US009603613B2

(12) **United States Patent**
Schoenefeld et al.

(10) **Patent No.: US 9,603,613 B2**
(45) **Date of Patent: Mar. 28, 2017**

(54) **PATIENT-SPECIFIC SACROILIAC GUIDES AND ASSOCIATED METHODS**

(71) Applicant: **Biomet Manufacturing, LLC**, Warsaw, IN (US)

(72) Inventors: **Ryan John Schoenefeld**, Fort Wayne, IN (US); **Robert C. Gutierrez**, Huntington Beach, CA (US); **Philip Mellinger**, Ladera Ranch, CA (US)

(73) Assignee: **Biomet Manufacturing, LLC**, Warsaw, IN (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **15/224,764**

(22) Filed: **Aug. 1, 2016**

(65) **Prior Publication Data**

US 2016/0338714 A1 Nov. 24, 2016

Related U.S. Application Data

(63) Continuation of application No. 14/753,560, filed on Jun. 29, 2015, now Pat. No. 9,439,659, which is a (Continued)

(51) **Int. Cl.**

A61B 17/17	(2006.01)
A61B 17/70	(2006.01)
A61B 17/56	(2006.01)

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

CPC ***A61B 17/1757*** (2013.01); ***A61B 17/7055*** (2013.01); *A61B 2017/567* (2013.01); *A61B 2017/568* (2013.01)

(58) **Field of Classification Search**

CPC . A61B 17/17; A61B 17/1703; A61B 17/1739; A61B 17/1742; A61B 17/1746;

(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

1,480,285	A	1/1924	Moore
2,181,746	A	11/1939	Siebrandt

(Continued)

FOREIGN PATENT DOCUMENTS

CA	2447694	A1	12/2002
CA	2501041	A1	4/2004

(Continued)

OTHER PUBLICATIONS

"3D-Implantatplanung und Stereolithographielmplantatbohrschablonen", Stomatologie 101.3, (2004), 55-59.

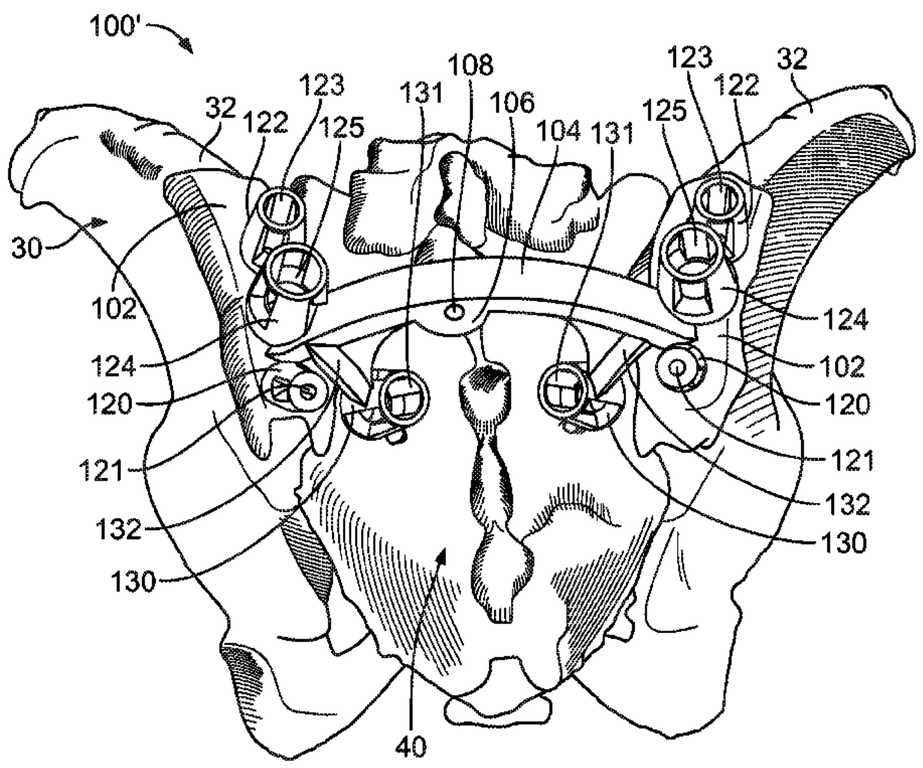
(Continued)

Primary Examiner — Christian Sevilla
Assistant Examiner — Eric S Gibson
(74) *Attorney, Agent, or Firm* — Schwegman Lundberg & Woessner, P.A.

(57) **ABSTRACT**

A patient-specific alignment guide includes a patient-specific portion and a guiding element having a through opening. The patient-specific portion has a patient-specific surface preoperatively configured to mate as a negative of a portion of an iliac crest of a pelvis of a specific patient and mate to the iliac crest only in one position. The guiding element has a preoperatively configured orientation and location relative to the patient-specific portion for preparing a bore in the bone of the patient to direct a bone screw at the preoperatively configured orientation and location for sacroiliac fixation.

20 Claims, 11 Drawing Sheets



Related U.S. Application Data

continuation of application No. 13/221,968, filed on Aug. 31, 2011, now Pat. No. 9,066,734.

(58) **Field of Classification Search**

CPC A61B 17/175; A61B 17/1753; A61B 17/1757; A61B 17/176; A61B 17/1764; A61B 17/1767

USPC ..... 606/86 A, 86 R–89, 96, 104, 246, 606/250–278; 623/17.11–17.16

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,407,845	A	9/1946	Orisan
2,416,228	A	2/1947	Sheppard
2,618,913	A	11/1952	Plancon et al.
2,910,978	A	11/1959	Urist
3,330,611	A	7/1967	Heifetz
3,840,904	A	10/1974	Tronzo
3,975,858	A	8/1976	Much
4,246,895	A	1/1981	Rehder
4,306,866	A	12/1981	Weissman
4,324,006	A	4/1982	Charnley
4,421,112	A	12/1983	Mains et al.
4,436,684	A	3/1984	White
4,457,306	A	7/1984	Borzone
4,475,549	A	10/1984	Oh
4,506,393	A	3/1985	Murphy
4,524,766	A	6/1985	Petersen
4,528,980	A	7/1985	Kenna
4,565,191	A	1/1986	Slocum
4,619,658	A	10/1986	Pappas et al.
4,621,630	A	11/1986	Kenna
4,632,111	A	12/1986	Roche
4,633,862	A	1/1987	Petersen
4,663,720	A	5/1987	Duret et al.
4,689,984	A	9/1987	Kellner
4,695,283	A	9/1987	Aldinger
4,696,292	A	9/1987	Heiple
4,703,751	A	11/1987	Pohl
4,704,686	A	11/1987	Aldinger
4,706,660	A	11/1987	Petersen
4,719,907	A	1/1988	Banko et al.
4,721,104	A	1/1988	Kaufman et al.
4,722,330	A	2/1988	Russell et al.
4,759,350	A	7/1988	Dunn et al.
4,778,474	A	10/1988	Homsy
4,800,874	A	1/1989	David et al.
4,821,213	A	4/1989	Cline et al.
4,822,365	A	4/1989	Walker et al.
4,841,975	A	6/1989	Woolson
4,846,161	A	7/1989	Roger
4,871,975	A	10/1989	Nawata et al.
4,892,545	A	1/1990	Day et al.
4,893,619	A	1/1990	Dale et al.
4,896,663	A	1/1990	Vandewalls
4,907,577	A	3/1990	Wu
4,927,422	A	5/1990	Engelhardt
4,936,862	A	6/1990	Walker et al.
4,952,213	A	8/1990	Bowman et al.
4,959,066	A	9/1990	Dunn et al.
4,976,737	A	12/1990	Leake
4,979,949	A	12/1990	Matsen, III et al.
4,985,037	A	1/1991	Petersen
5,002,579	A	3/1991	Copf et al.
5,006,121	A	4/1991	Hafeli
5,007,936	A	4/1991	Woolson
5,030,219	A	7/1991	Matsen et al.
5,030,221	A	7/1991	Buechel et al.
5,041,117	A	8/1991	Engelhardt
5,053,037	A	10/1991	Lackey et al.
5,053,039	A	10/1991	Hofmann et al.
5,056,351	A	10/1991	Stiver et al.
5,086,401	A	2/1992	Glassman et al.
5,098,383	A	3/1992	Hemmy et al.
5,098,436	A	3/1992	Ferrante et al.
5,102,412	A	4/1992	Rogozinski
5,108,425	A	4/1992	Hwang
5,122,144	A	6/1992	Bert et al.
5,123,927	A	6/1992	Duncan et al.
5,129,908	A	7/1992	Petersen
5,129,909	A	7/1992	Sutherland
5,133,660	A	7/1992	Fenick
5,133,760	A	7/1992	Petersen et al.
5,140,777	A	8/1992	Ushiyama et al.
5,141,512	A	8/1992	Farmer et al.
5,150,304	A	9/1992	Berchem et al.
5,176,684	A	1/1993	Ferrante et al.
5,194,066	A	3/1993	Van Zile
5,234,433	A	8/1993	Bert et al.
5,242,444	A	9/1993	Macmillan
5,246,444	A	9/1993	Schreiber
5,253,506	A	10/1993	Davis et al.
5,258,032	A	11/1993	Bertin
5,261,915	A	11/1993	Durlacher et al.
5,274,565	A	12/1993	Reuben
5,282,802	A	2/1994	Mahony, III
5,299,288	A	3/1994	Glassman et al.
5,300,077	A	4/1994	Howell
5,306,275	A	4/1994	Bryan
5,320,529	A	6/1994	Pompa
5,320,625	A	6/1994	Bertin
5,323,697	A	6/1994	Schrock
5,334,203	A	8/1994	Wagner
5,334,205	A	8/1994	Cain
5,342,366	A	8/1994	Whiteside et al.
5,344,423	A	9/1994	Dietz et al.
5,360,431	A	11/1994	Puno et al.
5,360,446	A	11/1994	Kennedy
5,364,402	A	11/1994	Mumme et al.
5,368,858	A	11/1994	Hunziker
5,370,692	A	12/1994	Fink et al.
5,370,699	A	12/1994	Hood et al.
5,405,395	A	4/1995	Coates
5,408,409	A	4/1995	Glassman et al.
5,411,521	A	5/1995	Putnam et al.
5,415,662	A	5/1995	Ferrante et al.
5,417,694	A	5/1995	Marik et al.
D359,557	S	6/1995	Hayes
5,438,263	A	8/1995	Dworkin et al.
5,440,496	A	8/1995	Andersson et al.
5,448,489	A	9/1995	Reuben
5,449,360	A	9/1995	Schreiber
5,452,407	A	9/1995	Crook
5,454,816	A	10/1995	Ashby
5,462,550	A	10/1995	Dietz et al.
5,472,415	A	12/1995	King et al.
5,474,559	A	12/1995	Bertin et al.
5,490,854	A	2/1996	Fisher et al.
5,496,324	A	3/1996	Barnes
5,507,833	A	4/1996	Bohn
5,514,519	A	5/1996	Neckers
5,520,695	A	5/1996	Luckman
5,527,317	A	6/1996	Ashby et al.
5,539,649	A	7/1996	Walsh et al.
5,540,695	A	7/1996	Levy
5,545,222	A	8/1996	Bonutti
5,549,688	A	8/1996	Ries et al.
5,554,190	A	9/1996	Draenert
5,560,096	A	10/1996	Stephens
5,571,110	A	11/1996	Matsen, III et al.
5,578,037	A	11/1996	Sanders et al.
5,593,411	A	1/1997	Stalcup et al.
5,595,703	A	1/1997	Swaelens et al.
5,601,565	A	2/1997	Huebner
5,607,431	A	3/1997	Dudasik et al.
5,611,802	A	3/1997	Samuelson et al.
5,613,969	A	3/1997	Jenkins, Jr.
5,620,448	A	4/1997	Puddu
5,634,927	A	6/1997	Houston et al.
5,641,323	A	6/1997	Caldarise
5,653,714	A	8/1997	Dietz et al.
5,658,294	A	8/1997	Sederholm

