permanent patient-specific prosthesis, the process typically begins with the installation of a dental implant in a patient's mouth. An attachment member, such as, for example, a healing abutment or an abutment, is typically attached to the dental implant and the mouth is allowed to heal therearound (e.g., osseointegration of the dental implant occurs). At some point thereafter, the patient returns to the dentist or clinician such that a model of the patient's mouth can be created for use in designing/developing and/or fabricating the permanent patient-specific prosthesis. The following disclosure includes description of a method(s) of creating such a model that can be used for designing/developing and/or fabricating the permanent patient-specific prosthesis thereon, where the model includes a dental implant analog.

[0028] The term "dental implant analog" as used herein has the meaning ascribed to it by persons of ordinary skill in the field of dental implants, dental implant systems, and related dental systems. Generally, the term "dental implant analog" refers to a component used in a model of a mouth of a patient that is used to represent the underlying dental implant

installed in the patient's mouth. The dental implant analog can be an actual dental implant that is just attached to the model of the patient's mouth instead of being installed in a real mouth of a patient. In most instances, the dental implant analog is a modified version of a dental implant installed in a patient's mouth. For example, the subgingival portion of a dental implant analog is generally different (e.g., no external threads) than the subgingival portion of a dental implant (e.g., external threads) installed in a patient's mouth.

[0029] Referring to FIG. 1, an illustrative flow diagram 1 of a mouth 20 of a patient 10 being scanned by an intraoral scanner 50 to create an unmodified virtual three-dimensional computer model 70 of the patient's mouth 20 is shown. The patient's mouth 20 includes teeth 25, gingival tissue 28, a dental implant 30 installed therein, and an attachment member such as, for example, a scanning member and/or an abutment 40 attached to the dental implant 30. As shown in FIG. 1, the scanning member/abutment 40 is a healing abutment such as, for example, an ENCODE® Healing abutment available from Biomet 3i, LLC; although the scanning member/abutment 40 can be any type of scanning member. The abutment 40 includes one or more informational markers 45 that when scanned by the scanner 50 and interpreted by, for example, the CPU 60 provide information about the location (e.g., position of a table of the dental implant along the Y-axis) and orientation (e.g., rotational position of a non-round feature of the dental implant about the Y-axis) of the underlying dental implant 30. Additional details on abutments, informational markers, uses of the same, and interpreting the same can be found in U.S. Pat. No. 6,790,040.

[0030] The scanner 50 used to scan the mouth 20 of the patient 10 can be any type or kind of scanner, such as, for example, a 3D dental scanner (e.g., model nos. D500, D700, D710, D800, and D810) available from 3Shape A/S located in Copenhagen, Denmark or a LAVA Chairside Oral Scanner available from 3M located in Saint Paul, Minnesota. The scanning of the mouth 20 generates scan data 55 associated with the teeth 25, the gingival tissue 28, and the abutment 40 that can be used by, for example, the CPU 60 to create the unmodified virtual three-dimensional computer model 70 of the mouth 20 of the patient 10. Thus, the scanning of the mouth 20 captures all of the contours, sizes, and shapes of the teeth 25, gingival tissue 28, and abutment 40 in a digital format that can be displayed as the unmodified virtual three-dimensional computer model 70 of the mouth 20 of the patient 10 on a display device 80 (e.g., computer monitor). Specifically, at a minimum, the area of the mouth 20 including the abutment 40 and the immediately adjacent teeth 25 and gingival

tissue 28 is scanned such that the unmodified virtual three-dimensional computer model 70 is a complete virtual replica of the scanned area of the mouth 20.

[0031] The unmodified virtual three-dimensional computer model 70 of the patient's mouth 20 includes virtual teeth 25', virtual gingival tissue 28', and a virtual abutment 40'. Each of the virtual teeth 25', virtual gingival tissue 28', and virtual abutment 40' is coupled to a virtual base 75' for supporting the same thereon. The virtual teeth 25' correspond to the teeth 25 in the mouth 20 of the patient 10. Similarly, the virtual gingival tissue 28' and the virtual abutment 40' correspond to the gingival tissue 28 and the abutment 40, respectively. Notably, the unmodified virtual three-dimensional computer model 70 does not include a virtual dental implant that corresponds with the dental implant 30 as the dental implant 30 is not viewable and/or scannable by the scanner 50 (e.g., the dental implant 30 is obscured by the gingival tissue 28 and/or the abutment 40).

[0032] The unmodified virtual three-dimensional computer model 70 is modified into a modified virtual three-dimensional computer model 90, shown in the illustrative flow diagram 2 of FIG. 2. Specifically, the unmodified virtual three-dimensional computer model 70 is virtually modified into the modified virtual three-dimensional computer model 90 by virtually removing the virtual abutment 40' (e.g., the modified virtual three-dimensional computer model 90 lacks the virtual abutment 40'). Additionally, the unmodified virtual three-dimensional computer model 70 is virtually modified into the modified virtual three-dimensional computer model 90 by virtually creating a virtual bore 100' and by virtually creating one or more virtual guide struts 110a-c' adjacent to the virtual bore 100', as shown in FIG. 2.

[0033] The virtual bore 100' is generally cylindrical and has a central axis 100'_{CA}. The central axis 100'_{CA} of the virtual bore 100' is substantially vertical (e.g., parallel with vertical or the Y-axis). Each of the virtual guide struts 110a-c' has a generally cylindrical rod-like shape with respective central axes 110a-c'_{CA}. The central axes 110a-c'_{CA} of the virtual guide struts 110a-c' are also substantially vertical (e.g., parallel with vertical or the Y-axis).

[0034] In some alternative implementations, the central axis 100'_{CA} of the virtual bore 100' and/or the central axes 110a-c'_{CA} of the virtual guide struts 110a-c' can be at an angle with respect to vertical (e.g., the Y-axis), which is not shown in the FIGS. In some such alternative implementations, the central axis 100'_{CA} of the virtual bore 100' is parallel with the central axes 110a-c'_{CA} of the virtual guide struts 110a-c'. In other such alternative

implementations, the central axis 100'_{CA} of the virtual bore 100' is not parallel with the central axes 110a-c'_{CA} of the virtual guide struts 110a-c'.

[0035] In order to determine the location (e.g., X-Z plane position) and orientation (e.g., angle of the central axis with respect to the Y-axis) for the virtual bore 100' and/or the virtual guide struts 110a-c' in the modified virtual three-dimensional computer model 90, the CPU 60 analyzes the scan data 55 using, for example, one or more software programs. In particular, the one or more software programs analyze and/or determine information associated with the informational markers 45 on the abutment 40, which provides information about the location and orientation of the actual underlying dental implant 30 in the mouth 20 of the patient 10. Based on the determined location and orientation of the actual underlying dental implant 30, the one or more software programs determine appropriate locations and orientations for the virtual bore 100' and the virtual guide struts 110a-c' in the modified virtual three-dimensional computer model 90.

[0036] Examples of the one or more software programs used to create the unmodified virtual three-dimensional computer model 70 and the modified virtual three-dimensional computer model 90 include CAD Design Software available from 3Shape A/S located in Copenhagen, Denmark; DentalCAD available from exocad GmbH in Darmstadt, Germany; and DentCAD available from Delcam plc in Birmingham, United Kingdom.

[0037] After creating the modified virtual three-dimensional computer model 90, three-dimensional physical model instructions 120 (FIG. 2) are generated by, for example, the CPU 60. The three-dimensional physical model instructions 120 are sent to and/or transferred from the CPU 60 to a fabrication machine 130, such as, for example, a rapid-prototyping machine and/or a milling machine, for creating a modified physical model 140 (FIG. 3) of the mouth 20 of the patient 10. As shown in FIG. 3, the modified physical model 140 is substantially an exact replica of the modified virtual three-dimensional computer model 90.

[0038] Specifically, the modified physical model 140 includes model teeth 25'', model gingival tissue 28'', a model bore 100'', and model guide struts 110a-c''. Each of the model teeth 25'', model gingival tissue 28'', and model guide struts 110a-c'' is coupled to a model base 75'' for supporting the same thereon. Additionally, the model bore 100'' is formed within the model base 75''. The model teeth 25'' correspond to the virtual teeth 25' in the modified three-dimensional computer model 90 of the mouth 20 of the patient 10. Similarly, the model gingival tissue 28'' corresponds to the virtual gingival tissue 28'; the

model bore 100'' corresponds to the virtual bore 100'; and the model guide struts 110a-c'' correspond to the virtual guide struts 110a-c'. Additionally, the model base 75'', the model teeth 25'', the model gingival tissue 28'', and the model guide struts 110a-c'' are all made of the same material. For example, if a rapid prototype machine is used to fabricate the modified physical model 140, the model base 75'', the model teeth 25'', the model gingival tissue 28'', and the model guide struts 110a-c'' are all made of the same rapid prototype material. For another example, if a milling machine (e.g., a computer numerical controlled (CNC) milling machine) is used to fabricate the modified physical model 140, the model base 75'', the model teeth 25'', the model gingival tissue 28'', and the model guide struts 110a-c'' are all milled from a block of material (e.g., plastic, wax, metal, etc.).

[0039] With the modified physical model 140 created (FIG. 3), a dental implant analog is ready to be placed and secured thereto for use in developing a final dental prosthesis on the modified physical model 140. By the term "modified physical model" it is meant that the modified physical model 140 is a modified version of a model of the mouth 20 of the patient 10. Specifically, the modified physical model 140 is modified as compared to an unmodified physical model (not shown) of the mouth 20 of the patient 10 in that the modified physical model 140 includes the model bore 100'' and the model guide struts 110a-c'', which are not natural elements of the mouth 20 of the patient 10.

[0040] A dental implant analog can be placed and secured to the modified physical model 140 using a placement jig according to several aspects of the present disclosure. For example, as shown in FIGS. 4A-4F, a placement jig assembly 200 includes a placement jig 210, a dental implant analog 230, a spacer and/or custom abutment 240, and a fastener 250 (e.g., a screw). The placement jig assembly 200 has an unassembled configuration (FIGS. 4A and 4B) and an assembled configuration (FIGS. 4C-4F).

[0041] To assemble the placement jig assembly 200, the components of the placement jig assembly 200 are initially arranged as shown in FIGS. 4A and 4B. The custom abutment 240 is non-rotationally coupled to the dental implant analog 230 via, for example, complementary non-round features of the dental implant analog (e.g., a polygonal socket 232 shown in FIG. 4B) and the custom abutment 240 (e.g., a polygonal boss 242 shown in FIGS. 4A and 4B). The custom abutment 240 is then engaged (e.g., non-rotationally engaged) with the placement jig 210 as shown in FIGS. 4C and 4D and the fastener 250 is partially positioned through a throughbore 216 of the placement jig 210 and removably coupled to an internal-partially threaded bore (shown in FIG. 4E) of the dental implant analog 230. When

the placement jig assembly 200 is so assembled (FIGS. 4C-4F), the placement jig assembly 200 can be used to place the dental implant analog 230 in the modified physical model 140 (FIG. 3) at a position and an orientation corresponding to the position and orientation of the actual underlying dental implant 30 in the mouth 20 of the patient 10 (FIG. 1).

[0042] Referring generally to FIGS. 4A-4F, the placement jig 210 includes a base 212 including an upper surface 213a (best shown in FIGS. 4B and 4D) and a lower surface 213b (best shown in FIGS. 4A and 4C). The upper and lower surfaces 213a,b are generally planar, but can have other non-planar and/or partially non-planar shapes. The placement jig 210 also includes guide-strut receiving features 214a-c, the throughbore 216, and an angled receiving feature 218. Each of the guide-strut receiving features 214a-c is sized and positioned within the base 212 to receive a corresponding one of the model guide struts 110a-c" (FIG. 3) of the modified physical model 140 to register the placement jig assembly 200 (FIGS. 4B-4E) on the modified physical model 140 (FIG. 3) as shown in FIG. 5.