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,662,656	A	9/1997	White
5,662,710	A	9/1997	Bonutti
5,671,018	A	9/1997	Ohara et al.
5,676,668	A	10/1997	McCue et al.
5,677,107	A	10/1997	Neckers
5,681,354	A	10/1997	Eckhoff
5,682,886	A	11/1997	Delp et al.
5,683,469	A	11/1997	Johnson et al.
5,690,635	A	11/1997	Matsen, III et al.
5,697,933	A	12/1997	Gundlapalli et al.
5,702,460	A	12/1997	Carls et al.
5,702,464	A	12/1997	Lackey et al.
5,704,941	A	1/1998	Jacober et al.
5,709,689	A	1/1998	Ferrante et al.
5,720,752	A	2/1998	Elliott et al.
5,722,978	A	3/1998	Jenkins, Jr.
5,725,376	A	3/1998	Poirier
5,725,593	A	3/1998	Caracciolo
5,735,277	A	4/1998	Schuster
5,745,834	A	4/1998	Bampton et al.
5,748,767	A	5/1998	Raab
5,749,875	A	5/1998	Puddu
5,749,876	A	5/1998	Duvillier et al.
5,762,125	A	6/1998	Mastrorio
5,766,251	A	6/1998	Koshino
5,768,134	A	6/1998	Swaelens et al.
5,769,092	A	6/1998	Williamson, Jr.
5,776,200	A	7/1998	Johnson et al.
5,786,217	A	7/1998	Tubo et al.
5,792,143	A	8/1998	Samuelson et al.
5,798,924	A	8/1998	Eufinger et al.
5,799,055	A	8/1998	Peshkin et al.
5,835,619	A	11/1998	Morimoto et al.
5,860,980	A	1/1999	Axelson, Jr. et al.
5,860,981	A	1/1999	Bertin et al.
5,871,018	A	2/1999	Delp et al.
5,876,456	A	3/1999	Sederholm et al.
5,879,398	A	3/1999	Swarts et al.
5,879,402	A	3/1999	Lawes et al.
5,880,976	A	3/1999	DiGioia, III et al.
5,885,297	A	3/1999	Matsen
5,885,298	A	3/1999	Herrington et al.
5,888,219	A	3/1999	Bonutti
5,895,389	A	4/1999	Schenk et al.
5,899,907	A	5/1999	Johnson
5,901,060	A	5/1999	Schall et al.
5,911,724	A	6/1999	Wehrli
5,921,988	A	7/1999	Legrand
5,925,049	A	7/1999	Gustilo et al.
5,942,370	A	8/1999	Neckers
5,967,777	A	10/1999	Klein et al.
5,976,149	A	11/1999	Masini
5,980,526	A	11/1999	Johnson et al.
6,008,433	A	12/1999	Stone
6,019,767	A	2/2000	Howell
6,033,415	A	3/2000	Mittelstadt et al.
6,042,612	A	3/2000	Voydeville
6,056,754	A	5/2000	Haines et al.
6,059,789	A	5/2000	Dinger
6,059,833	A	5/2000	Doets
6,066,142	A	5/2000	Serbousek et al.
6,066,175	A	5/2000	Henderson et al.
6,086,593	A	7/2000	Bonutti
6,120,510	A	9/2000	Albrektsson et al.
6,120,544	A	9/2000	Grundei et al.
6,126,690	A	10/2000	Ateshian et al.
6,126,692	A	10/2000	Robie et al.
6,136,033	A	10/2000	Suemer
6,156,069	A	12/2000	Amstutz
6,159,217	A	12/2000	Robie et al.
6,161,080	A	12/2000	Aouni-Ateshian et al.
6,162,257	A	12/2000	Gustilo et al.
6,165,223	A	12/2000	Metzger et al.
6,187,010	B1	2/2001	Masini
6,195,615	B1	2/2001	Lysen
6,203,546	B1	3/2001	Macmahon
6,205,411	B1	3/2001	Digioia, III et al.
6,206,927	B1	3/2001	Fell et al.
6,210,445	B1	4/2001	Zawadzki
6,238,435	B1	5/2001	Meulink et al.
6,254,604	B1	7/2001	Howell
6,258,097	B1	7/2001	Cook et al.
6,264,698	B1	7/2001	Lawes et al.
6,270,529	B1	8/2001	Terrill-Grisoni et al.
6,273,891	B1	8/2001	Masini
6,290,727	B1	9/2001	Otto et al.
6,293,971	B1	9/2001	Nelson et al.
6,302,888	B1	10/2001	Mellinger et al.
6,302,913	B1	10/2001	Ripamonti et al.
6,310,269	B1	10/2001	Friese et al.
6,312,258	B1	11/2001	Ashman
6,312,473	B1	11/2001	Oshida
6,319,285	B1	11/2001	Chamier et al.
6,322,728	B1	11/2001	Brodkin et al.
6,325,829	B1	12/2001	Schmotzer
6,327,491	B1	12/2001	Franklin et al.
6,338,738	B1	1/2002	Bellotti et al.
6,343,987	B2	2/2002	Hayama et al.
6,354,011	B1	3/2002	Albrecht
6,361,563	B2	3/2002	Terrill-Grisoni et al.
6,379,299	B1	4/2002	Borodulin et al.
6,379,388	B1	4/2002	Ensign et al.
6,383,228	B1	5/2002	Schmotzer
6,391,251	B1	5/2002	Keicher et al.
6,395,005	B1	5/2002	Lovell
6,413,279	B1	7/2002	Metzger et al.
6,424,332	B1	7/2002	Powell
6,427,698	B1	8/2002	Yoon et al.
6,459,948	B1	10/2002	Ateshian et al.
6,463,351	B1	10/2002	Clynch
6,475,243	B1	11/2002	Sheldon et al.
6,482,236	B2	11/2002	Habecker
6,488,715	B1	12/2002	Pope et al.
6,503,255	B1	1/2003	Albrektsson et al.
6,508,980	B1	1/2003	Sachs et al.
6,510,334	B1	1/2003	Schuster et al.
6,514,259	B2	2/2003	Picard et al.
6,517,583	B1	2/2003	Pope et al.
6,519,998	B2	2/2003	Ertl et al.
6,520,964	B2	2/2003	Tallarida et al.
6,524,312	B2	2/2003	Landry et al.
6,533,737	B1	3/2003	Brosseau et al.
6,547,823	B2	4/2003	Scarborough et al.
6,551,325	B2	4/2003	Neubauer et al.
6,554,837	B1	4/2003	Hauri et al.
6,556,008	B2	4/2003	Thesen
6,558,391	B2	5/2003	Axelson, Jr. et al.
6,558,428	B2	5/2003	Park
6,562,073	B2	5/2003	Foley
6,564,085	B2	5/2003	Meaney et al.
6,567,681	B1	5/2003	Lindequist
6,575,980	B1	6/2003	Robie et al.
6,575,982	B1	6/2003	Bonutti
6,589,283	B1	7/2003	Metzger et al.
6,591,581	B2	7/2003	Schmieding
6,605,293	B1	8/2003	Giordano et al.
6,610,067	B2	8/2003	Tallarida et al.
6,616,668	B2	9/2003	Altarac et al.
6,622,567	B1	9/2003	Hamel et al.
6,629,999	B1	10/2003	Serafin, Jr.
6,641,617	B1	11/2003	Merrill et al.
6,676,892	B2	1/2004	Das et al.
6,682,566	B2	1/2004	Draenert et al.
6,696,073	B2	2/2004	Boyce et al.
6,697,664	B2	2/2004	Kienzle, III et al.
6,701,174	B1	3/2004	Krause et al.
6,709,462	B2	3/2004	Hanssen
6,711,431	B2	3/2004	Sarin et al.
6,711,432	B1	3/2004	Krause et al.
6,712,856	B1	3/2004	Carignan et al.
6,716,249	B2	4/2004	Hyde
6,725,077	B1	4/2004	Balloni et al.
6,738,657	B1	5/2004	Franklin et al.
6,740,092	B2	5/2004	Lombardo et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,749,638	B1	6/2004	Saladiono
6,750,653	B1	6/2004	Zou et al.
6,772,026	B2	8/2004	Bradbury et al.
6,780,190	B2	8/2004	Maroney
6,786,930	B2	9/2004	Biscup
6,799,066	B2	9/2004	Steines et al.
6,823,871	B2	11/2004	Schmieding
6,827,723	B2	12/2004	Carson
6,887,247	B1	5/2005	Couture et al.
6,905,514	B2	6/2005	Carignan et al.
6,916,324	B2	7/2005	Sanford
6,923,817	B2	8/2005	Carson et al.
6,923,831	B2	8/2005	Fell et al.
6,932,842	B1	8/2005	Litschko et al.
6,942,475	B2	9/2005	Ensign et al.
6,944,518	B2	9/2005	Roose
6,945,976	B2	9/2005	Ball et al.
6,949,123	B2	9/2005	Reiley
6,953,480	B2	10/2005	Mears et al.
6,960,216	B2	11/2005	Kolb et al.
6,975,755	B1	12/2005	Baumberg
6,990,220	B2	1/2006	Ellis et al.
6,993,406	B1	1/2006	Cesarano, III et al.
7,001,385	B2	2/2006	Bonutti
7,029,479	B2	4/2006	Tallarida et al.
7,042,222	B2	5/2006	Zheng et al.
7,048,741	B2	5/2006	Swanson
7,050,877	B2	5/2006	Iseki et al.
7,060,074	B2	6/2006	Rosa et al.
7,074,241	B2	7/2006	Mckinnon
RE39,301	E	9/2006	Bertin
7,104,997	B2	9/2006	Lionberger et al.
7,105,026	B2	9/2006	Johnson et al.
7,115,131	B2	10/2006	Engh et al.
7,121,832	B2	10/2006	Hsieh et al.
7,141,053	B2	11/2006	Rosa et al.
D533,664	S	12/2006	Büttler et al.
7,166,111	B2	1/2007	Kolb et al.
7,169,185	B2	1/2007	Sidebotham
7,174,282	B2	2/2007	Hollister et al.
7,176,466	B2	2/2007	Rousso et al.
7,184,814	B2	2/2007	Lang et al.
7,198,628	B2	4/2007	Ondrla et al.
7,218,232	B2	5/2007	Disilvestro et al.
7,232,441	B2	6/2007	Altarac et al.
7,239,908	B1	7/2007	Alexander et al.
7,241,315	B2	7/2007	Evans
7,255,702	B2	8/2007	Serra et al.
7,258,701	B2	8/2007	Aram et al.
7,275,218	B2	9/2007	Petrella et al.
7,282,054	B2	10/2007	Steffensmeier et al.
7,291,177	B2	11/2007	Gibbs
7,294,129	B2	11/2007	Hawkins et al.
7,294,133	B2	11/2007	Zink et al.
7,297,164	B2	11/2007	Johnson et al.
7,309,339	B2	12/2007	Cusick et al.
7,333,013	B2	2/2008	Berger
7,335,231	B2	2/2008	Mclean
7,338,527	B2	3/2008	Blatt et al.
7,371,260	B2	5/2008	Malinin
7,383,164	B2	6/2008	Aram et al.
7,385,498	B2	6/2008	Dobosz
7,388,972	B2	6/2008	Kitson
7,390,327	B2	6/2008	Collazo et al.
7,392,076	B2	6/2008	Moctezuma de La Barrera
7,396,360	B2	7/2008	Lieberman
7,427,200	B2	9/2008	Noble et al.
7,427,272	B2	9/2008	Richard et al.
7,465,320	B1	12/2008	Kito et al.
7,468,075	B2	12/2008	Lang et al.
7,474,223	B2	1/2009	Nycz et al.
7,488,325	B2	2/2009	Qian et al.
7,494,510	B2	2/2009	Zweymuller
7,517,365	B2	4/2009	Carignan et al.
7,519,540	B2	4/2009	Mayaud
7,527,631	B2	5/2009	Maroney et al.
7,534,263	B2	5/2009	Burdulis, Jr. et al.
7,537,664	B2	5/2009	O'neill et al.
7,542,791	B2	6/2009	Mire et al.
7,559,931	B2	7/2009	Stone
7,575,602	B2	8/2009	Amirouche et al.
7,578,851	B2	8/2009	Dong et al.
7,582,091	B2	9/2009	Duncan et al.
7,588,578	B2	9/2009	Triplett et al.
7,591,821	B2	9/2009	Kelman
7,601,155	B2	10/2009	Petersen
7,603,192	B2	10/2009	Martin et al.
7,604,638	B2	10/2009	Jacene et al.
7,604,639	B2	10/2009	Swanson
7,611,516	B2	11/2009	Maroney
7,618,451	B2	11/2009	Berez et al.
7,621,915	B2	11/2009	Frederick et al.
7,625,409	B2	12/2009	Saltzman et al.
7,646,161	B2	1/2010	Albu-schäffer et al.
7,651,501	B2	1/2010	Penenberg et al.
7,670,345	B2	3/2010	Plassky et al.
7,674,100	B2	3/2010	Hayes-pankhurst et al.
7,682,398	B2	3/2010	Croxton et al.
7,695,477	B2	4/2010	Creger et al.
7,695,521	B2	4/2010	Ely et al.
7,699,847	B2	4/2010	Sheldon et al.
7,699,876	B2	4/2010	Barry et al.
7,704,253	B2	4/2010	Bastian et al.
7,723,395	B2	5/2010	Ringeisen et al.
7,747,305	B2	6/2010	Dean et al.
D622,854	S	8/2010	Otto et al.
7,780,672	B2	8/2010	Metzger et al.
7,780,740	B2	8/2010	Steinberg
7,789,885	B2	9/2010	Metzger
7,794,466	B2	9/2010	Merchant et al.
7,794,467	B2	9/2010	McGinley et al.
7,794,504	B2	9/2010	Case
7,806,896	B1	10/2010	Bonutti
7,809,184	B2	10/2010	Neubauer et al.
7,819,925	B2	10/2010	King et al.
7,828,806	B2	11/2010	Graf et al.
7,833,245	B2	11/2010	Kaes et al.
7,837,040	B2	11/2010	Ward et al.
7,837,690	B2	11/2010	Metzger
7,846,382	B2	12/2010	Strand
7,850,698	B2	12/2010	Straszheim-Morley et al.
7,879,109	B2	2/2011	Borden et al.
7,892,261	B2	2/2011	Bonutti
7,896,921	B2	3/2011	Smith et al.
7,926,363	B2	4/2011	Miller et al.
7,935,119	B2	5/2011	Ammann et al.
7,935,150	B2	5/2011	Carignan et al.
7,938,861	B2	5/2011	King et al.
7,959,637	B2	6/2011	Fox et al.
7,962,196	B2	6/2011	Tuma
7,963,968	B2	6/2011	Dees, Jr.
7,967,823	B2	6/2011	Ammann et al.
7,967,868	B2	6/2011	White et al.
7,974,677	B2	7/2011	Mire et al.
7,981,158	B2	7/2011	Fitz et al.
7,988,736	B2	8/2011	May et al.
7,993,353	B2	8/2011	Roβner et al.
8,043,290	B2	10/2011	Harrison et al.
8,062,301	B2	11/2011	Ammann et al.
8,066,708	B2	11/2011	Lang et al.
8,070,752	B2	12/2011	Metzger et al.
8,083,745	B2	12/2011	Lang et al.
8,083,746	B2	12/2011	Novak
8,083,749	B2	12/2011	Taber
8,086,336	B2	12/2011	Christensen
8,092,465	B2	1/2012	Metzger et al.
8,105,330	B2	1/2012	Fitz et al.
8,122,582	B2	2/2012	Burdulis, Jr. et al.
8,133,230	B2	3/2012	Stevens et al.
8,133,234	B2	3/2012	Meridew et al.
8,137,406	B2	3/2012	Novak et al.
8,147,861	B2	4/2012	Jones et al.
8,160,345	B2	4/2012	Pavlovskaia et al.
8,167,951	B2	5/2012	Ammann et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,170,641 B2 5/2012 Belcher
8,177,785 B2 5/2012 Vaidya
8,182,489 B2 5/2012 Horacek
8,187,302 B2 5/2012 Henderson, Sr. et al.
8,192,441 B2 6/2012 Collazo
8,192,495 B2 6/2012 Simpson et al.
8,200,355 B2 6/2012 Lee et al.
8,211,112 B2 7/2012 Novak et al.
8,221,428 B2 7/2012 Trieu
8,221,430 B2 7/2012 Park et al.
8,241,292 B2 8/2012 Collazo
8,241,293 B2 8/2012 Stone et al.
8,246,680 B2 8/2012 Betz et al.
8,260,589 B1 9/2012 Kumar
8,265,790 B2 9/2012 Amiot et al.
8,268,099 B2 9/2012 O'neill et al.
8,268,100 B2 9/2012 O'neill et al.
D669,176 S 10/2012 Frey
8,282,642 B2 10/2012 Mcclintock et al.
8,282,646 B2 10/2012 Schoenefeld et al.
8,298,237 B2 10/2012 Schoenefeld et al.
8,303,596 B2 11/2012 Plaβky et al.
8,313,491 B2 11/2012 Green, II et al.
D672,038 S 12/2012 Frey
8,333,772 B2 12/2012 Fox et al.
8,337,503 B2 12/2012 Lian
8,355,773 B2 1/2013 Leitner et al.
8,372,078 B2 2/2013 Collazo
8,377,066 B2 2/2013 Katrana et al.
8,388,690 B2 3/2013 Singhatat et al.
8,398,635 B2 3/2013 Vaidya
8,398,646 B2 3/2013 Metzger et al.
8,403,934 B2 3/2013 Angibaud et al.
8,407,067 B2 3/2013 Uthgenannt et al.
8,414,594 B2 4/2013 Berger et al.
8,419,741 B2 4/2013 Carignan et al.
8,425,522 B2 4/2013 Bonutti
8,430,882 B2 4/2013 Lowry et al.
8,430,931 B2 4/2013 Acker et al.
8,439,675 B2 5/2013 De Moyer
8,439,925 B2 5/2013 Marino et al.
8,444,564 B2 5/2013 Mahfouz et al.
8,444,651 B2 5/2013 Kunz et al.
8,457,930 B2 6/2013 Schroeder
8,460,302 B2 6/2013 Park et al.
8,469,961 B2 6/2013 Alleyne et al.
8,473,305 B2 6/2013 Belcher et al.
8,486,150 B2 7/2013 White et al.
8,500,740 B2 8/2013 Bojarski et al.
8,532,361 B2 9/2013 Pavlovskaia et al.
8,532,806 B1 9/2013 Masson