[0043] Once registered, the lower surface 213b (FIGS. 4A and 4C) of the base 212 of the placement jig 210 is positioned at a selected and/or desired distance from a model opening 102" (FIG. 3) of the model bore 100". In particular, the model guide struts 110a-c" each has a selected and/or determined length such that registration of the placement jig 210 with the modified physical model 140 causes the lower surface 213b of the base 212 to be positioned at the selected and/or desired distance from the model opening 102". As such, the dental implant analog 230 coupled to the placement jig 210 can be automatically positioned at a position (e.g., a height along the Y-axis) within the model bore 100" corresponding to a position of the actual underlying dental implant 30 (FIG. 1) in the mouth 20 of the patient 10.

[0044] The throughbore 216 of the placement jig 210 passes from the upper surface 213a of the base 212 to the angled receiving feature 218. The throughbore 216 provides access for the fastener 250 to be received through the placement jig 210 and to be coupled to the dental implant analog 230 as best shown in FIG. 4E.

[0045] The angled receiving feature 218 of the placement jig 210 is positioned about the throughbore 216 on the lower surface 213b of the base 212 as best shown in FIG. 4A. The angled receiving feature 218 includes a mating surface 219 for engaging (e.g., abutting and/or touching) a top edge 244 (FIG. 4B) of the custom abutment 240 when the placement jig assembly 200 is assembled (e.g., FIGS. 4C-4F). The mating surface 219 is generally planar and is at an angle with respect to the lower surface 213b of the base 212, which is best shown in FIGS. 4E and 4F. In addition to, or in lieu of, the angled receiving feature 218

including the mating surface 219, the angled receiving feature 218 can include a non-round bore-type portion for receiving at least a portion of the custom abutment 240 therein in a non-rotational fashion (not shown).

[0046] As shown in FIGS. 4E and 4F, the mating surface 219 is at an angle with respect to the horizontal plane (e.g., the X-Z plane). Additionally, the angle of the mating surface can have X and Z components (e.g., a compound angle), such as the exemplary mating surface 219 of the present disclosure, which has an X-component as illustrated by angle β_x (FIG. 4E), and a Z-component as illustrated by angle β_z (FIG. 4F). As such, when the dental implant analog 230 is coupled to the placement jig 210 via the fastener 250 – with the custom abutment 240 between the dental implant analog 230 and the mating surface 219 – a central axis 230_{CA} of the dental implant analog 230 is at an angle with respect to vertical (e.g., the Y-axis). Additionally, the angle of the central axis 230_{CA} has X and Z components, such as the exemplary central axis 230_{CA} of the dental implant analog 230 of the present disclosure, which has an X-component as illustrated by angle α_x (FIG. 4E), and a Z-component as illustrated by angle α_z (FIG. 4F).

[0047] The angle of the central axis 230_{CA} of the dental implant analog 230 with respect to vertical (e.g., the Y-axis) corresponds to (e.g., is substantially the same as) an angle of a central axis (not shown) of the underlying dental implant 30 installed in the mouth 20 of the patient 10. In order for the angle of the central axis 230_{CA} of the dental implant analog 230 to correspond to the central axis (not shown) of the underlying dental implant 30 (FIG. 1), the angled receiving feature 218 is selected and/or designed with the mating surface 219 having the angle with respect to the horizontal plane as described herein and as shown in FIGS. 4E and 4F. Thus, it should be understood that for substantially all modified physical models of patients' mouths (e.g., the modified physical model 140) made in accordance with the disclosed aspects herein, the angled receiving feature 218 will likely include a mating surface at a different angle with respect to horizontal as it is unlikely that two dental implants will be installed in a patient's mouth at the same angle. Methods for designing and/or fabricating such angled receiving features are disclosed below.

[0048] Further, in addition to the central axis 230_{CA} of the dental implant analog 230 being at an angle with respect to vertical, a central axis 216_{CA} (FIG. 4A) of the through bore 216 is oriented at the same angle relative to the lower surface 213b of the base 212, which aids in the attachment of the dental implant analog 230 and the custom abutment 240 to the placement jig 210 as shown in FIGS. 4C-4F. Further the central axis 216_{CA} (FIG. 4A) of the

through bore 216 is perpendicular to the mating surface 219 of the angled receiving feature 218.

[0049] Referring to FIG. 5, the placement jig assembly 200 is registered with the modified physical model 140. Specifically, the placement jig assembly 200 is registered by inserting the dental implant analog 230 (FIG. 4B) into the model bore 100" (FIG. 3) and by aligning and inserting the model guide struts 110a-c" into the guide-strut receiving features 214a-c (FIGS. 4A and 4C) of the placement jig 210. To accommodate for the angle $\alpha_{x,z}$ of the dental implant analog 230 when the model guide struts 110a-c" align with the guide-strut receiving features 214a-c, the model bore 100" has a diameter that is larger than a maximum diameter of the dental implant analog 230. The diameter of the model bore 100" is increased as a function of the angle $\alpha_{x,z}$ of the dental implant analog 230. For example, the diameter of the model bore 100" is increased as the angle $\alpha_{x,z}$ of the dental implant analog 230 increases. As such, the diameter of the model bore 100" includes a sufficient clearance for the dental implant analog 230 to be inserted at the angle $\alpha_{x,z}$, while allowing the model guide struts 110a-c" to align with and engage the guide strut receiving features 214a-c, thereby registering the placement jig assembly 200 on the modified physical model 140 as shown in FIG. 5.

[0050] Once the placement jig assembly 200 is registered on the modified physical model 140 (FIG. 5), the dental implant analog 230 can be secured to the model base 75". Securing material, such as, for example, glue, epoxy, acrylic, plaster, cement, etc., can be used to attach the dental implant analog 230 to the model base 75". The clearance around and/or below the dental implant analog 230 in the model bore 100" is filled with the securing material and allowed to harden, thereby securely attaching the dental implant analog 230 to the modified physical model 140 in a location and orientation corresponding to the position and orientation of the actual underlying dental implant 30 in the mouth 20 of the patient 10.

[0051] After the securing material hardens, the placement jig 210 can be removed by removing the fastener 250 as shown in FIG. 6. Removal of the placement jig 210 exposes the custom abutment 240 attached to the dental implant analog 230. The custom abutment 240 can be removably coupled to the dental implant analog 230 via second fastener (not shown) that is similar to the fastener 250, but is shorter in length. The second fastener (not shown) aids in keeping the custom abutment 240 attached to the dental implant analog 230 during fabrication of a final dental prosthesis on the modified physical model 140. A clinician and/or dentist can then fabricate a final dental prosthesis using the custom abutment 240

attached to the dental implant analog 230 on the modified physical model 140 shown in FIG. 6.

[0052] In some alternative implementations, the custom abutment 240 is a spacer (e.g., a dummy and/or temporary abutment) and not a custom abutment designed specifically for use in the final dental prosthesis for the patient 10 (e.g., not customized for the patient 10). In such an alternative implementation, after removing the placement jig 210, the spacer/custom abutment 240 is also removed to expose the attached dental implant analog 230 as shown in FIG. 7. From there, a final dental prosthesis can be fabricated directly on the dental implant analog 230 secured to the modified physical model 140.

[0053] The custom abutment 240 is included in the placement jig assembly 200 (FIGS. 4A-4E) in part to aid in the proper vertical placement of the dental implant analog 230. Without the custom abutment 240, when a clinician attempts to register the guide strut receiving features 214a-c of the placement jig 210 with the model guide struts 110a-c", the adjacent model teeth 25" would likely obstruct and/or interfere with the proper placement of the dental implant analog 230. By including the custom abutment 240 in the placement jig assembly 200, the custom abutment 240 provides additional vertical clearance for the dental implant analog 230 to be positioned within the model bore 100" at a height along the Y-axis that corresponds to the height of the actual underlying dental implant 30 (FIG. 1) installed in the mouth 20 of the patient 10.

[0054] Alternatively, in lieu of the custom abutment 240 being included in the placement jig assembly 200, the placement jig 210 can include a protrusion (not shown), such as, for example, a rod, a column, a shaft, etc., that extends from the lower surface 213b of the base 212 to which the dental implant analog 230 is coupled. In some such alternative implementations, the protrusion (not shown) includes a non-round tip (e.g., a polygonal boss) that can non-rotationally engage a corresponding non-round feature (e.g., the polygonal socket 232) of the dental implant analog 230.

[0055] As described herein, the placement jig 210 aids in placing the dental implant analog 230 into the model bore 100" having an orientation (e.g., rotational position) that corresponds to the orientation of the underlying dental implant 30 in the mouth 20 of the patient 10. In some implementations of the present disclosure, to aid in such placement, the custom abutment 240 can include a marking (e.g., a line, an arrow, a dot, a notch, a groove, a divot, a raised pimple, etc.) on an outer surface thereof that is adjacent to the top edge 244 (FIG. 4B) of the custom abutment 240. The marking on the custom abutment 240 is aligned

by, for example, a clinician or dentist, with a corresponding marking on the placement jig (e.g., on the mating surface 219, on the angled receiving feature 218, on the lower surface 213b of the base 212, etc.) to set the orientation of the dental implant analog 230 to correspond with the orientation of the underlying dental implant 30 in the mouth 20 of the patient 10. The corresponding marking on the placement jig 210 is positioned on the placement jig 210 based on the information determined from the scanning and/or processing of the scan data 55 (FIG. 1) associated with the informational markers 45 on the abutment 40 attached to the dental implant 30 installed in the mouth 20 of the patient 10 (FIG. 1).

[0056] As shown in FIGS. 4A-4F, the placement jig 210 includes the angled receiving feature 218. In such implementations, the angled receiving feature 218 is a custom feature that is built into the placement jig 210. For example, the placement jig 210 can start out as a stock jig blank without the angled receiving feature 218 therein. The angled receiving feature 218 can be, for example, milled into the lower surface 213b of the base 212, using a milling machine (not shown), based on the modified virtual three-dimensional computer model 90 and/or the information determined from the scanning and/or processing of the scan data associated with the informational markers 45 on the abutment 40 attached to the dental implant 30 installed in the mouth 20 of the patient 10 (FIG. 1).

[0057] For another example, the placement jig 210 can be custom made by, for example, a fabrication machine (e.g., a rapid prototyping machine, a milling machine, etc.). In such implementations of the presently disclosed concepts, a virtual placement jig (not shown) is designed using, for example, the CPU 60 and one or more software programs described herein. The virtual placement jig is designed based on the modified virtual three-dimensional computer model 90. After the virtual placement jig is designed, the CPU 60 develops three-dimensional jig instructions from the designed virtual placement jig. The developed three-dimensional jig instructions are transferred and/or sent to the fabrication machine (e.g., the fabrication machine 130), which fabricates the placement jig 210 including the angled receiving feature 218 and the guide strut receiving features 214a-c.

[0058] According to some alternative implementations, the mating surface 219 of the angled receiving feature 218 is parallel and/or coplanar with the lower surface 213b of the base 212 such that the placement jig 210 essentially lacks the angled receiving feature 218. In such an alternative implementation, the central axis 216_{CA} of the throughbore 216 is perpendicular to (e.g., ninety degrees relative to) the lower surface 213b of the base 212 and the top edge 244 (FIG. 4B) of the custom abutment 240 directly abuts the lower surface 213b

of the base 212 such that the central axis 230_{CA} of the dental implant analog 230 is generally perpendicular to (e.g., ninety degrees relative to) the lower surface 213b. Further, in such an alternative implementation, the model guide struts 110a-c'' are designed and fabricated having relatively varying heights along the Y-axis such that registering the placement jig assembly 200 on the modified physical model 140 automatically positions the dental implant analog 230 in the model bore 100'' having a position and orientation corresponding to the position and orientation of the dental implant 30 installed in the mouth 20 of the patient 10 (FIG. 1). That is, by varying the relative heights of the model guide struts 110a-c'', the dental implant analog 230 can be angled relative to vertical (e.g., the Y-axis) when the placement jig assembly is registered on the modified physical model 140.