8,532,807 B2 9/2013 Metzger
8,535,387 B2 9/2013 Meridew et al.
8,543,234 B2 9/2013 Gao
8,545,508 B2 10/2013 Collazo
8,568,487 B2 10/2013 Witt et al.
8,591,516 B2 11/2013 Metzger et al.
8,597,365 B2 12/2013 Meridew
8,603,180 B2 12/2013 White et al.
8,608,748 B2 12/2013 Metzger et al.
8,608,749 B2 12/2013 Meridew et al.
8,617,170 B2 12/2013 Ashby et al.
8,617,174 B2 12/2013 Axelson, Jr. et al.
8,617,175 B2 12/2013 Park et al.
8,632,547 B2 1/2014 Maxson et al.
8,652,142 B2 2/2014 Geissler
8,668,700 B2 3/2014 Catanzarite et al.
8,702,712 B2 4/2014 Jordan et al.
8,702,715 B2 4/2014 Ammann et al.
8,706,285 B2 4/2014 Narainasamy et al.
8,715,289 B2 5/2014 Smith
8,728,387 B2 5/2014 Jones et al.
8,735,773 B2 5/2014 Lang
8,764,760 B2 7/2014 Metzger et al.
8,775,133 B2 7/2014 Schroeder
8,777,875 B2 7/2014 Park
8,828,016 B2 9/2014 Major et al.
8,828,087 B2 9/2014 Stone et al.
8,828,089 B1 9/2014 Perez et al.
8,834,568 B2 9/2014 Shapiro
8,858,561 B2 10/2014 White et al.
8,864,769 B2 10/2014 Stone et al.
8,900,244 B2 12/2014 Meridew et al.
8,903,530 B2 12/2014 Metzger
8,956,364 B2 2/2015 Catanzarite
8,979,936 B2 3/2015 White et al.
9,005,297 B2 4/2015 Katrana et al.
9,066,734 B2 6/2015 Schoenefeld et al.
9,295,497 B2 3/2016 Schoenefeld et al.
2001/0005797 A1 6/2001 Barlow et al.
2001/0011190 A1 8/2001 Park
2001/0021876 A1 9/2001 Terril-Grisoni et al.
2001/0054478 A1 12/2001 Watanabe et al.
2002/0007294 A1 1/2002 Bradbury et al.
2002/0029045 A1 3/2002 Bonutti
2002/0052606 A1 5/2002 Bonutti
2002/0059049 A1 5/2002 Bradbury et al.
2002/0082741 A1 6/2002 Mazumder et al.
2002/0087274 A1 7/2002 Alexander et al.
2002/0092532 A1 7/2002 Yoon
2002/0107522 A1 8/2002 Picard et al.
2002/0128872 A1 9/2002 Giammattei
2002/0147415 A1 10/2002 Martelli
2002/0186818 A1 12/2002 Arnaud et al.
2002/0193797 A1 12/2002 Johnson et al.
2002/0198528 A1 12/2002 Engh et al.
2002/0198531 A1 12/2002 Millard et al.
2003/0009171 A1 1/2003 Tornier
2003/0009234 A1 1/2003 Treacy et al.
2003/0011624 A1 1/2003 Ellis
2003/0018338 A1 1/2003 Axelson, Jr. et al.
2003/0039676 A1 2/2003 Boyce et al.
2003/0055502 A1 3/2003 Lang et al.
2003/0105526 A1 6/2003 Bryant et al.
2003/0109784 A1 6/2003 Loh et al.
2003/0120276 A1 6/2003 Tallarida et al.
2003/0130741 A1 7/2003 McMinn
2003/0139817 A1 7/2003 Tuke et al.
2003/0158606 A1 8/2003 Coon et al.
2003/0171757 A1 9/2003 Coon et al.
2003/0216669 A1 11/2003 Lang et al.
2004/0018144 A1 1/2004 Briscoe
2004/0030245 A1 2/2004 Noble et al.
2004/0054372 A1 3/2004 Corden et al.
2004/0054416 A1 3/2004 Wyss et al.
2004/0068187 A1 4/2004 Krause et al.
2004/0092932 A1 5/2004 Aubin et al.
2004/0098133 A1 5/2004 Carignan et al.
2004/0102852 A1 5/2004 Johnson et al.
2004/0102866 A1 5/2004 Harris et al.
2004/0106926 A1 6/2004 Leitner et al.
2004/0115586 A1 6/2004 Andreiko et al.
2004/0122436 A1 6/2004 Grimm
2004/0122439 A1 6/2004 Dwyer et al.
2004/0128026 A1 7/2004 Harris et al.
2004/0133276 A1 7/2004 Lang et al.
2004/0138754 A1 7/2004 Lang et al.
2004/0143336 A1 7/2004 Burkinshaw
2004/0147927 A1 7/2004 Tsougarakis et al.
2004/0148026 A1 7/2004 Bonutti
2004/0153079 A1 8/2004 Tsougarakis et al.
2004/0153087 A1 8/2004 Sanford et al.
2004/0158254 A1 8/2004 Eisermann
2004/0162619 A1 8/2004 Blaylock et al.
2004/0167390 A1 8/2004 Alexander et al.
2004/0171924 A1 9/2004 Mire et al.
2004/0172137 A1 9/2004 Blaylock et al.
2004/0181144 A1 9/2004 Cinquin et al.
2004/0193169 A1 9/2004 Schon et al.
2004/0204644 A1 10/2004 Tsougarakis et al.
2004/0204760 A1 10/2004 Fitz et al.
2004/0212586 A1 10/2004 Trueman, III
2004/0215190 A1 10/2004 Nguyen et al.
2004/0220583 A1 11/2004 Pieczynski, II et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2004/0236341	A1	11/2004	Petersen
2004/0236424	A1	11/2004	Berez et al.
2004/0243481	A1	12/2004	Bradbury et al.
2004/0254584	A1	12/2004	Sarin et al.
2004/0260301	A1	12/2004	Lionberger et al.
2005/0008887	A1	1/2005	Haymann et al.
2005/0010227	A1	1/2005	Paul
2005/0010300	A1	1/2005	Disilvestro et al.
2005/0015022	A1	1/2005	Richard et al.
2005/0019664	A1	1/2005	Matsumoto
2005/0021148	A1	1/2005	Gibbs
2005/0027303	A1	2/2005	Lionberger et al.
2005/0027361	A1	2/2005	Reiley
2005/0043806	A1	2/2005	Cook et al.
2005/0043837	A1	2/2005	Rubbert et al.
2005/0049524	A1	3/2005	Lefevre et al.
2005/0049603	A1	3/2005	Calton et al.
2005/0059873	A1	3/2005	Glozman et al.
2005/0060040	A1	3/2005	Auxepaules et al.
2005/0065628	A1	3/2005	Roose
2005/0070897	A1	3/2005	Petersen
2005/0071015	A1	3/2005	Sekel
2005/0075641	A1	4/2005	Singhatat et al.
2005/0096535	A1	5/2005	De La Barrera
2005/0113841	A1	5/2005	Sheldon et al.
2005/0113846	A1	5/2005	Carson
2005/0119664	A1	6/2005	Carignan et al.
2005/0131662	A1	6/2005	Ascenzi et al.
2005/0137708	A1	6/2005	Clark
2005/0143818	A1	6/2005	Yuan et al.
2005/0148843	A1	7/2005	Roose
2005/0149042	A1	7/2005	Metzger
2005/0171545	A1	8/2005	Walsh et al.
2005/0177245	A1	8/2005	Leatherbury et al.
2005/0203522	A1	9/2005	Vaughan
2005/0203536	A1	9/2005	Laffargue et al.
2005/0203540	A1	9/2005	Broyles
2005/0209605	A1	9/2005	Grimm et al.
2005/0216305	A1	9/2005	Funderud
2005/0222571	A1	10/2005	Ryan
2005/0222573	A1	10/2005	Branch et al.
2005/0228393	A1	10/2005	Williams, III et al.
2005/0234461	A1	10/2005	Burdulis, Jr. et al.
2005/0234465	A1	10/2005	Mccombs et al.
2005/0234468	A1	10/2005	Carson
2005/0240195	A1	10/2005	Axelson, Jr. et al.
2005/0240267	A1	10/2005	Randall et al.
2005/0244239	A1	11/2005	Shimp
2005/0245934	A1	11/2005	Tuke et al.
2005/0245936	A1	11/2005	Tuke et al.
2005/0251147	A1	11/2005	Novak
2005/0267353	A1	12/2005	Marquart et al.
2005/0267481	A1	12/2005	Carl et al.
2005/0267485	A1	12/2005	Cordes et al.
2005/0267584	A1	12/2005	Burdulis, Jr. et al.
2005/0273114	A1	12/2005	Novak
2005/0283252	A1	12/2005	Coon et al.
2005/0283253	A1	12/2005	Coon et al.
2006/0004284	A1	1/2006	Grunschlager et al.
2006/0015120	A1	1/2006	Richard et al.
2006/0030853	A1	2/2006	Haines
2006/0038520	A1	2/2006	Negoro
2006/0052725	A1	3/2006	Santilli
2006/0058803	A1	3/2006	Cuckler et al.
2006/0058884	A1	3/2006	Aram et al.
2006/0058886	A1	3/2006	Wozencroft
2006/0089621	A1	4/2006	Fard
2006/0093988	A1	5/2006	Swaelens et al.
2006/0094951	A1	5/2006	Dean et al.
2006/0095044	A1	5/2006	Grady, Jr. et al.
2006/0100832	A1	5/2006	Bowman
2006/0105011	A1	5/2006	Sun et al.
2006/0111722	A1	5/2006	Bouadi
2006/0122616	A1	6/2006	Bennett et al.
2006/0122618	A1	6/2006	Claypool et al.
2006/0136058	A1	6/2006	Pietrzak
2006/0142657	A1	6/2006	Quaid et al.
2006/0147332	A1	7/2006	Jones et al.
2006/0149283	A1	7/2006	May et al.
2006/0155380	A1	7/2006	Clemow et al.
2006/0161154	A1	7/2006	Mcafee
2006/0161165	A1	7/2006	Swanson et al.
2006/0161167	A1	7/2006	Myers et al.
2006/0172263	A1	8/2006	Quadling et al.
2006/0178497	A1	8/2006	Gevaert et al.
2006/0184177	A1	8/2006	Echeverri
2006/0184250	A1	8/2006	Bandoh et al.
2006/0190086	A1	8/2006	Clemow et al.
2006/0192319	A1	8/2006	Solar
2006/0195111	A1	8/2006	Couture
2006/0195194	A1	8/2006	Gunther
2006/0195198	A1	8/2006	James
2006/0200158	A1	9/2006	Farling et al.
2006/0204932	A1	9/2006	Haymann et al.
2006/0210644	A1	9/2006	Levin
2006/0217808	A1	9/2006	Novak
2006/0229618	A1	10/2006	Dube
2006/0235391	A1	10/2006	Sutterlin, III
2006/0235421	A1	10/2006	Rosa et al.
2006/0241635	A1	10/2006	Stumpo et al.
2006/0241636	A1	10/2006	Novak et al.
2006/0271058	A1	11/2006	Ashton et al.
2006/0276796	A1	12/2006	Creger et al.
2006/0276797	A1	12/2006	Botimer
2006/0287733	A1	12/2006	Bonutti
2006/0287891	A1	12/2006	Grasso et al.
2006/0293681	A1	12/2006	Claypool et al.
2007/0015995	A1	1/2007	Lang et al.
2007/0016008	A1	1/2007	Schoenefeld
2007/0016209	A1	1/2007	Ammann et al.
2007/0027680	A1	2/2007	Ashley et al.
2007/0039205	A1	2/2007	Erb et al.
2007/0043582	A1	2/2007	Peveto et al.
2007/0066917	A1	3/2007	Hodorek et al.
2007/0073133	A1	3/2007	Schoenefeld
2007/0073136	A1	3/2007	Metzger
2007/0073137	A1	3/2007	Schoenefeld
2007/0083214	A1	4/2007	Duncan et al.
2007/0083266	A1	4/2007	Lang
2007/0100258	A1	5/2007	Shoham et al.
2007/0100450	A1	5/2007	Hodorek
2007/0100462	A1	5/2007	Lang et al.
2007/0106299	A1	5/2007	Manspeizer
2007/0106305	A1	5/2007	Kao et al.
2007/0106383	A1	5/2007	Abdou
2007/0118055	A1	5/2007	Mccombs
2007/0118138	A1	5/2007	Seo et al.
2007/0118243	A1	5/2007	Schroeder et al.
2007/0123872	A1	5/2007	Brockmeyer et al.
2007/0129809	A1	6/2007	Meridew et al.
2007/0142914	A1	6/2007	Jones et al.
2007/0150068	A1	6/2007	Dong et al.
2007/0156066	A1	7/2007	Mcginley et al.
2007/0156171	A1	7/2007	Lang et al.
2007/0162021	A1	7/2007	Dinh et al.
2007/0162038	A1	7/2007	Tuke
2007/0162039	A1	7/2007	Wozencroft
2007/0173946	A1	7/2007	Bonutti
2007/0173948	A1	7/2007	Meridew et al.
2007/0185498	A2	8/2007	Lavallee
2007/0191962	A1	8/2007	Jones
2007/0198022	A1	8/2007	Lang et al.
2007/0203430	A1	8/2007	Lang et al.
2007/0203605	A1	8/2007	Melton et al.
2007/0219639	A1	9/2007	Otto et al.
2007/0219640	A1	9/2007	Steinberg
2007/0224238	A1	9/2007	Mansmann et al.
2007/0225713	A1	9/2007	Altarac et al.
2007/0226986	A1	10/2007	Park et al.
2007/0233121	A1	10/2007	Carson et al.
2007/0233136	A1	10/2007	Wozencroft
2007/0233140	A1	10/2007	Metzger et al.
2007/0233141	A1	10/2007	Park et al.
2007/0233269	A1	10/2007	Steines et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2007/0233272 A1 10/2007 Boyce et al.
2007/0238069 A1 10/2007 Lovald et al.
2007/0239282 A1 10/2007 Caylor, III et al.
2007/0239481 A1 10/2007 Disilvestro et al.
2007/0244487 A1 10/2007 Ammann et al.
2007/0250169 A1 10/2007 Lang
2007/0253617 A1 11/2007 Arata et al.
2007/0255288 A1 11/2007 Mahfouz et al.
2007/0255412 A1 11/2007 Hajaj et al.
2007/0262867 A1 11/2007 Westrick et al.
2007/0272747 A1 11/2007 Woods et al.
2007/0276224 A1 11/2007 Lang et al.
2007/0276400 A1 11/2007 Moore et al.
2007/0276501 A1 11/2007 Betz et al.
2007/0288029 A1 12/2007 Justin et al.
2007/0288030 A1 12/2007 Metzger et al.
2008/0009952 A1 1/2008 Hodge
2008/0015599 A1 1/2008 D'alessio et al.
2008/0015603 A1 1/2008 Collazo
2008/0015604 A1 1/2008 Collazo
2008/0015605 A1 1/2008 Collazo
2008/0021299 A1 1/2008 Meulink
2008/0021494 A1 1/2008 Schmelzeisen-redeker et al.
2008/0021567 A1 1/2008 Meulink et al.
2008/0027563 A1 1/2008 Johnson et al.
2008/0033442 A1 2/2008 Amiot et al.
2008/0039850 A1 2/2008 Rowley et al.
2008/0051799 A1 2/2008 Bonutti et al.
2008/0051910 A1 2/2008 Kammerzell et al.
2008/0058945 A1 3/2008 Hajaj et al.
2008/0058947 A1 3/2008 Earl et al.
2008/0062183 A1 3/2008 Swaelens
2008/0065225 A1 3/2008 Wasielewski et al.
2008/0094396 A1 4/2008 Sabczynsdi et al.
2008/0097451 A1 4/2008 Chen et al.
2008/0112996 A1 5/2008 Harlow et al.
2008/0114370 A1 5/2008 Schoenefeld
2008/0133022 A1 6/2008 Caylor
2008/0140081 A1 6/2008 Heavener et al.
2008/0140209 A1 6/2008 Iannotti et al.
2008/0140213 A1 6/2008 Ammann et al.
2008/0146969 A1 6/2008 Kurtz
2008/0147072 A1 6/2008 Park et al.
2008/0147073 A1 6/2008 Ammann et al.
2008/0147074 A1 6/2008 Ammann et al.
2008/0154306 A1 6/2008 Heinz
2008/0161815 A1 7/2008 Schoenefeld et al.
2008/0161816 A1 7/2008 Stevens et al.
2008/0172125 A1 7/2008 Ek
2008/0195099 A1 8/2008 Minas
2008/0195107 A1 8/2008 Cuckler et al.
2008/0195108 A1 8/2008 Bhatnagar et al.
2008/0195109 A1 8/2008 Hunter et al.
2008/0195216 A1 8/2008 Philipp
2008/0200926 A1 8/2008 Verard et al.
2008/0208200 A1 8/2008 Crofford
2008/0208353 A1 8/2008 Kumar et al.
2008/0215059 A1 9/2008 Carignan et al.
2008/0230422 A1 9/2008 Pleil et al.
2008/0234664 A1 9/2008 May et al.
2008/0234683 A1 9/2008 May
2008/0234685 A1 9/2008 Gjerde
2008/0234833 A1 9/2008 Bandoh et al.
2008/0243127 A1 10/2008 Lang et al.
2008/0255674 A1 10/2008 Rahaman et al.
2008/0257363 A1 10/2008 Schoenefeld et al.
2008/0262500 A1 10/2008 Collazo
2008/0262624 A1 10/2008 White et al.
2008/0269596 A1 10/2008 Revie et al.
2008/0269906 A1 10/2008 Iannotti et al.
2008/0275452 A1 11/2008 Lang et al.
2008/0281328 A1 11/2008 Lang et al.
2008/0281329 A1 11/2008 Fitz et al.
2008/0281426 A1 11/2008 Fitz et al.
2008/0287926 A1 11/2008 Abou El
2008/0287953 A1 11/2008 Sers
2008/0287954 A1 11/2008 Kunz et al.