[0059] As best shown in FIGS. 4A-4D, the guide-strut receiving features 214a-c are cylindrical bores in the base 212 of the placement jig 210. Alternatively, one or more of the guide-strut receiving features 214a-c can be a non-cylindrical or a non-round bore (e.g., a polygonal bore, etc.) having a non-round cross-section. In such alternative implementations including a guide-strut receiving feature with a non-cylindrical bore, the placement jig 210 can include only one guide-strut receiving feature and the modified physical model 140 can likewise include only one guide strut having a corresponding non-cylindrical or non-round cross-section. Such a non-round guide-strut receiving feature can be registered on such a non-round guide strut for placing the dental implant analog 230 in the model bore 100'' at a position and orientation corresponding to the position and orientation of the dental implant 30 installed in the mouth 20 of the patient 10.

[0060] Now referring generally to FIGS. 8A-8C, an alternative placement jig 310 includes an adjustable arm 320 in lieu of an angled receiving feature (e.g., the angled receiving feature 218) and a throughbore (e.g., the throughbore 216). The placement jig 310 further includes a base 312 having an upper surface 313a and a lower surface 313b, and guide-strut receiving features 314a-c that are the same as, or similar to, the base 212 having the upper surface 213a and the lower surface 213b, and the guide-strut receiving features 214a-c of the placement jig 210 shown in FIGS. 4A-4F and described herein.

[0061] The adjustable arm 320 includes a pivoting member 325, a stationary member 330, and two adjusting rods 335a,b (e.g., solenoids). The pivoting member 325 moves (e.g., pivots) about the stationary member 330 that is rigidly attached to the lower surface 313b of the base 312. The adjusting rods 335a,b are also attached to the lower surface 313b of the base 312 and are able to extend in a linear fashion therefrom. The first adjusting rod 335a is

coupled to a first stem 326a of the pivoting member 325 and can move the pivoting member 325 in a first degree of freedom. Similarly, the second adjusting rod 335b is coupled to a second stem 326b of the pivoting member 325 and can move the pivoting member 325 in a second degree of freedom.

[0062] Movement of the adjusting rods 335a,b relative to the lower surface 313b of the base 312 causes the pivoting member 325 to move. In particular, the adjusting rods 335a,b can be moved (e.g., extended relative to the lower surface 313b) to cause the pivoting member 325 to move (e.g., rotate and/or pivot) such that an implant analog attachment element 328 of the pivoting member 325 is oriented with its central axis 328_{CA} at any one of a multitude of angles with respect to vertical (e.g., Y-axis). As such, the implant analog attachment element 328 can generally be moved with two degrees of freedom with respect to the base 312 of the placement jig 310. Put another way, the angular orientation of the implant analog attachment element 328 can be adjusted by selectively extending the adjusting rods 335a,b.

[0063] The implant analog attachment element 328 can include a non-round feature (e.g., a polygonal boss) for non-rotationally coupling with the dental implant analog 230 for placement into the modified physical model 140 in the same, or similar, manner as described above in connection with the placement jig assembly 200. In some implementations, prior to attaching the dental implant analog, or after a dental implant analog is attached to the placement jig 310, the pivoting member 325 is adjusted (e.g., moved, rotated, pivoted, etc.) such that registration of the placement jig 310 with the modified physical model 140 places the dental implant analog in the model bore 100" at a position and orientation corresponding to the position and orientation of the dental implant 30 installed in the mouth 20 of the patient 10.

[0064] The adjusting of the pivoting member 325 can be manual and/or automatic. For example, a dentist or a clinician can manually move the pivoting member 325 by directly touching and moving the pivoting member 325. In such an implementation, the placement jig 310 does not need the adjusting rods 335a,b. Further, the manual adjusting of the pivoting member 325 can be based on information associated with the modified virtual three-dimensional computer model 90.

[0065] In some other implementations, the pivoting member 325 can be moved by the model bore 100" during the registration of the placement jig 310 on the modified physical model 140 such that the central axis 230_{CA} of the dental implant analog 230 coupled to the

placement jig 310 is substantially coaxial with the central axis 100''_{CA} (FIG. 3) of the model bore 100'' of the modified physical model 140. In such implementations, the model bore 100'' can be designed to snugly fit about the dental implant analog 230, thereby automatically positioning the dental implant analog 230.

[0066] For yet another example, the placement jig 310 can include an input device (not shown) that receives a code or similar input instruction that causes the pivoting member 325 to automatically move into a specific orientation. The code can be determined by, for example, the CPU 60 (FIG. 1) based on the information determined from the scanning and/or processing of the scan data 55 (FIG. 1) associated with the informational markers 45 on the abutment 40 attached to the dental implant 30 installed in the mouth 20 of the patient 10 (FIG. 1). In addition thereto and/or in lieu thereof, the code can be determined based on information associated with the modified virtual three-dimensional computer model 90. In such an alternative example, the input device (not shown) can be built into the base 312 and/or electronically coupled thereto (e.g., via one or more electrical wires).

[0067] The above disclosure discusses the scanning of the mouth 20 of the patient 10 (FIG. 1) including an attachment member (e.g., a scanning member/abutment 40) that includes one or more informational markers 45 that when scanned by the scanner 50 and interpreted by the CPU 60 provide information about the location (e.g., position of a table of the dental implant along the Y-axis) and orientation (e.g., rotational position of a non-round feature of the dental implant about the Y-axis) of the underlying dental implant 30. Alternatively to scanning the mouth 20 with the abutment 40 therein, the mouth 20 can lack (e.g., not include) the abutment 40 altogether during the scanning (not shown). In such alternative implementations, the upper portion of the dental implant 30 is viewable and, thus, scannable, by the scanner 50. As such, the unmodified virtual three-dimensional computer model 70 can be created by, for example, the CPU 60 using the scan data 55 to include a virtual dental implant that corresponds with the dental implant 30 installed in the mouth 20 of the patient 10 (e.g., the dental implant 30 is no longer obscured by the abutment 40).

[0068] While the present disclosure has been described with reference to one or more particular embodiments and implementations, those skilled in the art will recognize that many changes may be made thereto without departing from the spirit and scope of the present disclosure. Each of these embodiments and implementations and obvious variations thereof is contemplated as falling within the spirit and scope of the present invention, which is set forth in the claims that follow.

WHAT IS CLAIMED IS:

1. A method of locating a dental implant analog in a model of a patient's mouth for use in creating a tooth prosthesis, comprising:
 - scanning at least a portion of the patient's mouth to generate scan data, the scanned portion of the patient's mouth including teeth and an attachment member, the attachment member including at least one informational marker indicating the location of a dental implant installed in the patient's mouth;
 - creating a three-dimensional computer model of at least a portion of the patient's mouth using the scan data, the three-dimensional computer model including (i) virtual teeth that correspond with the teeth in the patient's mouth, (ii) a virtual bore at a position based on the at least one informational marker, and (iii) at least one virtual guide strut positioned adjacent to the virtual teeth; and
 - fabricating, using a fabrication machine, a physical model of the at least a portion of the patient's mouth based on the three-dimensional computer model, the physical model including (i) a bore corresponding to the virtual bore, and (ii) at least one guide strut corresponding to the at least one virtual guide strut, the at least one guide strut to be used in positioning the dental implant analog within the bore of the physical model at a position and an orientation corresponding to the location and the orientation of the dental implant in the patient's mouth.
2. The method of claim 1, further comprising coupling the dental implant analog to a placement jig, the placement jig including at least one guide-strut receiving feature.
3. The method of claim 2, further comprising registering the placement jig on the physical model of the at least a portion of the patient's mouth, the registering including mating the at least one guide-strut receiving feature of the placement jig with the at least one guide strut of the physical model such that the dental implant analog is positioned within the bore of the physical model at the position and the orientation corresponding to the location and the orientation of the dental implant in the patient's mouth.
4. The method of claim 3, wherein the dental implant analog is coupled to the placement jig such that a central axis of the dental implant analog is perpendicular to a base of the placement jig.

5. The method of claim 4, wherein the at least one guide strut and a central axis of the bore of the physical model are at an angle α with respect to vertical such that in response to the registering, the dental implant analog is positioned within the bore with its central axis at the angle α with respect to vertical.

6. The method of claim 5, wherein the angle α is based on an angle of a central axis of the dental implant in the patient's mouth with respect to vertical.

7. The method of claim 2, wherein the placement jig further includes an angled receiving feature.

8. The method of claim 7, further comprising fabricating, using a milling machine, the placement jig from a stock jig blank, the fabricating including milling the angled receiving feature in the stock jig blank based on the three-dimensional computer model.

9. The method of claim 7, wherein the coupling further comprises placing a custom abutment between the angled receiving feature of the placement jig and the dental implant analog.

10. The method of claim 2, further comprising designing a virtual placement jig based on the three-dimensional computer model.

11. The method of claim 10, further comprising developing three-dimensional jig instructions from the designed virtual placement jig for fabricating the placement jig.

12. The method of claim 11, further comprising transmitting the developed three-dimensional jig instructions to the fabrication machine or a different fabrication machine to fabricate the placement jig.

13. The method of claim 12, further comprising fabricating, using the fabrication machine or a different fabrication machine, the placement jig based on the three-dimensional jig instructions.

14. The method of claim 1, further comprising coupling the dental implant analog to an adjustable arm of a placement jig, the adjustable arm having at least two degrees of rotational freedom with respect to a base of the placement jig, the base of the placement jig further including at least one guide-strut receiving feature.

15. The method of claim 14, further comprising manually adjusting the orientation of the adjustable arm with respect to the base of the placement jig based on the three-dimensional computer model.

16. The method of claim 14, further comprising automatically adjusting the orientation of the adjustable arm with respect to the base of the placement jig in response to the placement jig receiving an input.

17. The method of claim 16, wherein the input is based on the three-dimensional computer model.

18. The method of claim 14, further comprising registering the placement jig on the physical model of the at least a portion of the patient's mouth, the registering including mating the at least one guide-strut receiving feature of the placement jig with the at least one guide strut of the physical model such that the dental implant analog is positioned within the bore of the physical model at the position and the orientation corresponding to the location and the orientation of the dental implant in the patient's mouth.

19. The method of claim 18, wherein the registering automatically causes the adjustable arm of the placement jig to move such that a central axis of the dental implant analog coupled thereto is substantially coaxial with a central axis of the bore of the physical model.

20. The method of claim 1, wherein the three-dimensional computer model further includes a virtual attachment member that corresponds with the attachment member in the patient's mouth, the method further comprising removing the virtual attachment member from the three-dimensional computer model.

21. The method of claim 1, further comprising developing three-dimensional physical model instructions from the three-dimensional computer model for fabricating the physical model of the at least a portion of the patient's mouth and transmitting the developed three-dimensional physical model instructions to the fabrication machine to fabricate the physical model of the at least a portion of the patient's mouth.

22. The method of claim 18, further comprising securing the dental implant analog to the bore of the physical model with a securing material.

23. The method of claim 22, further comprising decoupling the placement jig from the dental implant analog and coupling a custom abutment to the dental implant analog.

24. The method of claim 23, further comprising creating the tooth prosthesis using the physical model of the at least a portion of the patient's mouth with the secured dental implant analog and the custom abutment coupled to the dental implant analog.

25. A method of locating a dental implant analog in a model of a patient's mouth for use in creating a tooth prosthesis, comprising:

creating a three-dimensional computer model of at least a portion of the patient's mouth using scan data from a scan of the patient's mouth, the three-dimensional computer model including (i) virtual teeth that correspond with teeth in the patient's mouth, (ii) a virtual bore at a position based on at least one informational marker on an attachment member in the patient's mouth, the at least one informational marker indicating the location and the orientation of a dental implant installed in the patient's mouth, and (iii) a virtual guide strut positioned adjacent to the virtual teeth;

fabricating, using a fabrication machine, a physical model of the at least a portion of the patient's mouth based on the three-dimensional computer model, the physical model including (i) a bore corresponding to the virtual bore, and (ii) a guide strut corresponding to the virtual guide strut; and

coupling the dental implant analog to a placement jig, the placement jig including a guide-strut receiving feature to be used in conjunction with the guide strut of the physical model in positioning the dental implant analog within the bore of the physical model at a position and an orientation corresponding to the location and the orientation of the dental implant in the patient's mouth.

26. The method of claim 25, further comprising registering the placement jig on the physical model by mating the guide-strut receiving feature with the guide strut.

27. The method of claim 26, wherein the dental implant analog is coupled to the placement jig such that a central axis of the dental implant analog is perpendicular to a base of the placement jig and wherein a central axis of the guide strut and a central axis of the bore are both at an angle α with respect to vertical such that in response to the registering, the dental implant analog being positioned within the bore with its central axis at the angle α with respect to vertical, the angle α being based on an angle of a central axis of the dental implant in the patient's mouth with respect to vertical.

28. The method of claim 27, further comprising securing the dental implant analog to the bore of the physical model with a securing material and decoupling the placement jig from the dental implant analog and coupling a custom abutment to the dental implant analog.

29. The method of claim 28, further comprising creating the tooth prosthesis using the physical model of the at least a portion of the patient's mouth with the secured dental implant analog and the custom abutment coupled to the dental implant analog.

30. A method of locating a dental implant analog in a physical model of a patient's mouth for use in creating a tooth prosthesis, comprising:

creating a three-dimensional computer model of at least a portion of the patient's mouth using scan data from a scan of the patient's mouth, the three-dimensional computer model including (i) virtual teeth that correspond with teeth in the patient's mouth, (ii) a virtual bore at a position based on at least one informational marker on an attachment member in the patient's mouth, the at least one informational marker indicating the location and the orientation of a dental implant installed in the patient's mouth, and (iii) a virtual guide strut positioned adjacent to the virtual teeth;

fabricating, using a fabrication machine, a physical model of the at least a portion of the patient's mouth based on the three-dimensional computer model, the physical model including (i) a bore corresponding to the virtual bore, and (ii) a guide strut corresponding to the virtual guide strut; and

coupling the dental implant analog to an adjustable arm of a placement jig, the adjustable arm having at least two degrees of rotational freedom with respect to a base of the placement jig, the base of the placement jig further including a guide-strut receiving feature to be used in conjunction with the guide strut of the physical model in positioning the dental implant analog within the bore of the physical model at a position and an orientation corresponding to the location and the orientation of the dental implant in the patient's mouth.

31. The method of claim 30, further comprising manually adjusting the orientation of the adjustable arm with respect to the base of the placement jig based on the three-dimensional computer model.

32. The method of claim 30, further comprising automatically adjusting the orientation of the adjustable arm with respect to the base of the placement jig in response to the placement jig receiving an input, the input being based on the three-dimensional computer model.

33. The method of claim 30, further comprising registering the placement jig on the physical model, the registering including mating the guide-strut receiving feature with the guide strut such that the dental implant analog is positioned within the bore of the physical model at the position and the orientation corresponding to the location and the orientation of the dental implant in the patient's mouth.

34. The method of claim 33, wherein the registering automatically causes the adjustable arm of the placement jig to move such that a central axis of the dental implant analog coupled thereto is substantially coaxial with a central axis of the bore of the physical model.

35. The method of claim 34, further comprising securing the dental implant analog to the bore of the physical model with a securing material and decoupling the adjustable arm of the placement jig from the dental implant analog and coupling a custom abutment to the dental implant analog.

36. The method of claim 35, further comprising creating the tooth prosthesis using the physical model of the at least a portion of the patient's mouth with the secured dental implant analog and the custom abutment coupled to the dental implant analog.

37. A placement jig for locating a dental implant analog in a physical model of at least a portion of a patient's mouth for use in creating a tooth prosthesis, comprising:

- a base having an upper surface and a lower surface;
- a guide-strut receiving feature positioned within the base, the guide-strut receiving feature being configured to receive a guide-strut of the physical model thereby positioning the lower surface of the placement jig at a desired distance from an opening of a bore in the physical model;
- a throughbore for receiving a screw therethrough, the screw being configured to be coupled with the dental implant analog such that the dental implant analog is removably coupled to the base, the throughbore having a central axis oriented at an angle relative to the lower surface of the base; and
- an angled receiving feature positioned about the throughbore on the lower surface of the base, the angled receiving feature including a mating surface that is configured to abut a custom abutment positioned between the mating surface and the dental implant analog, the central axis of the throughbore being perpendicular to the angled receiving feature.

38. The placement jig of claim 37, wherein a central axis of the bore in the physical model is coaxial with the central axis of the throughbore of the placement jig in response to the guide-strut of the physical model being received within the guide-strut receiving feature of the placement jig.

39. The placement jig of claim 37, wherein the guide-strut receiving feature is a cylindrical bore in the base of the placement jig.

40. The placement jig of claim 39, wherein the guide-strut receiving feature includes a non-round cross-section.

41. The placement jig of claim 37, wherein the angle of the central axis of the throughbore relative to the lower surface of the base is ninety degrees such that the mating surface and the lower surface of the base are parallel, coplanar, or both.

42. The placement jig of claim 37, wherein the placement jig is a stock jig blank that includes the base, the guide-strut receiving feature, and the throughbore, the angled receiving feature is formed in the base using a milling machine that mills the angled receiving feature in the stock jig blank.

43. The placement jig of claim 37, wherein the placement jig is fabricated using a rapid-prototype machine.

44. A placement jig for locating a dental implant analog in a physical model of at least a portion of a patient's mouth for use in creating a tooth prosthesis, comprising:

- a base having an upper surface spaced from a lower surface;

- a guide-strut receiving feature positioned within the base, the guide-strut receiving feature being configured to receive a guide-strut of the physical model to position the lower surface of the placement jig a desired distance from an opening of a bore in the physical model; and

- an adjustable arm extending from the lower surface of the base and being configured to be removably coupled to the dental implant analog, the adjustable arm having at least two degrees of rotational freedom with respect to the base.

45. The placement jig of claim 44, wherein the guide-strut receiving feature is a cylindrical bore in the base of the placement jig.

46. The placement jig of claim 45, wherein the guide-strut receiving feature includes a non-round cross-section.

47. The placement jig of claim 44, wherein the angular orientation of the adjustable arm is manually adjustable with respect to the base.

48. The placement jig of claim 44, wherein the angular orientation of the adjustable arm is automatically adjusted with respect to the base in response to the placement jig receiving an input.

49. A physical model of a patient's mouth for use in creating a tooth prosthesis, comprising:

a model base;

model teeth protruding from the model base, the model teeth corresponding with teeth in the patient's mouth;

a bore in the model base configured to receive a dental implant analog therein, the bore being positioned adjacent to at least one of the model teeth; and

a first guide strut protruding from the model base and being configured to mate with a positioning jig to position the dental implant analog within the bore at a position and an orientation corresponding to the location and the orientation of a dental implant in the patient's mouth.

50. The physical model of claim 49, wherein the model base, the model teeth, and the first guide strut are all made of the same material.

51. The physical model of claim 49, wherein the first guide strut and a central axis of the bore in the model base are at an angle α with respect to vertical such that in response to the first guide strut mating with the positioning jig, the dental implant analog is positioned within the bore with its central axis at the angle α with respect to vertical.

52. The physical model of claim 51, wherein the angle α is based on an angle of a central axis of the dental implant in the patient's mouth with respect to vertical.

53. The physical model of claim 49, wherein at least a portion of the first guide strut includes a non-round cross-section.

54. The physical model of claim 49, further including a second guide strut, the second guide strut protruding from the model base adjacent to a first side of the bore and the first guide strut protruding from the model base adjacent to a second opposing side of the bore.

55. The physical model of claim 49, wherein the dental implant analog is coupled to the positioning jig with a custom abutment positioned between the placement jig and the dental implant analog.

56. The physical model of claim 49, wherein the first guide strut is configured to be received within a guide-strut receiving feature of the placement jig to position the dental implant analog within the bore at the position corresponding to the location of the dental implant in the patient's mouth.

57. The physical model of claim 49, wherein the physical model of the patient's mouth is fabricated using a fabrication machine following three-dimensional physical model instructions developed using a three-dimensional computer model of the patient's mouth.

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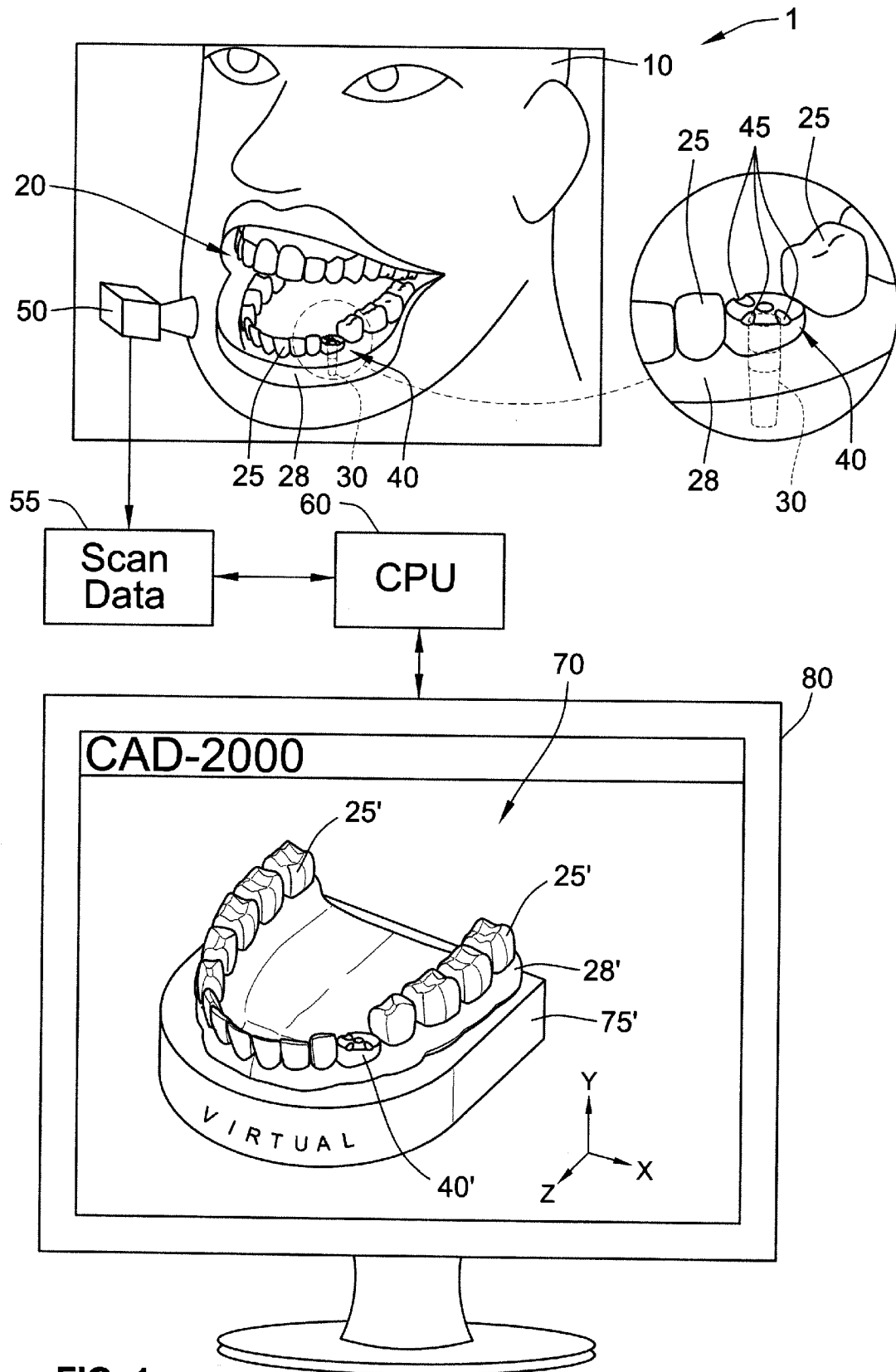