2008/0294170 A1 11/2008 O'brien
2008/0294266 A1 11/2008 Steinberg
2008/0300600 A1 12/2008 Guelat et al.
2008/0306485 A1 12/2008 Coon et al.
2008/0306558 A1 12/2008 Hakki
2008/0312659 A1 12/2008 Metzger et al.
2008/0319448 A1 12/2008 Lavallee et al.
2008/0319491 A1 12/2008 Schoenefeld
2009/0012526 A1 1/2009 Fletcher
2009/0018546 A1 1/2009 Daley
2009/0018666 A1 1/2009 Grundei et al.
2009/0024131 A1 1/2009 Metzger et al.
2009/0024169 A1 1/2009 Triplett et al.
2009/0043556 A1 2/2009 Axelson et al.
2009/0048618 A1 2/2009 Harrison et al.
2009/0076371 A1 3/2009 Lang et al.
2009/0076512 A1 3/2009 Ammann et al.
2009/0076520 A1 3/2009 Choi
2009/0076555 A1 3/2009 Lowry et al.
2009/0082770 A1 3/2009 Worner et al.
2009/0082774 A1 3/2009 Oti et al.
2009/0087276 A1 4/2009 Rose
2009/0088674 A1 4/2009 Caillouette et al.
2009/0088753 A1 4/2009 Aram et al.
2009/0088754 A1 4/2009 Aker et al.
2009/0088755 A1 4/2009 Aker et al.
2009/0088758 A1 4/2009 Bennett
2009/0088759 A1 4/2009 Aram et al.
2009/0088760 A1 4/2009 Aram et al.
2009/0088761 A1 4/2009 Roose et al.
2009/0088763 A1 4/2009 Aram et al.
2009/0088865 A1 4/2009 Brehm
2009/0088866 A1 4/2009 Case
2009/0089034 A1 4/2009 Penney et al.
2009/0089081 A1 4/2009 Haddad
2009/0093815 A1 4/2009 Fletcher et al.
2009/0093816 A1 4/2009 Roose et al.
2009/0096613 A1 4/2009 Westrick
2009/0099567 A1 4/2009 Zajac
2009/0105837 A1 4/2009 Lafosse et al.
2009/0116621 A1 5/2009 Yuan et al.
2009/0118736 A1 5/2009 Kreuzer
2009/0118764 A1 5/2009 Vaughan
2009/0118769 A1 5/2009 Sixto, Jr. et al.
2009/0131941 A1 5/2009 Park et al.
2009/0131942 A1 5/2009 Aker et al.
2009/0138020 A1 5/2009 Park et al.
2009/0143716 A1 6/2009 Lowry et al.
2009/0149964 A1 6/2009 May et al.
2009/0149965 A1 6/2009 Quaid
2009/0149977 A1 6/2009 Schendel
2009/0151736 A1 6/2009 Belcher et al.
2009/0157083 A1 6/2009 Park et al.
2009/0163922 A1 6/2009 Meridew et al.
2009/0163923 A1 6/2009 Flett et al.
2009/0164024 A1 6/2009 Rudan et al.
2009/0177282 A1 7/2009 Bureau et al.
2009/0187191 A1 7/2009 Carl et al.
2009/0187193 A1 7/2009 Maroney et al.
2009/0209884 A1 8/2009 Van Vorhis et al.
2009/0209961 A1 8/2009 Ferrante et al.
2009/0222014 A1 9/2009 Bojarski et al.
2009/0222015 A1 9/2009 Park et al.
2009/0222016 A1 9/2009 Park et al.
2009/0222103 A1 9/2009 Fitz et al.
2009/0226068 A1 9/2009 Fitz et al.
2009/0228016 A1 9/2009 Alvarez
2009/0234360 A1 9/2009 Alexander
2009/0248044 A1 10/2009 Amiot et al.
2009/0250413 A1 10/2009 Hoeppner
2009/0254093 A1 10/2009 White et al.
2009/0254367 A1 10/2009 Belcher et al.
2009/0259261 A1 10/2009 Reiley
2009/0259312 A1 10/2009 Shterling et al.
2009/0270868 A1 10/2009 Park et al.
2009/0270917 A1 10/2009 Boehm
2009/0274350 A1 11/2009 Pavlovskaia et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2009/0287217 A1 11/2009 Ammann et al.
2009/0287309 A1 11/2009 Walch et al.
2009/0306676 A1 12/2009 Lang et al.
2009/0307893 A1 12/2009 Burdulis, Jr. et al.
2009/0318836 A1 12/2009 Stone et al.
2009/0318921 A1 12/2009 White et al.
2010/0010493 A1 1/2010 Dower
2010/0016984 A1 1/2010 Trabish
2010/0016986 A1 1/2010 Trabish
2010/0023015 A1 1/2010 Park
2010/0030231 A1 2/2010 Revie et al.
2010/0036404 A1 2/2010 Yi et al.
2010/0042105 A1 2/2010 Park et al.
2010/0049195 A1 2/2010 Park et al.
2010/0057088 A1 3/2010 Shah
2010/0076439 A1 3/2010 Hatch
2010/0076505 A1 3/2010 Borja
2010/0076563 A1 3/2010 Otto et al.
2010/0076571 A1 3/2010 Hatch
2010/0082034 A1 4/2010 Remia
2010/0082035 A1 4/2010 Keefer
2010/0082067 A1 4/2010 Kondrashov
2010/0087829 A1 4/2010 Metzger
2010/0094295 A1 4/2010 Schnieders et al.
2010/0105011 A1 4/2010 Karkar et al.
2010/0121334 A1 5/2010 Couture et al.
2010/0121335 A1 5/2010 Penenberg et al.
2010/0137869 A1 6/2010 Borja et al.
2010/0137924 A1 6/2010 Tuke et al.
2010/0139377 A1 6/2010 Huang et al.
2010/0145343 A1 6/2010 Johnson et al.
2010/0145344 A1 6/2010 Jordan et al.
2010/0152782 A1 6/2010 Stone et al.
2010/0160917 A1 6/2010 Fitz et al.
2010/0160919 A1 6/2010 Axelson, Jr. et al.
2010/0160925 A1 6/2010 Heilala et al.
2010/0168752 A1 7/2010 Edwards
2010/0168754 A1 7/2010 Fitz et al.
2010/0168857 A1 7/2010 Hatch
2010/0168866 A1 7/2010 Shih
2010/0179663 A1 7/2010 Steinberg
2010/0185202 A1 7/2010 Lester et al.
2010/0191244 A1 7/2010 White et al.
2010/0198067 A1 8/2010 Mahfouz et al.
2010/0198224 A1 8/2010 Metzger
2010/0212138 A1 8/2010 Carroll et al.
2010/0217109 A1 8/2010 Belcher
2010/0217270 A1 8/2010 Polinski et al.
2010/0217336 A1 8/2010 Crawford et al.
2010/0217338 A1 8/2010 Carroll et al.
2010/0217399 A1 8/2010 Groh
2010/0222783 A1 9/2010 May et al.
2010/0228257 A1 9/2010 Bonutti
2010/0249657 A1 9/2010 Nycz et al.
2010/0249796 A1 9/2010 Nycz
2010/0256649 A1 10/2010 Capsal et al.
2010/0262150 A1 10/2010 Lian
2010/0274253 A1 10/2010 Ure
2010/0281678 A1 11/2010 Burdulis, Jr. et al.
2010/0286700 A1 11/2010 Snider et al.
2010/0291401 A1 11/2010 Medina et al.
2010/0292743 A1 11/2010 Singhal et al.
2010/0298894 A1 11/2010 Bojarski et al.
2010/0305574 A1 12/2010 Fitz et al.
2010/0318088 A1 12/2010 Warne et al.
2010/0324692 A1 12/2010 Uthgenannt et al.
2011/0004317 A1 1/2011 Hacking et al.
2011/0008754 A1 1/2011 Bassett et al.
2011/0009869 A1 1/2011 Marino et al.
2011/0014081 A1 1/2011 Jones et al.
2011/0015636 A1 1/2011 Katrana et al.
2011/0015639 A1 1/2011 Metzger et al.
2011/0015752 A1 1/2011 Meridew
2011/0016690 A1 1/2011 Narainasamy et al.
2011/0022049 A1 1/2011 Huebner et al.
2011/0022174 A1 1/2011 Holdstein et al.
2011/0029088 A1 2/2011 Rauscher et al.
2011/0029091 A1 2/2011 Bojarski et al.
2011/0029093 A1 2/2011 Bojarski
2011/0029116 A1 2/2011 Jordan et al.
2011/0035012 A1 2/2011 Linares
2011/0040303 A1 2/2011 Iannotti et al.
2011/0040334 A1 2/2011 Kaes et al.
2011/0046631 A1 2/2011 Suter et al.
2011/0046735 A1 2/2011 Metzger et al.
2011/0054478 A1 3/2011 Vanasse et al.
2011/0066193 A1 3/2011 Lang et al.
2011/0066245 A1 3/2011 Lang et al.
2011/0071528 A1 3/2011 Carson
2011/0071529 A1 3/2011 Carson
2011/0071530 A1 3/2011 Carson
2011/0071532 A1 3/2011 Carson
2011/0071533 A1 3/2011 Metzger et al.
2011/0071581 A1 3/2011 Lang et al.
2011/0071802 A1 3/2011 Bojarski et al.
2011/0087332 A1 4/2011 Bojarski et al.
2011/0092804 A1 4/2011 Schoenefeld et al.
2011/0093086 A1 4/2011 Witt et al.
2011/0106093 A1 5/2011 Romano et al.
2011/0106254 A1 5/2011 Abel et al.
2011/0125264 A1 5/2011 Bagga et al.
2011/0125284 A1 5/2011 Gabbrielli et al.
2011/0130795 A1 6/2011 Ball
2011/0151027 A1 6/2011 Clineff et al.
2011/0151259 A1 6/2011 Jarman-smith et al.
2011/0153025 A1 6/2011 Mcminn
2011/0160736 A1 6/2011 Meridew et al.
2011/0160867 A1 6/2011 Meridew et al.
2011/0166578 A1 7/2011 Stone et al.
2011/0172672 A1 7/2011 Dubeau et al.
2011/0177590 A1 7/2011 Clyne et al.
2011/0184419 A1 7/2011 Meridew et al.
2011/0184526 A1 7/2011 White et al.
2011/0190899 A1 8/2011 Pierce et al.
2011/0190901 A1 8/2011 Weissberg et al.
2011/0213376 A1 9/2011 Maxson et al.
2011/0214279 A1 9/2011 Park et al.
2011/0218545 A1 9/2011 Catanzarite et al.
2011/0224674 A1 9/2011 White et al.
2011/0238071 A1 9/2011 Fernandez-scoma
2011/0238181 A1 9/2011 Trieu
2011/0245835 A1 10/2011 Dodds et al.
2011/0251617 A1 10/2011 Ammann et al.
2011/0257657 A1 10/2011 Turner et al.
2011/0264229 A1 10/2011 Donner
2011/0269100 A1 11/2011 Furrer et al.
2011/0270315 A1 11/2011 Vaughan
2011/0275032 A1 11/2011 Tardieu et al.
2011/0276145 A1 11/2011 Carignan et al.
2011/0282473 A1 11/2011 Pavlovskaia et al.
2011/0295887 A1 12/2011 Palmese et al.
2011/0313424 A1 12/2011 Bono et al.
2011/0319745 A1 12/2011 Frey
2012/0010619 A1 1/2012 Barsoum
2012/0010710 A1 1/2012 Frigg
2012/0010711 A1 1/2012 Antonyshyn et al.
2012/0029345 A1 2/2012 Mahfouz et al.
2012/0029520 A1 2/2012 Lang et al.
2012/0041445 A1 2/2012 Roose et al.
2012/0041446 A1 2/2012 Wong et al.
2012/0041564 A1 2/2012 Landon
2012/0065640 A1 3/2012 Metzger et al.
2012/0078254 A1 3/2012 Ashby et al.
2012/0078258 A1 3/2012 Lo et al.
2012/0078259 A1 3/2012 Meridew
2012/0089192 A1 4/2012 Biedermann
2012/0089595 A1 4/2012 Jaecksch et al.
2012/0101586 A1 4/2012 Carson
2012/0109137 A1 5/2012 Iannotti et al.
2012/0109138 A1 5/2012 Meridew et al.
2012/0109226 A1 5/2012 Iannotti et al.
2012/0116203 A1 5/2012 Vancraen et al.
2012/0123422 A1 5/2012 Agnihotri et al.
2012/0130382 A1 5/2012 Iannotti et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2012/0136365	A1	5/2012	Iannotti et al.
2012/0141034	A1	6/2012	Iannotti et al.
2012/0143197	A1	6/2012	Lang et al.
2012/0143198	A1	6/2012	Boyer et al.
2012/0143267	A1	6/2012	Iannotti et al.
2012/0150242	A1	6/2012	Mannion
2012/0158002	A1	6/2012	Carignan et al.
2012/0165954	A1	6/2012	Nimal
2012/0192401	A1	8/2012	Pavlovskaia et al.
2012/0196314	A1	8/2012	Nawaz et al.
2012/0203236	A1	8/2012	Mamourian
2012/0209276	A1	8/2012	Schuster
2012/0215225	A1	8/2012	Philippon et al.
2012/0215310	A1	8/2012	Sharp et al.
2012/0221017	A1	8/2012	Bonutti
2012/0226283	A1	9/2012	Meridew et al.
2012/0232596	A1	9/2012	Ribeiro
2012/0245587	A1	9/2012	Fang et al.
2012/0259335	A1	10/2012	Scifert et al.
2012/0265208	A1	10/2012	Smith
2012/0271131	A1	10/2012	Kling et al.
2012/0271314	A1	10/2012	Stemniski et al.
2012/0271366	A1	10/2012	Katrana et al.
2012/0276509	A1	11/2012	Iannotti et al.
2012/0277751	A1	11/2012	Catanzarite et al.
2012/0289965	A1	11/2012	Gelaude et al.
2012/0296339	A1	11/2012	Iannotti et al.
2012/0296428	A1	11/2012	Donner
2012/0303004	A1	11/2012	Uthgenannt et al.
2012/0303033	A1	11/2012	Weiner et al.
2012/0310364	A1	12/2012	Li et al.
2012/0310399	A1	12/2012	Metzger
2012/0316564	A1	12/2012	Serbousek et al.
2012/0323246	A1	12/2012	Catanzarite et al.
2012/0323282	A1	12/2012	Brianza et al.
2012/0323323	A1	12/2012	Vargas et al.
2013/0001121	A1	1/2013	Metzger
2013/0006250	A1	1/2013	Metzger et al.
2013/0018483	A1	1/2013	Li et al.
2013/0035766	A1	2/2013	Meridew
2013/0046310	A1	2/2013	Ranawat et al.
2013/0053854	A1	2/2013	Schoenefeld et al.
2013/0056912	A1	3/2013	O'neill et al.
2013/0060253	A1	3/2013	Couture et al.
2013/0072940	A1	3/2013	Dawood et al.
2013/0085500	A1	4/2013	Meridew et al.
2013/0085590	A1	4/2013	Bryan et al.
2013/0119579	A1	5/2013	Iannotti et al.
2013/0123850	A1	5/2013	Schoenefeld et al.
2013/0131681	A1	5/2013	Katrana et al.
2013/0144392	A1	6/2013	Hughes
2013/0197528	A1	8/2013	Zakaria et al.
2013/0197529	A1	8/2013	Metzger
2013/0197687	A1	8/2013	Pavlovskaia et al.
2013/0218163	A1	8/2013	Frey
2013/0245631	A1	9/2013	Bettenga
2013/0245801	A1	9/2013	Schroeder
2013/0261503	A1	10/2013	Sherman et al.
2013/0264749	A1	10/2013	Jones et al.
2013/0268085	A1	10/2013	Dong
2013/0289730	A1	10/2013	Gabriel et al.
2013/0317511	A1	11/2013	Bojarski et al.
2013/0326878	A1	12/2013	Boehm et al.
2013/0338673	A1	12/2013	Keppler
2014/0005672	A1	1/2014	Edwards et al.
2014/0012266	A1	1/2014	Bonin, Jr. et al.
2014/0052270	A1	2/2014	Witt et al.
2014/0066937	A1	3/2014	Wiebe, III et al.
2014/0081275	A1	3/2014	Metzger et al.
2014/0081659	A1	3/2014	Nawana et al.
2014/0088724	A1	3/2014	Meridew
2014/0094816	A1	4/2014	White et al.
2014/0100578	A1	4/2014	Metzger et al.
2014/0107651	A1	4/2014	Meridew et al.
2014/0107654	A1	4/2014	Kehres et al.
2014/0107715	A1	4/2014	Heilman et al.
2014/0127211	A1	5/2014	Geles et al.
2014/0135775	A1	5/2014	Maxson
2014/0163564	A1	6/2014	Bollinger
2014/0163565	A1	6/2014	Bollinger
2014/0172116	A1	6/2014	Maxson et al.
2014/0188119	A1	7/2014	Catanzarite et al.
2014/0222157	A1	8/2014	Al Hares et al.
2014/0243833	A1	8/2014	Smith
2014/0257304	A1	9/2014	Eash
2014/0257508	A1	9/2014	Bojarski et al.
2014/0276854	A1	9/2014	Schoenefeld et al.
2014/0276856	A1	9/2014	Schoenefeld
2014/0276870	A1	9/2014	Eash
2014/0276873	A1	9/2014	Meridew et al.
2014/0303938	A1	10/2014	Schoenefeld et al.
2014/0303990	A1	10/2014	Schoenefeld et al.
2014/0309644	A1	10/2014	Metzger et al.
2014/0324058	A1	10/2014	Metzger et al.
2014/0378979	A1	12/2014	Stone et al.
2015/0088293	A1	3/2015	Metzger
2015/0112348	A1	4/2015	Schoenefeld et al.
2015/0112349	A1	4/2015	Schoenefeld
2015/0374389	A1	12/2015	Schoenefeld et al.