FIG. 1

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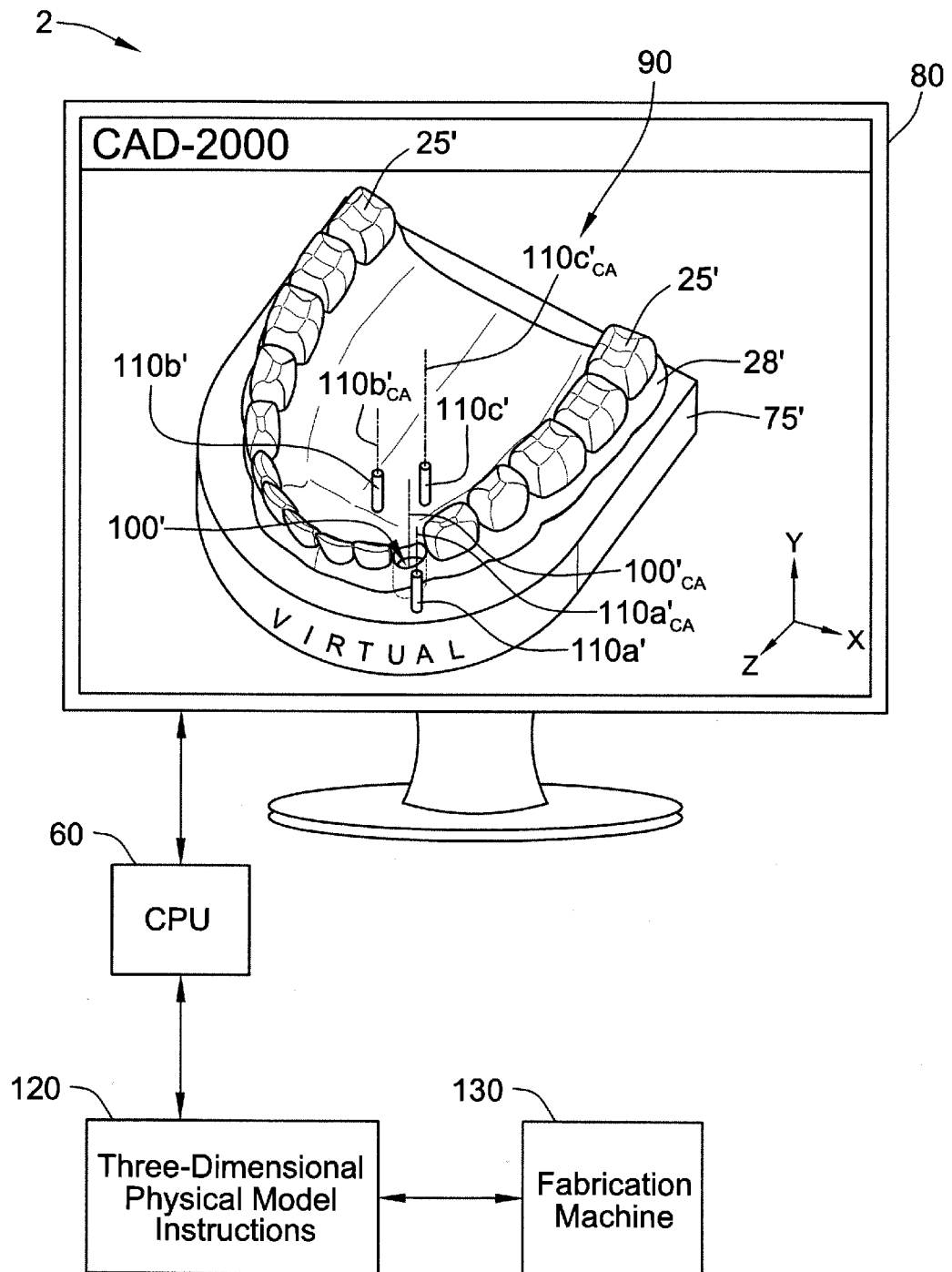


FIG. 2

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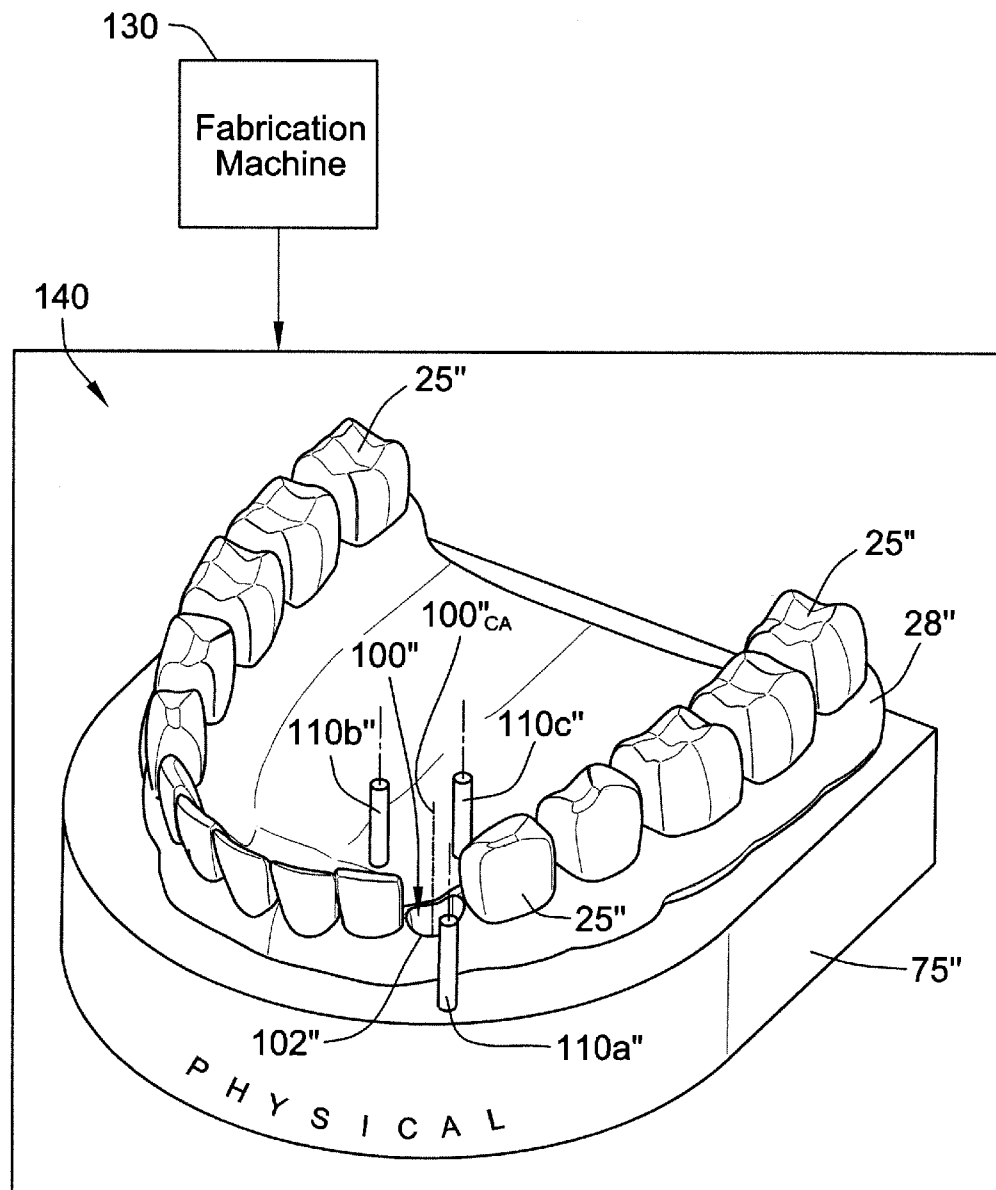


FIG. 3

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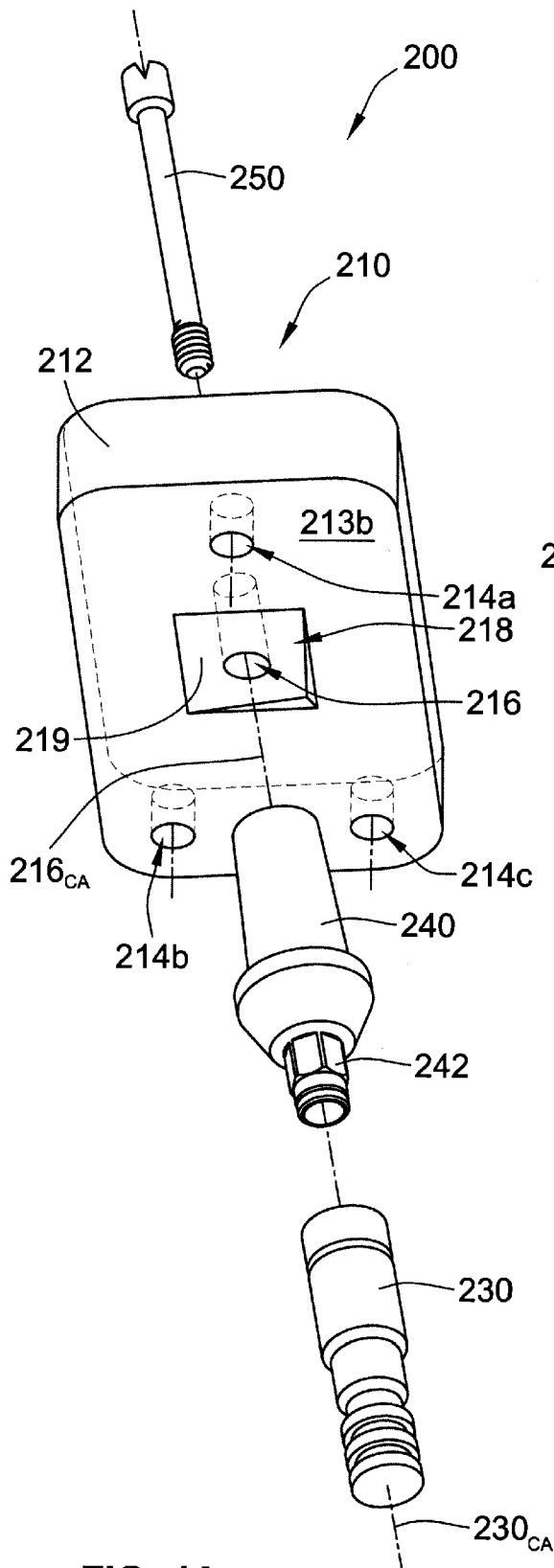


FIG. 4A

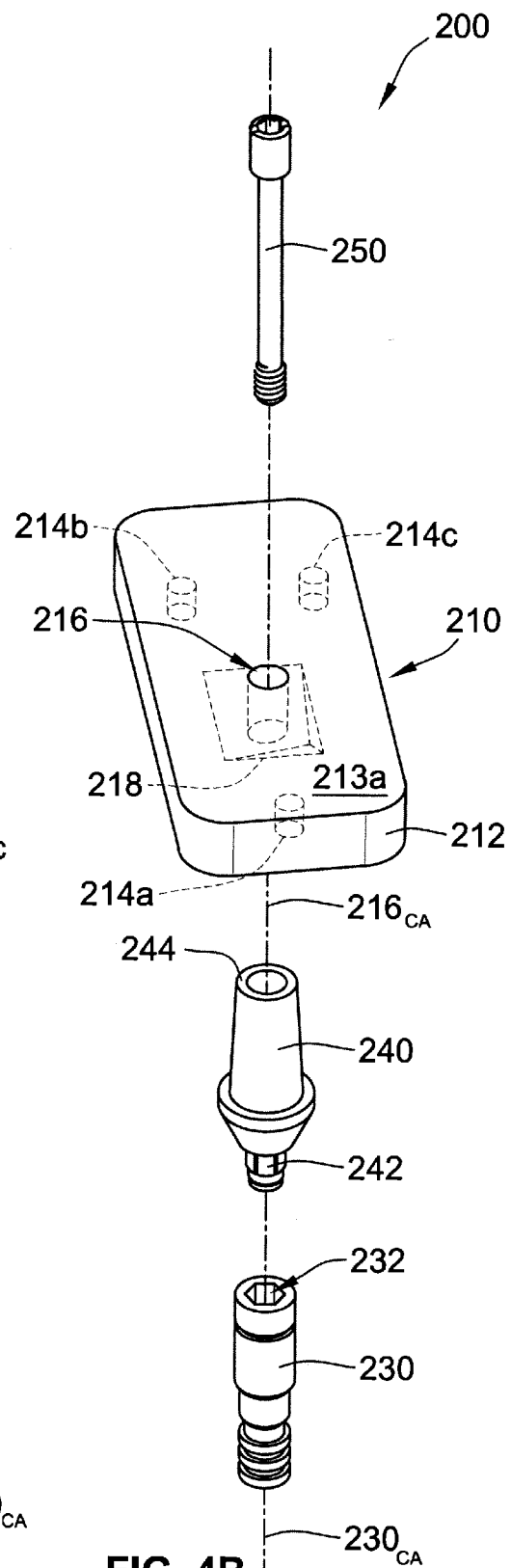
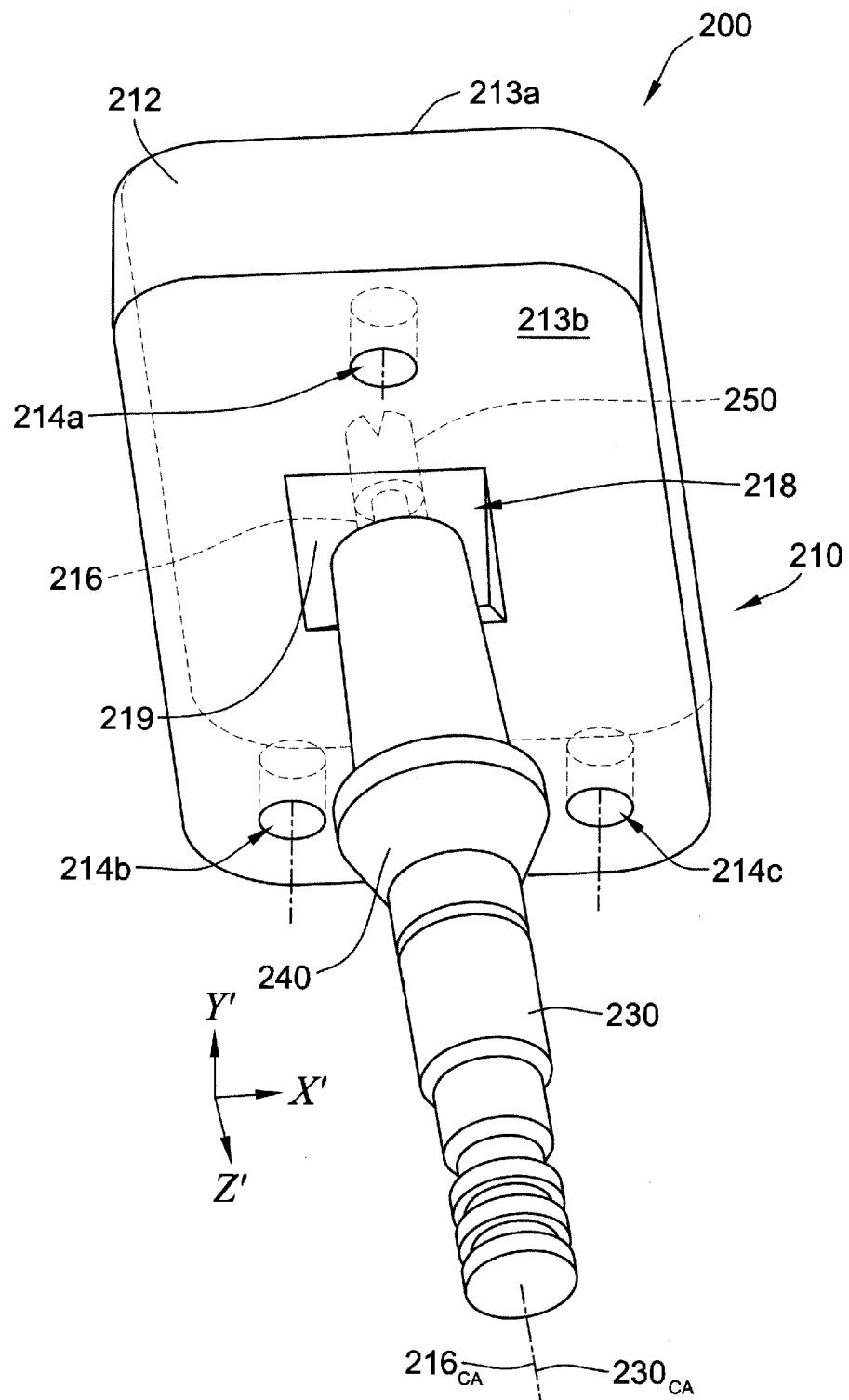


FIG. 4B

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**FIG. 4C**

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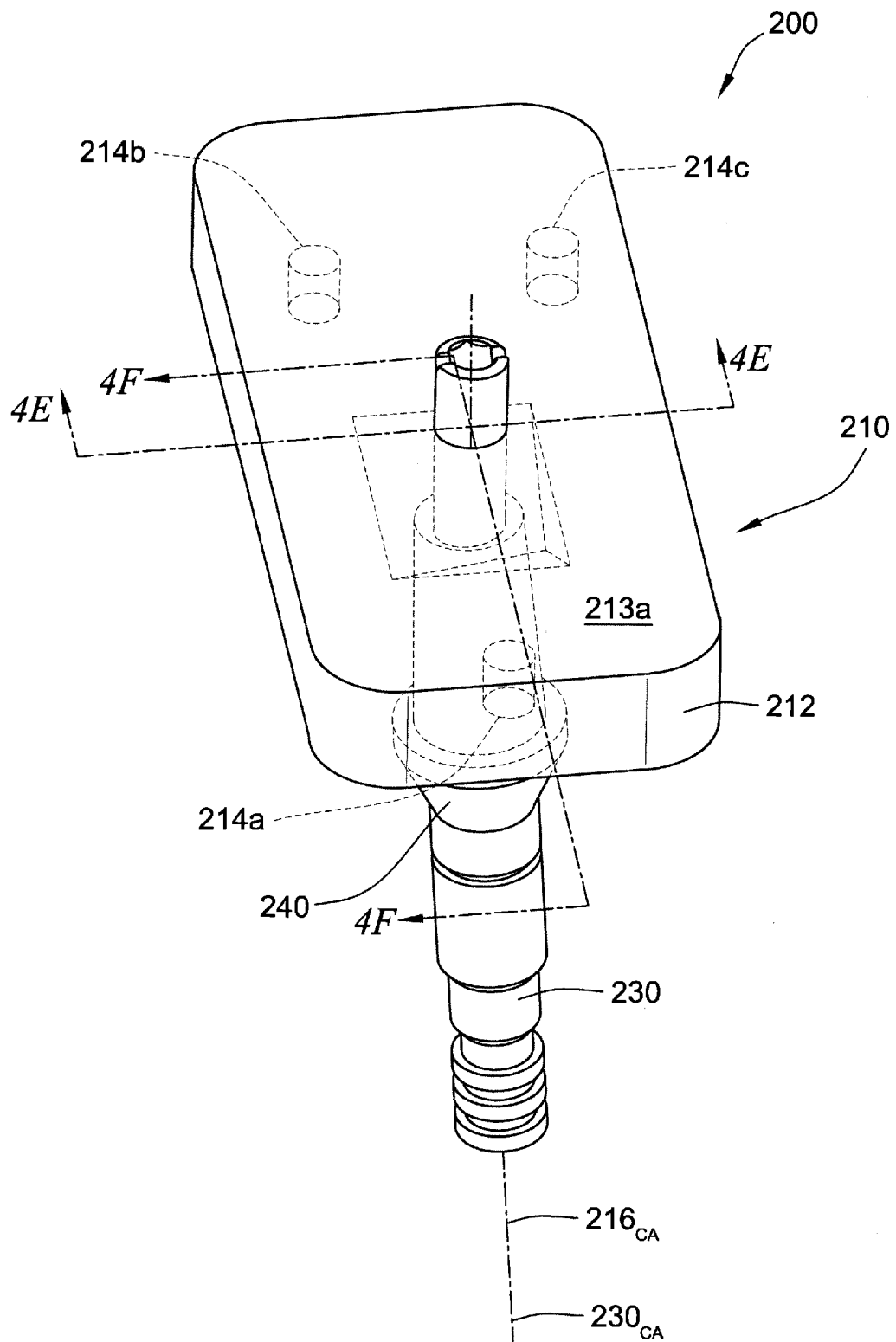