FOREIGN PATENT DOCUMENTS

CA	2505371	A1	5/2004
CA	2505419	A1	6/2004
CA	2506849	A1	6/2004
CA	2546958	A1	6/2005
CA	2546965	A1	6/2005
CA	2588907	A1	6/2006
CA	2590534	A1	6/2006
CN	1630495	A	6/2005
CN	1728976	A	2/2006
CN	1729483	A	2/2006
CN	1729484	A	2/2006
CN	1913844	A	2/2007
CN	101111197	A	1/2008
CN	102038553	A	5/2011
CN	102335742	A	2/2012
DE	3447365	A1	7/1986
DE	04219939	A1	12/1993
DE	4421153	A1	12/1995
DE	10341187	A1	3/2005
DE	102009028503	A1	2/2011
DE	102011082902	A1	3/2012
DE	102012205820	A1	10/2012
DE	112010003901	T5	11/2012
EP	0114505	A1	8/1984
EP	0255797	A1	2/1988
EP	0326768	A2	8/1989
EP	0579868	A2	1/1994
EP	0591985	A1	4/1994
EP	0645984	A1	4/1995
EP	0650706	A1	5/1995
EP	0916324	A2	5/1999
EP	1321107	A1	6/2003
EP	1327424	A1	7/2003
EP	1437102	A1	7/2004
EP	01486900	A1	12/2004
EP	1634551	A2	3/2006
EP	1832239	A1	9/2007
EP	1852072	A2	11/2007
EP	2029061	A2	3/2009
EP	2168507	A2	3/2010
EP	2303146	A1	4/2011
EP	2303192	A1	4/2011
EP	2352445	A1	8/2011
EP	2396741	A1	12/2011
EP	2398381	A1	12/2011
EP	2403437	A2	1/2012
EP	2491873	A2	8/2012
EP	2502582	A1	9/2012
EP	2709568	A1	3/2014
EP	2914187	A1	9/2015
FR	2659226	A2	9/1991
FR	2721195	A1	12/1995

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

FR	2768916	A1	4/1999
FR	2979817	A1	3/2013
GB	2094590	A	9/1982
GB	2197790	A1	6/1988
GB	2442441	A	4/2008
GB	2447702	A	9/2008
GB	2483980	A	3/2012
GB	2486390	A	6/2012
GB	2490220	A	10/2012
GB	2491526	A	12/2012
GB	2509271	A	6/2014
JP	59157715	A	9/1984
JP	60231208	A	11/1985
JP	6233790	A	8/1994
JP	2000245758	A	9/2000
JP	2005218861	A	8/2005
JP	2009514612	A	4/2009
JP	2011505080	A	2/2011
JP	2011527885	A	11/2011
JP	5710014	B2	4/2015
KR	20050072500	A	7/2005
KR	20050084024	A	8/2005
RU	2083179	C1	7/1997
RU	2113182	C1	6/1998
RU	2125835	C1	2/1999
RU	2138223	C1	9/1999
RU	2175534	C2	11/2001
RU	2187975	C1	8/2002
RU	2218242	C2	12/2003
TW	231755	A	5/2005
TW	201114409	A	5/2011
WO	WO-8807840	A1	10/1988
WO	WO-9107139	A1	5/1991
WO	WO-9325157	A1	12/1993
WO	WO-9528688	A1	10/1995
WO	WO-9952473	A1	10/1999
WO	WO-9959106	A1	11/1999
WO	WO-0170142	A1	9/2001
WO	WO-0184479	A1	11/2001
WO	WO-0217821	A2	3/2002
WO	WO-0226145	A1	4/2002
WO	WO-0236024	A1	5/2002
WO	WO-02096268	A2	12/2002
WO	WO-03051210	A2	6/2003
WO	WO-03051211	A1	6/2003
WO	WO-2004032806	A1	4/2004
WO	WO-2004049981	A2	6/2004
WO	WO-2004051301	A2	6/2004
WO	WO-2004078069	A2	9/2004
WO	WO-2005051233	A2	6/2005
WO	WO-2005051239	A1	6/2005
WO	WO-2005051240	A1	6/2005
WO	WO-2005077039	A2	8/2005
WO	WO-2006058057	A2	6/2006
WO	WO-2006060795	A1	6/2006
WO	WO-2006092600	A1	9/2006
WO	WO-2006127486	A2	11/2006
WO	WO-2006134345	A1	12/2006
WO	WO-2006136955	A1	12/2006
WO	WO-2007041375	A2	4/2007
WO	WO-2007053572	A2	5/2007
WO	WO-2007062079	A2	5/2007
WO	WO-2007092841	A2	8/2007
WO	WO-2007137327	A1	12/2007
WO	WO-2007145937	A2	12/2007
WO	WO-2008014618	A1	2/2008
WO	WO-2008021494	A2	2/2008
WO	WO-2008040961	A1	4/2008
WO	WO-2008044055	A1	4/2008
WO	WO-2008091358	A1	7/2008
WO	WO-2008101090	A2	8/2008
WO	WO-2008109751	A1	9/2008
WO	WO-2008112996	A1	9/2008
WO	WO-2008140748	A1	11/2008
WO	WO-2009001083	A1	12/2008
WO	WO-2009001109	A1	12/2008
WO	WO-2009025783	A1	2/2009
WO	WO-2009073781	A2	6/2009
WO	WO-2009129063	A1	10/2009
WO	WO-2009129067	A1	10/2009
WO	WO-2010033431	A1	3/2010
WO	WO-2010093902	A1	8/2010
WO	WO-2010096553	A1	8/2010
WO	WO-2010096557	A2	8/2010
WO	WO-2010124164	A1	10/2010
WO	WO-2010129870	A1	11/2010
WO	WO-2010144705	A1	12/2010
WO	WO-2010148103	A1	12/2010
WO	WO-2010150223	A1	12/2010
WO	WO-2011018458	A1	2/2011
WO	WO-2011019797	A3	2/2011
WO	WO-2011041398	A1	4/2011
WO	WO-2011060536	A1	5/2011
WO	WO-2011080260	A1	7/2011
WO	WO-2011106711	A1	9/2011
WO	WO-2011109260	A1	9/2011
WO	WO-2011110374	A1	9/2011
WO	WO-2011117644	A2	9/2011
WO	WO-2012006444	A2	1/2012
WO	WO-2012033821	A1	3/2012
WO	WO-2012058344	A1	5/2012
WO	WO-2012058349	A4	5/2012
WO	WO-2012058353	A4	5/2012
WO	WO-2012058355	A4	5/2012
WO	WO-2012061042	A1	5/2012
WO	WO-2012116206	A1	8/2012
WO	WO-2012141790	A1	10/2012
WO	WO-2012158917	A1	11/2012
WO	WO-2012173929	A1	12/2012
WO	WO-2012174008	A1	12/2012
WO	WO-2013033205	A1	3/2013
WO	WO-2013170872	A1	11/2013
WO	WO-2014019712	A1	2/2014
WO	WO-2014070889		5/2014
WO	WO-2015084831	A1	6/2015

OTHER PUBLICATIONS

"Amazing Precision. Beautiful Results. The next evolution of MAKOplasty® is here", MAKO Surgical Corp., (Feb. 2009), 6 pgs.

"U.S. Appl. No. 13/221,968, Advisory Action mailed Sep. 18, 2014", 8 pgs.

"U.S. Appl. No. 13/221,968, Final Office Action mailed Jun. 10, 2014", 16 pgs.

"U.S. Appl. No. 13/221,968, Non Final Office Action mailed Nov. 13, 2013", 21 pgs.

"U.S. Appl. No. 13/221,968, Notice of Allowance mailed Feb. 11, 2015", 7 pgs.

"U.S. Appl. No. 13/221,968, Notice of Allowance mailed Oct. 31, 2014", 5 pgs.

"U.S. Appl. No. 13/221,968, Response filed Feb. 13, 2014 to Non Final Office Action mailed Nov. 13, 2013", 12 pgs.

"U.S. Appl. No. 13/221,968, Response filed Sep. 5, 2014 to Final Office Action mailed Jun. 10, 2014", 11 pgs.

"U.S. Appl. No. 13/221,968, Response filed Sep. 30, 2014 to Advisory Action mailed Sep. 18, 2014", 15 pgs.

"U.S. Appl. No. 13/718,129, Final Office Action mailed Aug. 5, 2015", 17 pgs.

"U.S. Appl. No. 13/718,129, Non Final Office Action mailed Feb. 5, 2015", 19 pgs.

"U.S. Appl. No. 13/718,129, Notice of Allowance mailed Nov. 18, 2015", 10 pgs.

"U.S. Appl. No. 13/718,129, Response filed Jan. 20, 2015 to Restriction Requirement mailed Nov. 19, 2014", 1 pg.

"U.S. Appl. No. 13/718,129, Response filed Jun. 5, 2015 to Non Final Office Action mailed Feb. 5, 2015", 14 pgs.

"U.S. Appl. No. 13/718,129, Response filed Nov. 3, 2015 to Final Office Action mailed Aug. 5, 2015", 14 pgs.

"U.S. Appl. No. 13/718,129, Restriction Requirement mailed Nov. 19, 2014", 6 pgs.

(56) **References Cited**

OTHER PUBLICATIONS

"U.S. Appl. No. 14/753,560, Final Office Action mailed Dec. 30, 2015", 26 pgs.
"U.S. Appl. No. 14/753,560, Notice of Allowance mailed May 2, 2016", 8 pgs.
"U.S. Appl. No. 14/753,560, Preliminary Amendment Sep. 14, 2015", 6 pgs.
"U.S. Appl. No. 14/753,560, Response filed Mar. 30, 2016 to Final Office Action mailed Dec. 30, 2015", 14 pgs.
"Ascent Total Knee System", Biomet, Inc., (Oct. 31, 1999), 16 pgs.
"Australian Application Serial No. 2013222609, First Examiner Report mailed Feb. 16, 2015", 5 pgs.
"Biomet Orthopedics", Brochure E-POL Y HSLPE (EXH2O), (2007), 23 pgs.
"Comprehensive® Reverse Shoulder System", Biomet Orthopedics brochure, (2009), 8 pgs.
"Comprehensive® Reverse Shoulder System Surgical Technique", Biomet Orthopedics, (2009-2012), 48 pgs.
"Comprehensive® Reverse Shoulder System Technical Design Features", Biomet Orthopedics, (2009), 3 pgs.
"Comprehensive® Shoulder System Surgical Technique", Biomet Orthopedics brochure, (2007), 1-53.
"Comprehensive® Total Shoulder System", Biomet Orthopedics brochure, (2011), 4 pgs.
"Customized Patient Instruments, Patient specific instruments for patient specific needs", DePuy Orthopaedics, Inc., (2008), 14 pgs.
"Customized Patient Instruments, Primary Cruciate Retaining Surgical Technique for use with the Sigma® Knee System Utilizing Specialist® 2 Instrumentation", DePuy Orthopaedics, Inc., (2008), 1-23.
"Discovery® Elbow System", Biomet Orthopedics, Inc., (Nov. 30, 2007), 3 pgs.
"Discovery® Elbow System Surgical Technique", Biomet Orthopedics, Inc., (Dec. 31, 2008), 1-25.
"European Application Serial No. 07809326.7, Examination Notification Art. 94(3) mailed Jan. 22, 2015", 6 pgs.
"European Application Serial No. 07809326.7, Extended European Search Report mailed Nov. 15, 2011", 6 pgs.
"European Application Serial No. 09731923.0, Examination Notification Art. 94(3) mailed Feb. 10, 2015", 7 pgs.
"European Application Serial No. 10705064.3, Examination Notification Art. 94(3) mailed Feb. 4, 2015", 6 pgs.
"European Application Serial No. 12724475.4, Examination Notification Art. 94(3) mailed Nov. 24, 2014", 7 pgs.
"European Application Serial No. 13786880.8, Office Action mailed Jun. 10, 2015", 2 pgs.
"European Application Serial No. 13786880.8, Response filed Dec. 16, 2015 to Office Action mailed Jun. 10, 2015", 14 pgs.
"German Application Serial No. 1120120036360, Office Action mailed Apr. 16, 2014", 2 pgs.
"Great Britain Application Serial No. 1116054.6, Search Report mailed Dec. 21, 2011", 4 pgs.
"Hipsextant Instructions of Use", Surgical Planning Associates, Inc., (2011), 19 pgs.
"International Application Serial No. PCT/EP2010/061630, International Search Report mailed Nov. 30, 2010", 3 pgs.
"International Application Serial No. PCT/US2007/013223, International Preliminary Report on Patentability mailed Dec. 24, 2008", 5 pgs.
"International Application Serial No. PCT/US2007/013223, International Search Report mailed Nov. 26, 2007", 3 pgs.
"International Application Serial No. PCT/US2007/013223, Written Opinion mailed Nov. 26, 2007", 4 pgs.
"International Application Serial No. PCT/US2009/039507, International Preliminary Report on Patentability mailed Oct. 28, 2010", 9 pgs.
"International Application Serial No. PCT/US2009/039507, International Search Report mailed Jul. 14, 2009", 6 pgs.
"International Application Serial No. PCT/US2009/039507, Written Opinion mailed Jul. 14, 2009", 7 pgs.
"International Application Serial No. PCT/US2009/039578, International Preliminary Report on Patentability mailed Oct. 28, 2010", 9 pgs.
"International Application Serial No. PCT/US2009/039578, International Search Report mailed Jul. 31, 2009", 6 pgs.
"International Application Serial No. PCT/US2009/039578, Written Opinion mailed Jul. 31, 2009", 7 pgs.
"International Application Serial No. PCT/US2009/056670, International Preliminary Report on Patentability mailed Mar. 31, 2011", 12 pgs.
"International Application Serial No. PCT/US2009/056670, International Search Report mailed Mar. 2, 2010", 7 pgs.
"International Application Serial No. PCT/US2009/056670, Invitation to Pay Additional Fees and Partial Search Report mailed Nov. 26, 2009".
"International Application Serial No. PCT/US2009/056670, Written Opinion mailed Mar. 2, 2010", 10 pgs.
"International Application Serial No. PCT/US2010/024073, International Preliminary Report on Patentability mailed Aug. 25, 2011", 8 pgs.
"International Application Serial No. PCT/US2010/024073, International Search Report mailed Jun. 4, 2010", 4 pgs.
"International Application Serial No. PCT/US2010/024073, Written Opinion mailed Jun. 4, 2010", 6 pgs.
"International Application Serial No. PCT/US2010/024579, International Preliminary Report on Patentability mailed Sep. 1, 2011", 7 pgs.
"International Application Serial No. PCT/US2010/024579, International Search Report mailed Apr. 22, 2010", 3 pgs.
"International Application Serial No. PCT/US2010/024579, Written Opinion mailed Apr. 22, 2010", 5 pgs.
"International Application Serial No. PCT/US2010/024584, International Preliminary Report on Patentability mailed Sep. 1, 2011", 8 pgs.
"International Application Serial No. PCT/US2010/024584, International Search Report mailed Aug. 19, 2010", 6 pgs.
"International Application Serial No. PCT/US2010/024584, Written Opinion mailed Aug. 19, 2010", 6 pgs.
"International Application Serial No. PCT/US2010/038177, International Preliminary Report on Patentability mailed Dec. 22, 2011", 10 pgs.
"International Application Serial No. PCT/US2010/038177, International Search Report mailed Aug. 24, 2010", 4 pgs.
"International Application Serial No. PCT/US2010/038177, Written Opinion mailed Aug. 24, 2010", 8 pgs.
"International Application Serial No. PCT/US2010/038845, International Preliminary Report on Patentability mailed Jan. 5, 2012", 9 pgs.
"International Application Serial No. PCT/US2010/038845, International Search Report mailed Oct. 5, 2010", 4 pgs.
"International Application Serial No. PCT/US2010/038845, Written Opinion mailed Oct. 5, 2010", 7 pgs.
"International Application Serial No. PCT/US2010/050701, International Preliminary Report on Patentability mailed Apr. 12, 2012", 10 pgs.
"International Application Serial No. PCT/US2010/050701, International Search Report mailed Dec. 7, 2010", 6 pgs.
"International Application Serial No. PCT/US2010/050701, Written Opinion mailed Dec. 7, 2010", 8 pgs.
"International Application Serial No. PCT/US2011/026333, International Preliminary Report on Patentability mailed Sep. 7, 2012", 10 pgs.
"International Application Serial No. PCT/US2011/026333, International Search Report mailed Aug. 9, 2011", 6 pgs.
"International Application Serial No. PCT/US2011/026333, Invitation to Pay Additional Fees mailed May 3, 2011".
"International Application Serial No. PCT/US2011/026333, Written Opinion mailed Aug. 9, 2011", 8 pgs.
"International Application Serial No. PCT/US2011/026412, International Search Report mailed May 9, 2011", 5 pgs.
"International Application Serial No. PCT/US2011/026412, Written Opinion mailed May 9, 2011", 6 pgs.

(56) **References Cited**

OTHER PUBLICATIONS

"International Application Serial No. PCT/US2011/057300, International Search Report mailed Mar. 5, 2012", 7 pgs.
"International Application Serial No. PCT/US2011/057300, Written Opinion mailed Mar. 5, 2012", 9 pgs.
"International Application Serial No. PCT/US2012/026356, International Preliminary Report on Patentability mailed Sep. 6, 2013", 8 pgs.
"International Application Serial No. PCT/US2012/026356, International Search Report mailed May 8, 2012", 5 pgs.
"International Application Serial No. PCT/US2012/026356, Written Opinion mailed May 8, 2012", 6 pgs.
"International Application Serial No. PCT/US2012/038351, International Preliminary Report on Patentability mailed Nov. 28, 2013", 9 pgs.
"International Application Serial No. PCT/US2012/038351, Written Opinion mailed Jul. 6, 2012", 8 pgs.
"International Application Serial No. PCT/US2012/041893, International Search Report mailed Oct. 23, 2012", 5 pgs.
"International Application Serial No. PCT/US2012/042081, International Preliminary Report on Patentability mailed Jan. 3, 2014", 7 pgs.
"International Application Serial No. PCT/US2012/042081, Written Opinion mailed Sep. 5, 2012", 6 pgs.
"International Application Serial No. PCT/US2012/052853, International Preliminary Report on Patentability mailed Mar. 13, 2014", 14 pgs.
"International Application Serial No. PCT/US2012/052853, International Search Report mailed Nov. 15, 2012", 6 pgs.
"International Application Serial No. PCT/US2012/052853, Written Opinion mailed Nov. 15, 2012", 12 pgs.
"International Application Serial No. PCT/US2012/059189, International Preliminary Report on Patentability mailed Apr. 24, 2014", 10 pgs.
"International Application Serial No. PCT/US2012/059189, International Search Report mailed Dec. 18, 2012", 6 pgs.
"International Application Serial No. PCT/US2012/059189, Written Opinion mailed Dec. 18, 2012", 9 pgs.
"International Application Serial No. PCT/US2012/060842, International Preliminary Report on Patentability mailed May 8, 2014", 7 pgs.
"International Application Serial No. PCT/US2012/060842, International Search Report mailed Feb. 6, 2013", 4 pgs.
"International Application Serial No. PCT/US2012/060842, Written Opinion mailed Feb. 6, 2013", 5 pgs.
"International Application Serial No. PCT/US2012/060848, International Preliminary Report on Patentability mailed May 8, 2014", 11 pgs.
"International Application Serial No. PCT/US2012/060848, International Search Report mailed Apr. 12, 2013", 6 pgs.
"International Application Serial No. PCT/US2012/060848, Invitation to Pay Additional Fees mailed Feb. 6, 2013".
"International Application Serial No. PCT/US2012/060848, Written Opinion mailed Apr. 12, 2013", 9 pgs.
"International Application Serial No. PCT/US2012/060853, International Preliminary Report on Patentability mailed May 8, 2014", 11 pgs.
"International Application Serial No. PCT/US2012/060853, Invitation to Pay Additional Fees mailed Feb. 7, 2013", 4 pgs.
"International Application Serial No. PCT/US2012/060853, Written Opinion mailed Apr. 9, 2013", 9 pgs.
"International Application Serial No. PCT/US2012/060854, International Preliminary Report on Patentability mailed May 8, 2014", 8 pgs.
"International Application Serial No. PCT/US2012/060854, International Search Report mailed Feb. 6, 2013", 4 pgs.
"International Application Serial No. PCT/US2012/060854, Written Opinion mailed Feb. 6, 2013", 6 pgs.
"International Application Serial No. PCT/US2013/026875, International Preliminary Report on Patentability mailed Sep. 4, 2014", 9 pgs.
"International Application Serial No. PCT/US2013/026875, International Search Report mailed Jun. 7, 2013", 5 pgs.
"International Application Serial No. PCT/US2013/026875, Written Opinion mailed Jun. 7, 2013", 8 pgs.
"International Application Serial No. PCT/US2013/057097, International Preliminary Report on Patentability mailed Mar. 12, 2015", 10 pgs.
"International Application Serial No. PCT/US2013/057097, International Search Report mailed Oct. 14, 2013", 6 pgs.
"International Application Serial No. PCT/US2013/057097, Written Opinion mailed Oct. 14, 2013", 9 pgs.
"International Application Serial No. PCT/US2013/067505, International Preliminary Report on Patentability mailed May 14, 2015", 13 pgs.
"International Application Serial No. PCT/US2013/067505, International Search Report mailed Apr. 14, 2014", 5 pgs.
"International Application Serial No. PCT/US2013/067505, Invitation to Pay Additional Fees mailed Feb. 6, 2014", 6 pgs.
"International Application Serial No. PCT/US2013/067505, Written Opinion mailed Apr. 14, 2014", 11 pgs.
"International Application Serial No. PCT/US2013/074288, International Search Report mailed May 23, 2014", 7 pgs.
"International Application Serial No. PCT/US2013/074288, Written Opinion mailed May 23, 2014", 11 pgs.
"International Application Serial No. PCT/US2014/022000, International Search Report mailed Jun. 24, 2014", 3 pgs.
"International Application Serial No. PCT/US2014/022000, Written Opinion mailed Jun. 24, 2014", 5 pgs.
"International Application Serial No. PCT/US2014/023655, International Search Report mailed Jun. 10, 2014", 4 pgs.
"International Application Serial No. PCT/US2014/023655, Written Opinion mailed Jul. 10, 2014", 6 pgs.
"International Application Serial No. PCT/US2014/068131, International Search Report mailed May 8, 2015", 5 pgs.
"International Application Serial No. PCT/US2014/068131, Written Opinion mailed May 8, 2015", 9 pgs.
"Is Subchondroplasty® Right for Me?", [Online] retrieved from the internet: <http://www.subchondroplast}'..com/about subchondroplast}'./is subchondroplasty right for >, (Jul. 1, 2013), 1 pg.
"Japanese Application Serial No. 2014511538, Office Action mailed Apr. 7, 2015", (W/ English Translation), 8 pgs.
"Knee tensor combined with laser femoral head locator", Research Disclosure, No. 507, (Jul. 2006), 903.
"MAX-Ti™ Modular Protrusio Cage", Surgical Technique brochure. Biomet Orthopedics, Inc., (2003), 10 pgs.
"Method for constructing an allograft sleeve", Research Disclosure, No. 476, (Dec. 2003), 1294.
"OSS™ Orthopaedic Salvage System, Femoral/Tibial Augmentation", Biomet Orthopedics, Inc.,, (Mar. 31, 2004), 1-8.
"Oxford® Partial Knee", Biomet, (Feb. 2011), 8 pgs.
"Oxford® Partial Knee Microplasty® Instrumentation Surgical Technique", Biomet, (May 2011), 1-54.
"Patient Matched PMI Implants, C.A.M.R.A. 3-D Imaging", Brochure, Biomet, Inc., Form Y-BMI-191/013191, (1991), 6 pgs.
"Regenerex® Tibial Cone Augment, Surgical Technique Addendum to the Vanguard® SSK Revision System", brochure. Biomet® Orthopedics., (Mar. 31, 2010), 1-8.
"Signature™ Hip Technology Personalized Patient Care brochure", Biomet® Orthopedics., (2013), 8 pgs.
"Signature™ Personalized Patient Care", Surgical Technique Acetabular Guide System brochure, Biomet® Orthopedics, (2013), 1-13.
"Signature™ Personalized Patient Care, Surgical Technique Addendum to the Vanguard Knee System", Biomet® Orthopedics Brochure, (May 15, 2009), 1-8.
"Subchondroplasty", [Online] retrieved from the internet: <http://www.subchondroplasty.com/>, (Jul. 1, 2013), 1 pg.
"The Oxford® Partial Knee Surgical Technique", Biomet, (Feb. 2010), 1-38.