FIG. 4D

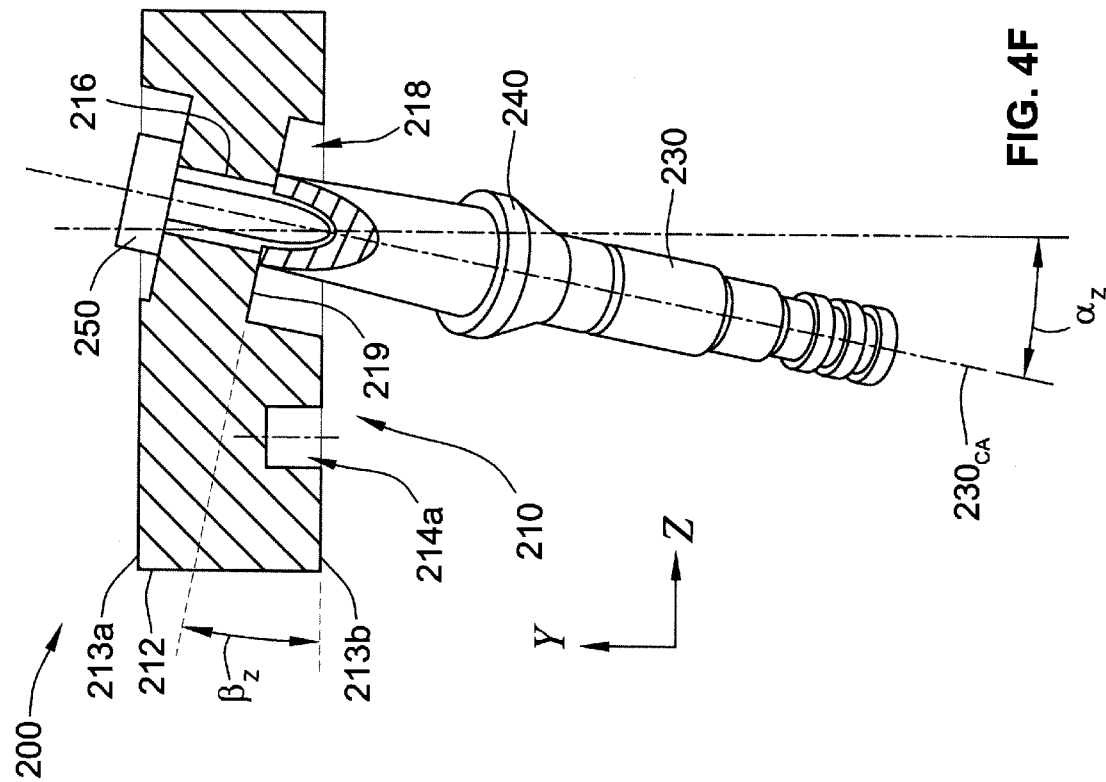


FIG. 4E

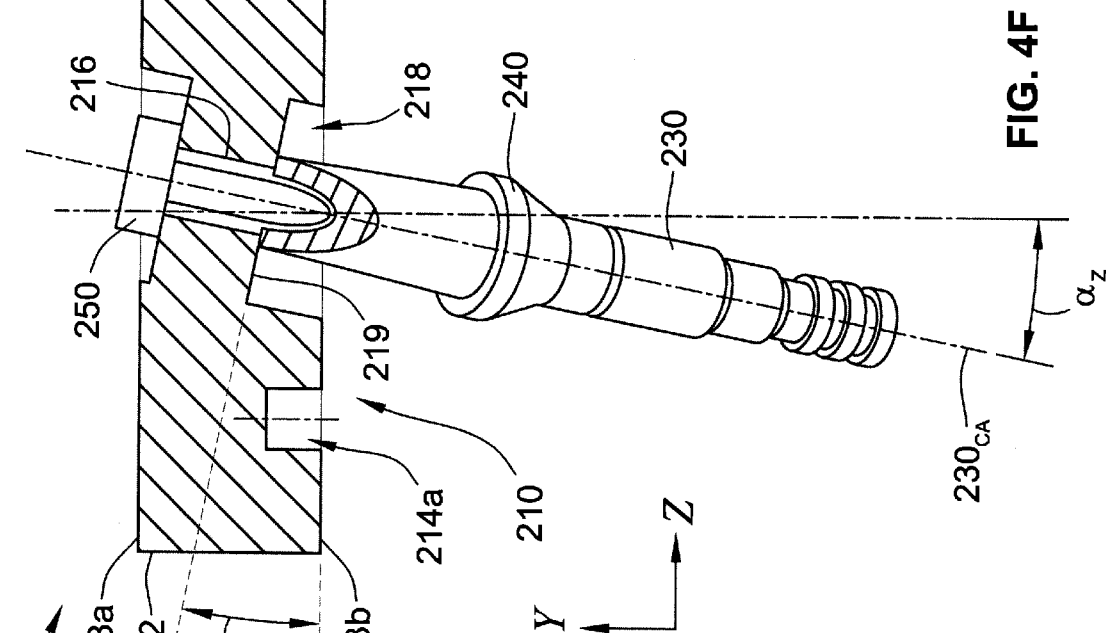


FIG. 4F

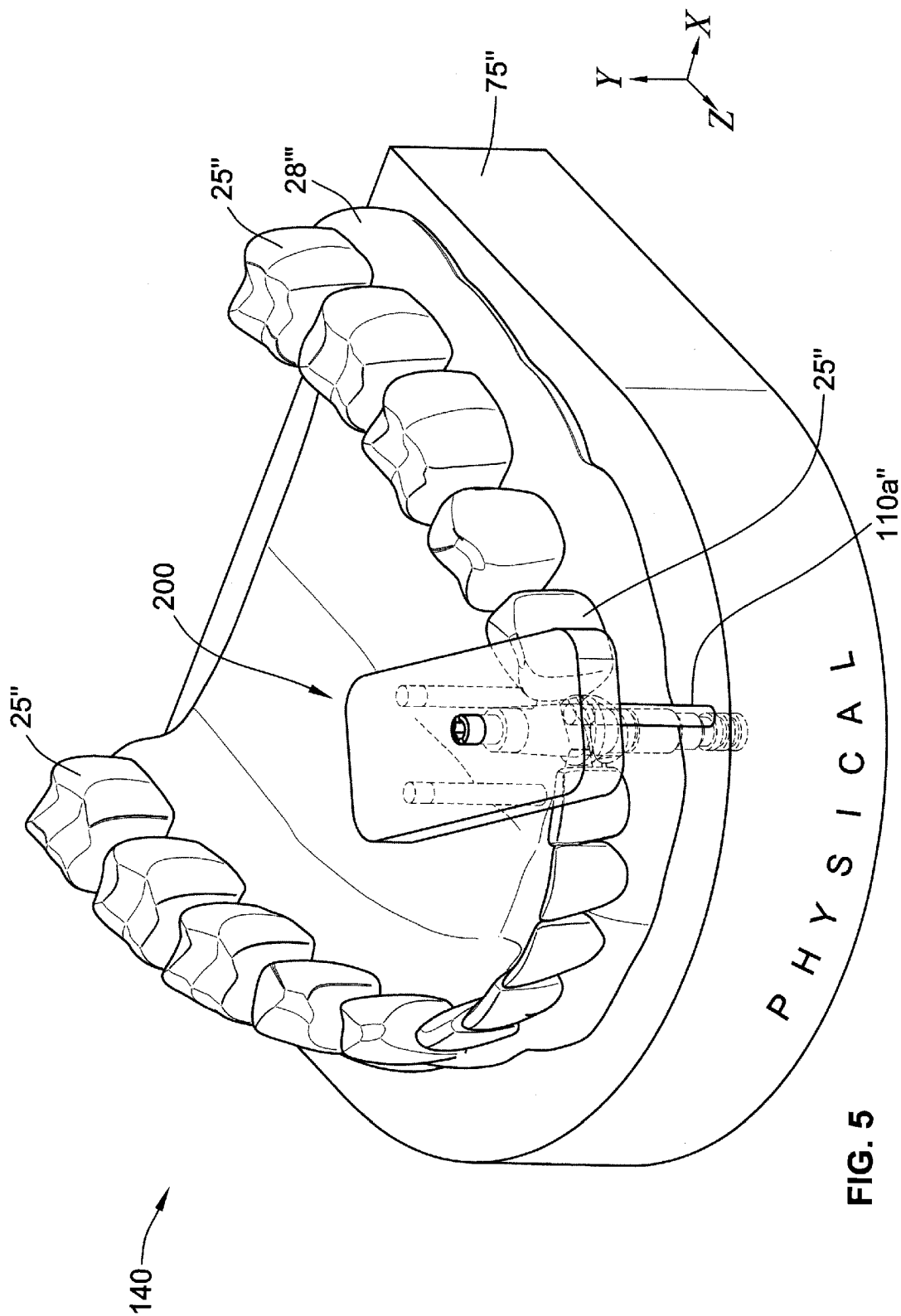


FIG. 5

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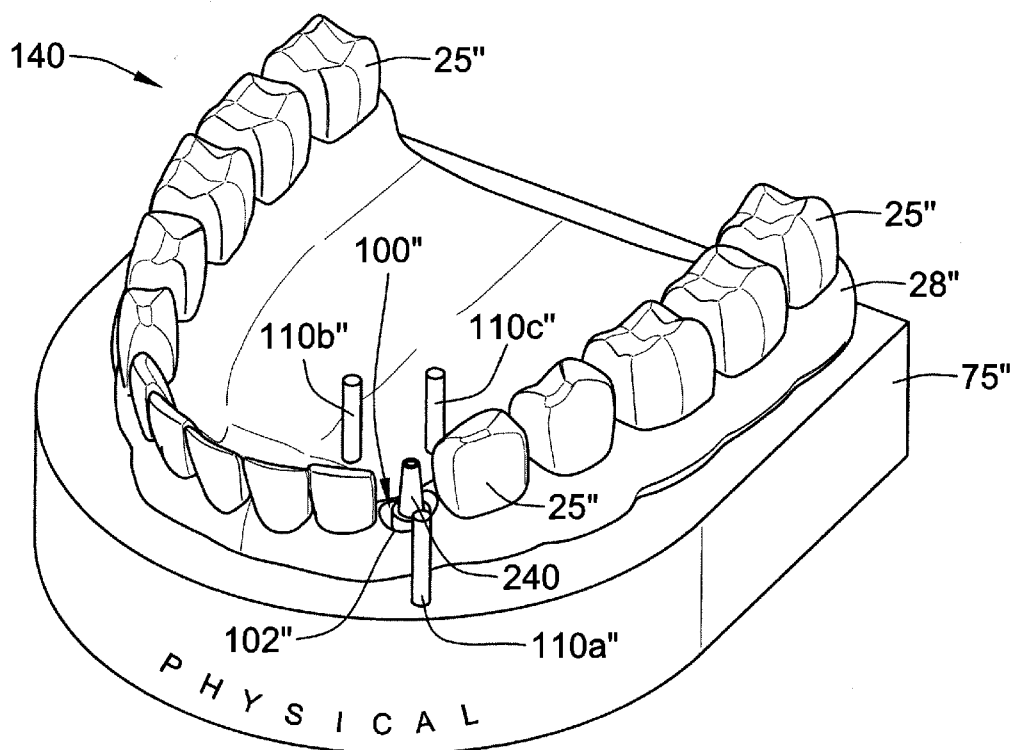