(56) **References Cited**

OTHER PUBLICATIONS

"TruMatch™ Personalized knee replacement solutions", SIGMA® DePuy Orthopaedics, Inc, tri-fold brochure, (2009), 2 pgs.
"United Kingdom Application Serial No. 1405068.6, Office Action mailed May 27, 2014", 2 pgs.
"Vanguard® PFR Partial Knee Patellofemoral Replacement System", Surgical Technique, Biomet Orthopaedics,, (Aug. 31, 2010), 1-25.
"What is Subchondroplasty", [Online]. Retrieved from the Internet: <http://www.subchondroplasty.com/about subchondroplasty/what is subchondroplasty.>, (Jul. 1, 2013), 2 pgs.
"Zimmer® UniSpacer® Knee System", Zimmer, Inc., (2005), 4 pgs.
Birnbaum, Klaus M. D, "Computer-Assisted Orthopedic Surgery With Individual Templates and Comparison to Conventional Method", SPINE vol. 26, No. 4, Lippincott Williams & Wilkins, Inc., (2001), 365-370.
Botha, Charl P, "Technical Report: DeVIDE—The Delft Visualisation and Image processing Development Environment", (May 31, 2006), 1-49.
Cohen, Zohara A, et al., "Knee cartilage topography, thickness, and contact areas from MRI: in-vitro calibration and in-vivo measurements", Journal of the OsteoArthritis Research Society International. Osteoarthritis and Cartilage, vol. 7; No. 1, (1999), 95-109.
Deakon, "Posterior Cruciate Ligament Reconstruction Technique Using the Modular ACL/PCL Guide Rationale and Surgical Technique", Arthrotek®, a Biomet Company, (2003), 6 pgs.
Eckhoff, Donald G, et al., "Three-Dimensional Mechanics, Kinematics, and Morphology of the Knee Viewed in Virtual Reality", The Journal of Bone & Joint Surgery, vol. 81, (Dec. 4, 2005), 71-80.
Farr, J, et al., "Anteromedial Tibial Tubercle Osteotomy (Fulkerson Osteotomy)", Re-print from V. Sanchis-Alfonso (ed), Anterior Knee Pain and patellar Instability, DOI: 10.1007/978-0-85729-507-1_40, © Springer-Verlag London Limited, (2011), 9 pgs.
Farr, J, et al., "Surgical Technique for Anteromedialization of the Tibial Tubercle with the Tracker™ AMZ Guide System", Sports Medicine and Arthroscopy Review, vol. 2, No. 3, (1994), 12 pgs.
Fortin, Thomas, et al., "Precise Dental Implant Placement in Bone Using Surgical Guides in Conjunction with Medical Imaging Techniques", Journal of Oral Implantology, Clinical, vol. 26, No. 4, (2000), 300-303.
Friedman, R J, et al., "The Use of Computerized Tomography in the Measurement of Glenoid Version", Journal of Bone & Joint Surgery Am. (JBJS) 1992;74, (Aug. 1992), 1032-1037.
Haaker, R G, et al., "Minimal-invasive navigiert implantierte unikondylare Knieendoprothese", Orthopade 2006 35: Spinger Medizin Verlag, (Sep. 13, 2006), 1073-1079.
Hafez, M A, et al., "Computer-assisted Total Knee Arthroplasty Using Patient-specific Templating", Clinical Orthopaedics and Related Research, No. 444 Lippincott Williams & Wilkins, (2006), 184-192.
Hazan, Eric J, "Computer-Assisted Orthopaedic Surgery, A New Paradigm", Techniques in Orthopaedics® vol. 18, No. 2,, (2003), 221-229.
Hutmacher, Dietmar W, "Scaffolds in tissue engineering bone and cartilage", Biomaterials, 21(24), (2000), 2529-2543.
Kaus, Michael R, "Automated Segmentation of MR Images of Brain Tumors", Radiology, vol. 218, No. 2,, (2001), 586-591.
Kelly, Todd C, "Role of Navigation in Total Hip Arthroplasty", The Journal of Bone & Joint Surgery(2009) vol. 91-A, Supplement 1, (2009), 153-8.
Klein, M, "Robot assisted insertion of craniofacial implants—clinical experience", CARS 2001, Elsevier Science B.V., (2001), 133-138.
Lombardi, Adolph, et al., "Patient-Specific Approach in Total Knee Arthroplasty", Knee Orthopedics, ORTHOSuperSite, [Online]. Retrieved from the Internet: <http://www.orthosupersite.com/view.aspx?rid=31419,>, (Sep. 1, 2008), 5 pgs.
Lynch, John A, et al., "Cartilage segmentation of 3D MRI scans of the osteoarthritic knee combining user knowledge and active contours", Medical Imaging 2000: Image Processing SPIE vol. 3979, (2000), 925-935.
Murphy, S B, et al., "The Hip Sextant: Navigation of Acetabular Component Orientation Using a Mechanical Instrument", (2009), 1 pg.
Nicholls, Paul M. D, "Trauma Grand Rounds PMI (Patient-Matched Implants)", Biomet Orthopedics, Inc.,, (Feb. 29, 2000), 1 pg.
Overhoff, H M, et al., "Total Knee Arthroplasty: Coordinate System Definition and Planning based on 3-D Ultrasound Image Volumes", CARS 2001, Elsevier Science B.V., (2001), 283-288.
Portheine, F, "CT-basierte Planung und DISOS-Schablonennavigation in der Kniegelenkendoprothetik", Navigation und Robotic in der Gelenk—und Wirbelsaulenchiruqie, Kapitel 32, Springer Verlag, (2003), 262-269.
Portheine, F, et al., "Entwicklung eines klinischen Demonstrators fur die computerunterstutzte Orthopadische Chirurgie mit CT-Bildbasierten Individualschablonen, Bildverarbeitung fur die Medizin", English version: FIP ID 752773, (1998), 5 pgs.
Portheine, K, "Development of a clinical demonstrator for computer assisted orthopedic surgery with CT-image based individual templates", Computer Assisted Radiology and Surgery Elsevier Science B.V., English Version of FIP ID 752770, (1997), 944-949.
Radermacher, K, et al., "Computer Integrated Orthopaedic Surgery: Connection of Planning and Execution in Surgical Intervention", Computer-integrated surgery: technology and clinical applications, (1996), 451-463.
Radermacher, K, et al., "CT Image-Based Planning and Execution of Interventions in Orthopedic Surgery Using Individual Templates, Experimental Results and Aspects of Clinical Applications", Computer Assisted Orthopedic Surgery (CAOS), Hogrefe & Huber Publishers, (1995), 42-52.
Radermacher, K, et al., "Image Guided Orthopedic Surgery Using Individual Templates", Springer Berlin/Heidelberg, CVRMed-MRCAS'97, vol. 1205, (1997), 606-615.
Radermacher, K, et al., "Technique for Better Execution of CT Scan Planned Orthopedic Surgery on Bone Structures", British Library—"The world's knowledge" 2nd Congress of ISCAS Conference, (Jun. 1995), 933-938.
Radermacher, Klaus, et al., "Computer Assisted Orthopaedic Surgery with Image Based Individual Templates", Clinical Orthopaedics and Related Research No. 354, Lippincott Williams & Wilkins, (Sep. 1998), 28-38.
Sharp, Michael S, "Patient-Specific, Resurfacing Bi-Compartmental Arthuroplasty Futuretech", Orthopaedic Product News, (Apr. 2008), 12-15.
Sisto, Domenick J, et al., "Custom Patellofemoral Arthroplasty of the Knee Surgical Technique", Journal of Bone and Joint Surgery, vol. 89-A, (2006), 214-225.
Slamin, John, et al., "Do You Have This Implant in My Size?", MDT Medical Design Technology, [Online]. Retrieved from the Internet: <http://www.mdtmag.com/scripts/ShowPR.asp-?PUBCODE=046&ACCT=0007796& ISSUE . . . >, (Jul. 31, 2008), 3 pgs.
Steinwachs, Matthias Reinhard, "Cartilage Repair—Autologous Chondrocyte Transplantation and Autologous Matrix-induced Chondrogenesis", European Musculoskeletal Review, (2006), 65-68.
Subburaj, K, et al., "Automated 3D Geometric Reasoning in Computer Assisted Joint Reconstructive Surgery", IEEE International Conference on Automation Science and Engineering, (2009), 367-372.
Thoma, W, et al., "Endoprothetischen Versorgung des Kniegelenks auf der Basis eines 3D-computertomographischen Subtraktionversfahrens", Topic: Computer-aided orthopedic surgery. Orthopedist 2000 29: Springer Verlag W/ Original German Document, (2000), 641-644.
"United Kingdom Application Serial No. 1405068.6, Office Action mailed Nov. 1, 2016", 4 pgs.
"United Kingdom Application Serial No. 1405068.6, Response filed Jan. 5, 2017 to Office Action mailed Nov. 1, 2016", 8 pgs.

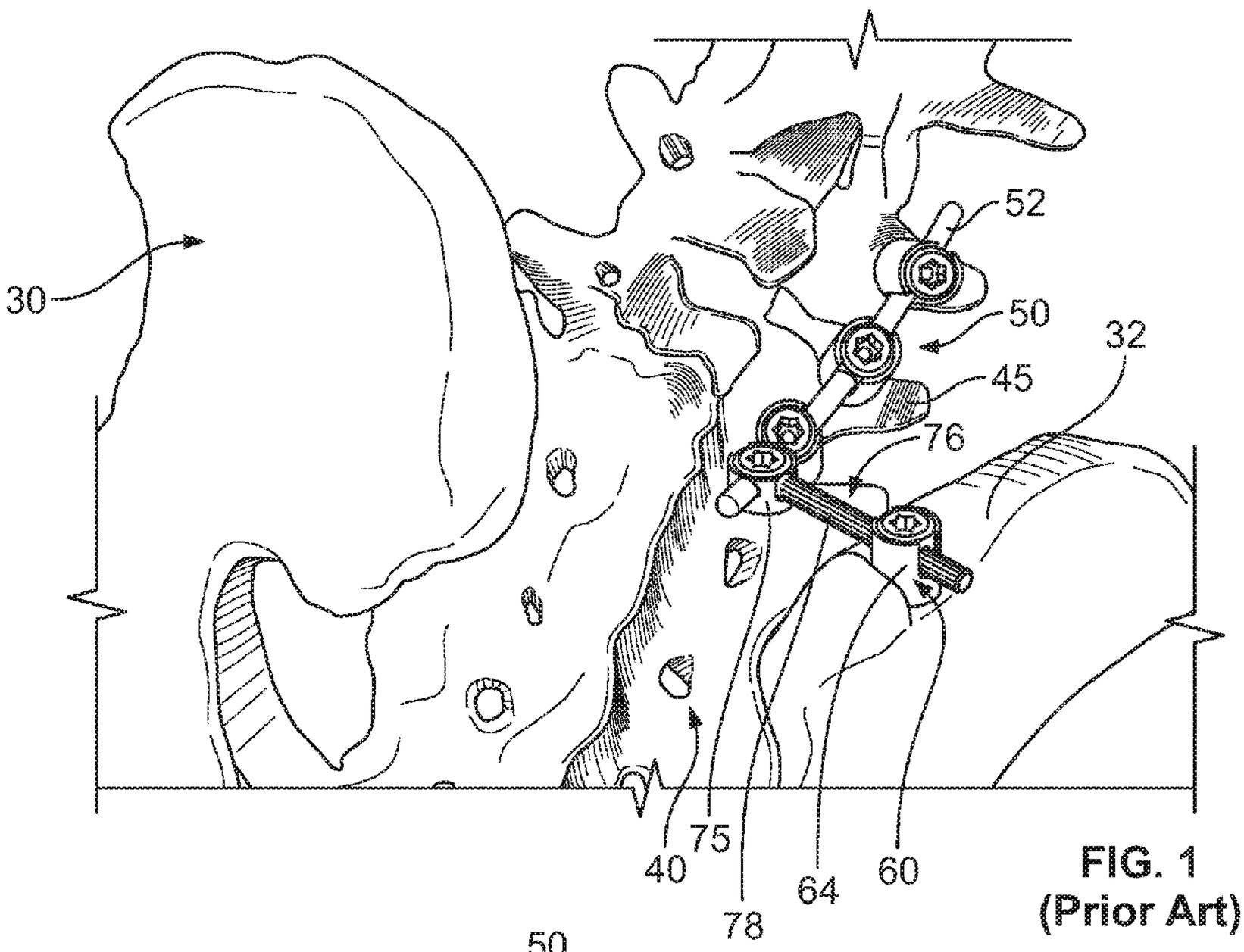


FIG. 1
(Prior Art)

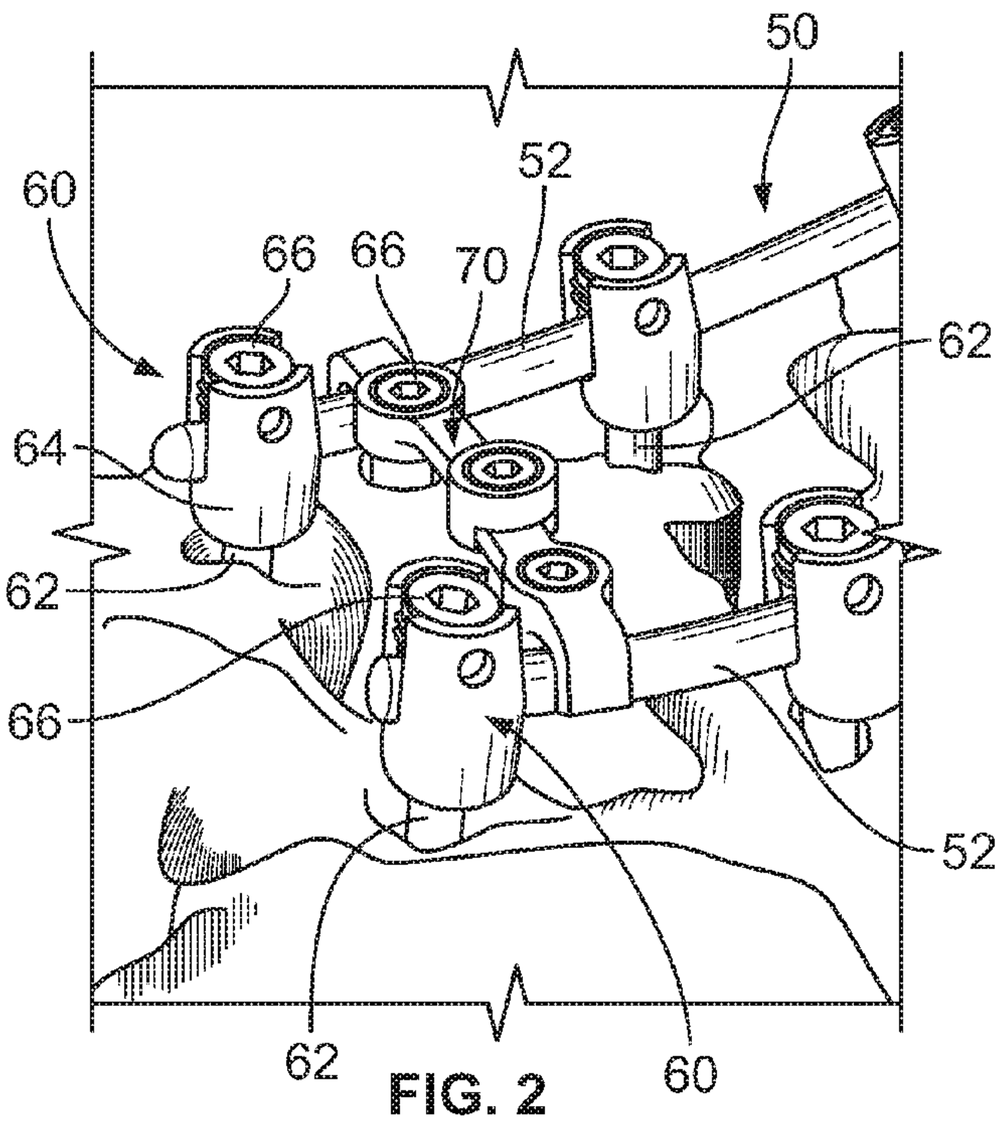


FIG. 2
(Prior Art)

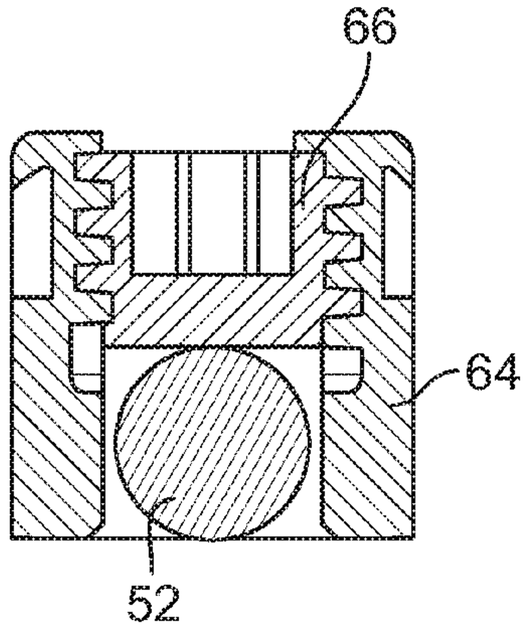


FIG. 3
(Prior Art)