FIG. 6

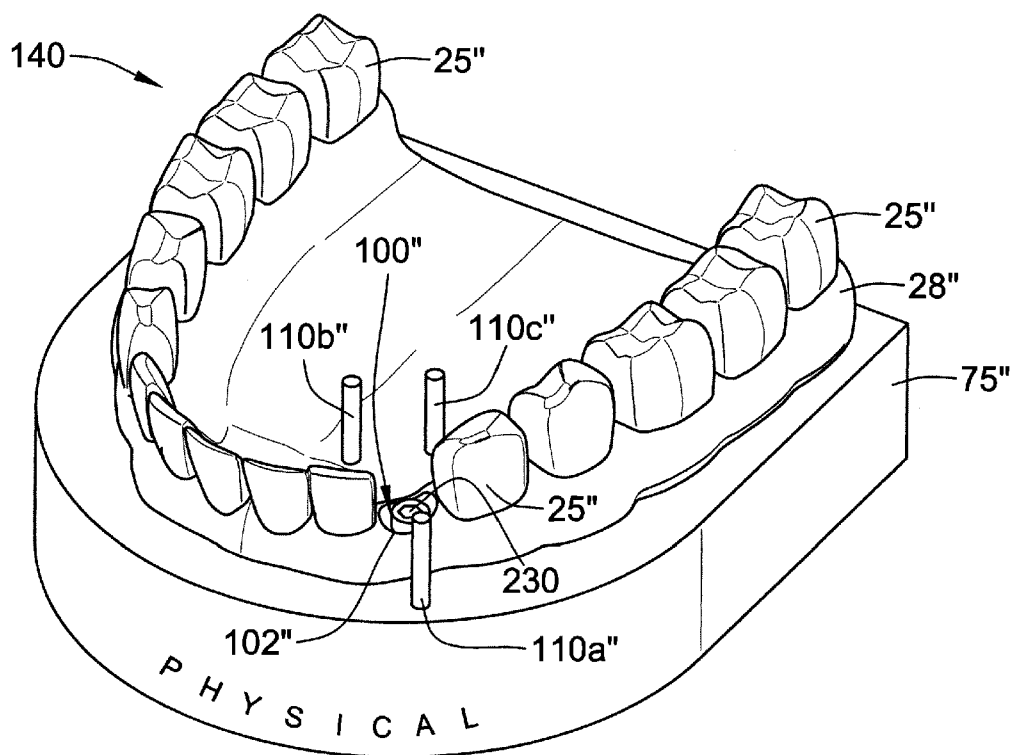
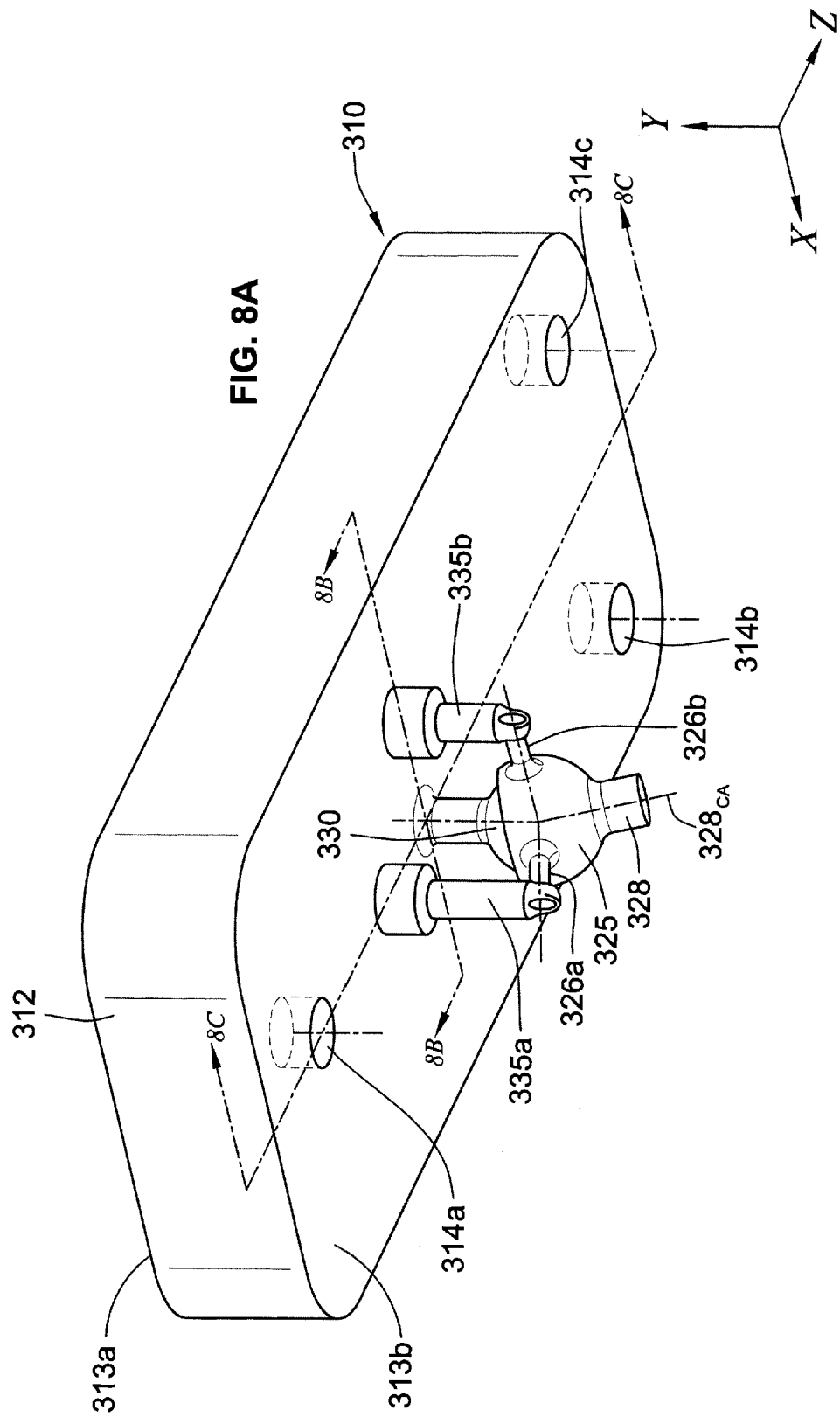
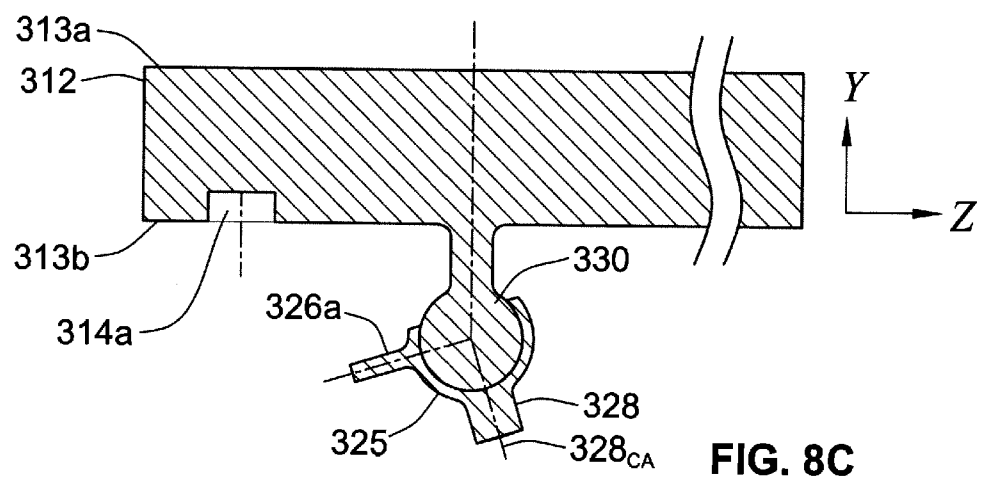
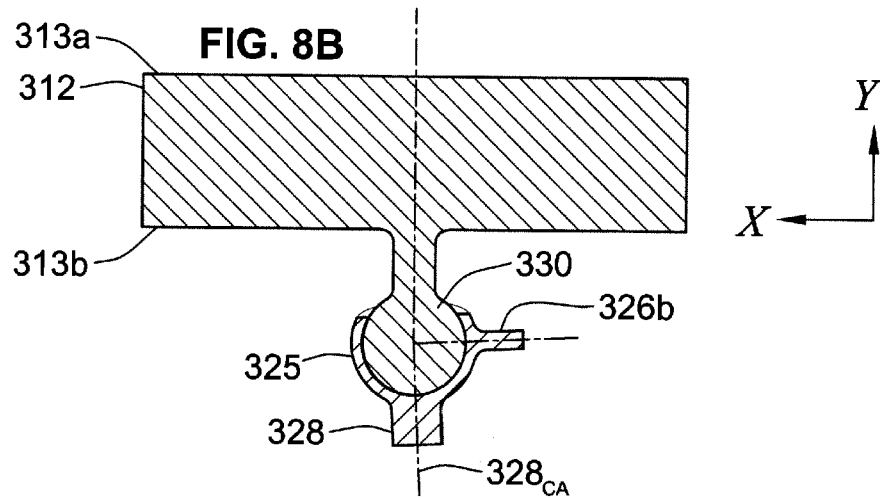


FIG. 7





INTERNATIONAL SEARCH REPORT

International application No.

PCT/US13/73864

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - A61C 8/00, 13/12, 13/23 (2014.01)

USPC - 433/172, 180, 213; 700/118, 119

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(8): A61C 8/00, 13/12, 13/23 (2014.01)

USPC: 433/172, 180, 213; 700/118, 119

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

MicroPatent (US-G, US-A, EP-A, EP-B, WO, JP-bib, DE-C,B, DE-A, DE-T, DE-U, GB-A, FR-A); IP.com; Google/Google Scholar; PubMed/MEDLINE: dental, jig, strut, three-dimensional, abutment, teeth, tooth, model, scan.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ---	WO 2012/095851 A2, A3 (KOPELMAN, A) July 19, 2012; pages 28, 34, 43-44	1-6, 10-13, 20-21, 25-29
Y		7-9, 14-19, 22-24, 33-36
X ---	US 2011/0200970 A1 (BERCKMANS III, B et al.) August 18, 2011; figures 12-16; paragraphs [0110], [0118], [0133]; claim 1	30-32
Y		14-19, 22-24, 33-36
X ---	US 2010/0021859 A1 (KOPELMAN, A) January 28, 2010; figures 5, 8; paragraphs [0088]-[0089], [0121]-[0122]	49-57
Y		7-9
A	US 2011/0183289 A1 (POWELL, TM et al.) July 28, 2011; entire document	1-36, 49-57
A	US 2005/0177266 A1 (KOPELMAN, A et al.) August 11, 2005; entire document	1-36, 49-57
A	US 2011/0151399 A1 (DE CLERCK, RD et al.) June 23, 2011; entire document	1-36, 49-57
A	US 2006/0127856 A1 (WEN, H) June 15, 2006; entire document	1-36, 49-57

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


* 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

31 March 2014 (31.03.2014)

Date of mailing of the international search report

21 APR 2014

Name and mailing address of the ISA/US

Mail Stop PCT, Attn: ISA/US, Commissioner for Patents
P.O. Box 1450, Alexandria, Virginia 22313-1450
Facsimile No. 571-273-3201

Authorized officer:

Shane Thomas

PCT Helpdesk: 571-272-4300
PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US13/73864

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

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

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

his application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I: Claims 1-36 and 49-57 are directed toward a method of locating a dental implant analog in a model of a patient's mouth for use in creating a tooth prosthesis.

Group II: Claims 37-48 are directed toward a placement jig for locating a dental implant analog in a physical model of at least a portion of a patient's mouth for use in creating a tooth prosthesis.

Continued on Supplemental Page

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-36 and 49-57

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US13/73864

-Continued from Box III: Observations where unity of invention is lacking-

The inventions listed as Groups I-II do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: the special technical features of Group I include scanning at least a portion of the patient's mouth to generate scan data, the scanned portion of the patient's mouth including teeth and an attachment member, the attachment member including at least one informational marker indicating the location of a dental implant installed in the patient's mouth; creating a three-dimensional computer model of at least a portion of the patient's mouth using the scan data, the three-dimensional computer model including (i) virtual teeth that correspond with the teeth in the patient's mouth, (ii) a virtual bore at a position based on the at least one informational marker, and (iii) at least one virtual guide strut positioned adjacent to the virtual teeth; and fabricating, using a fabrication machine, a physical model of the at least a portion of the patient's mouth based on the three-dimensional computer model, the physical model including (i) a bore corresponding to the virtual bore, and (ii) at least one guide strut corresponding to the at least one virtual guide strut, the at least one guide strut to be used in positioning the dental implant analog within the bore of the physical model at a position and an orientation corresponding to the location and the orientation of the dental implant in the patient's mouth, which are not present in Group II; the special technical features of Group II include being configured to receive a guide-strut of the physical model thereby positioning the lower surface of the placement jig at a desired distance from an opening of a bore in the physical model; a throughbore for receiving a screw therethrough, the screw being configured to be coupled with the dental implant analog such that the dental implant analog is removably coupled to the base, the throughbore having a central axis oriented at an angle relative to the lower surface of the base; and an angled receiving feature positioned about the throughbore on the lower surface of the base, the angled receiving feature including a mating surface that is configured to abut a custom abutment positioned between the mating surface and the dental implant analog, the central axis of the throughbore being perpendicular to the angled receiving feature, which are not present in Group I.

The common technical features of Groups I and II are a base; a guide-strut receiving feature positioned within the base; a bore; and an adjustable arm of a placement jig having at least two degrees of rotational freedom with respect to a base of the placement jig.

These common technical features are disclosed by US 2011/0200970 A1 to Berckmans et al. (hereinafter 'Berckmans'). Berckmans discloses a base (base structure 2302; figure 23); a guide-strut receiving feature positioned within the base (a surgical guide to be placed in the patient's mouth for installing an implant in the patient's mouth at substantially the same location and orientation as the virtual implant on the 3D-computer model; claim 1); a bore (threaded bore 2390; figure 23); and an adjustable arm of a placement jig (moving arms 2304; figure 23) having at least two degrees of rotational freedom with respect to a base of the placement jig (numerous types of robots are available having various control features, motors, and manipulating arms and tools; for example, the robot 2300 could be an Epson PS5 six-axis robot (at least two degrees of rotational freedom) with an Epson RC520; figure 23).

Since the common technical features are previously disclosed by the Berckmans reference, the common features are not special and so Groups I and II lack unity.