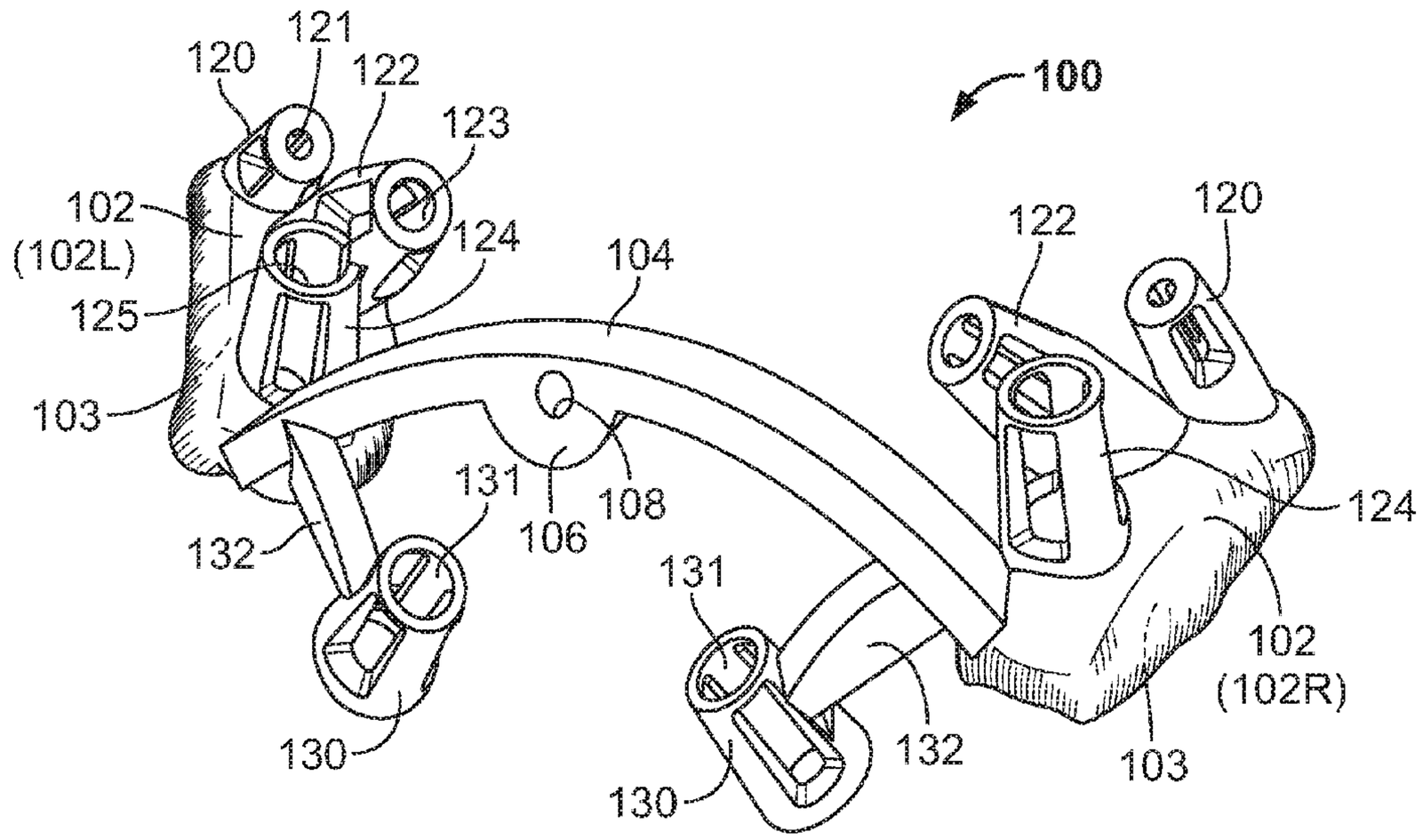


FIG. 4

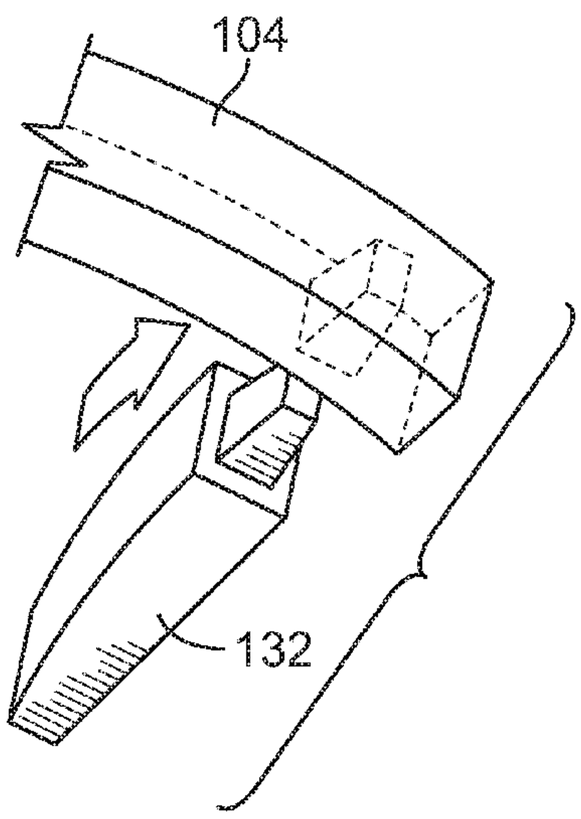


FIG. 4A

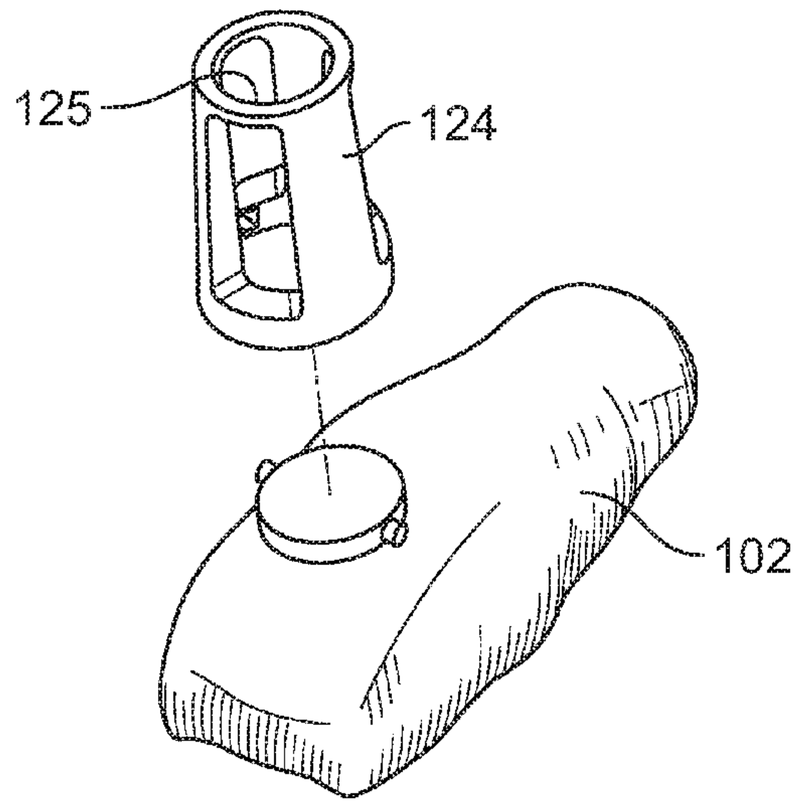


FIG. 4B

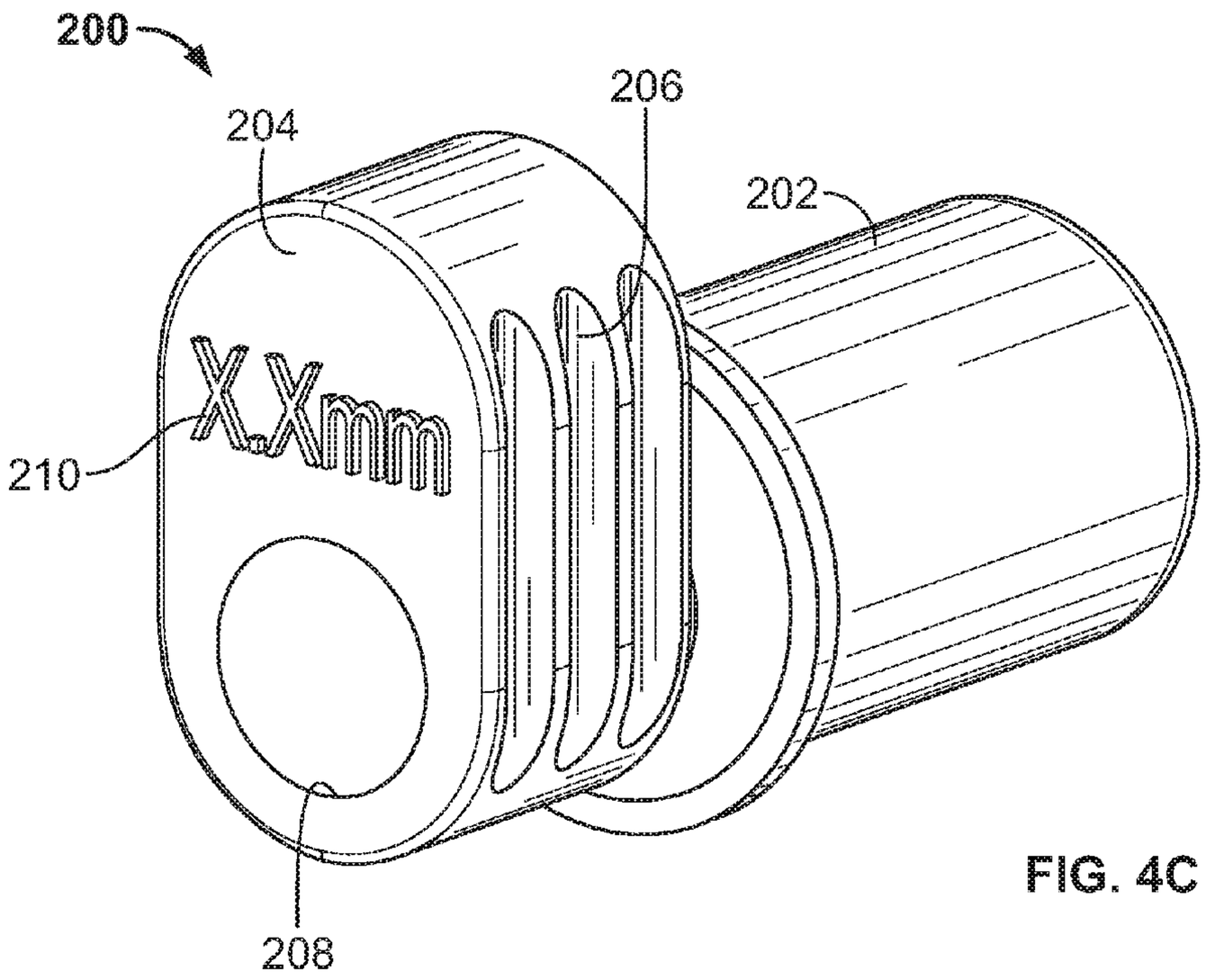


FIG. 4C

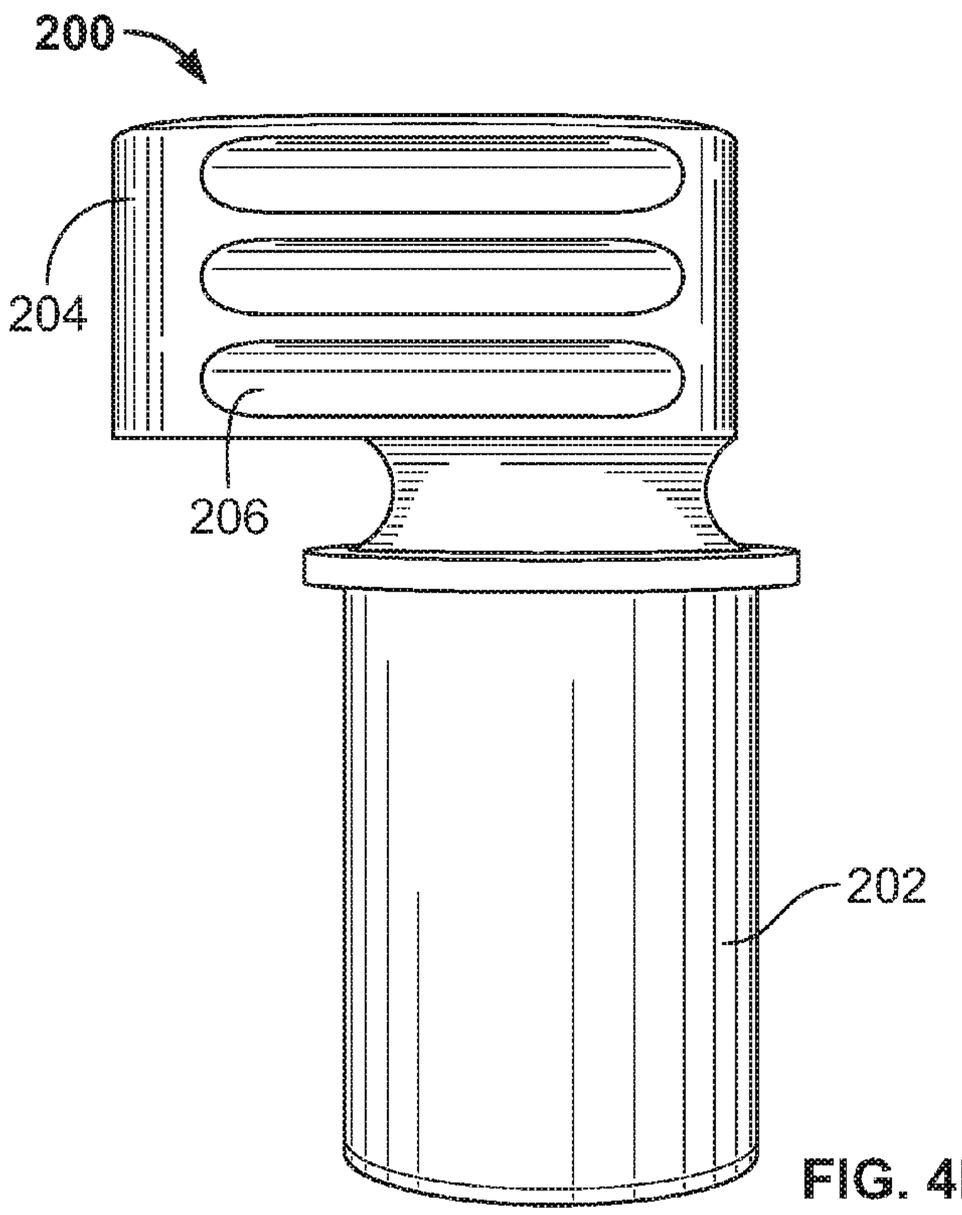


FIG. 4D

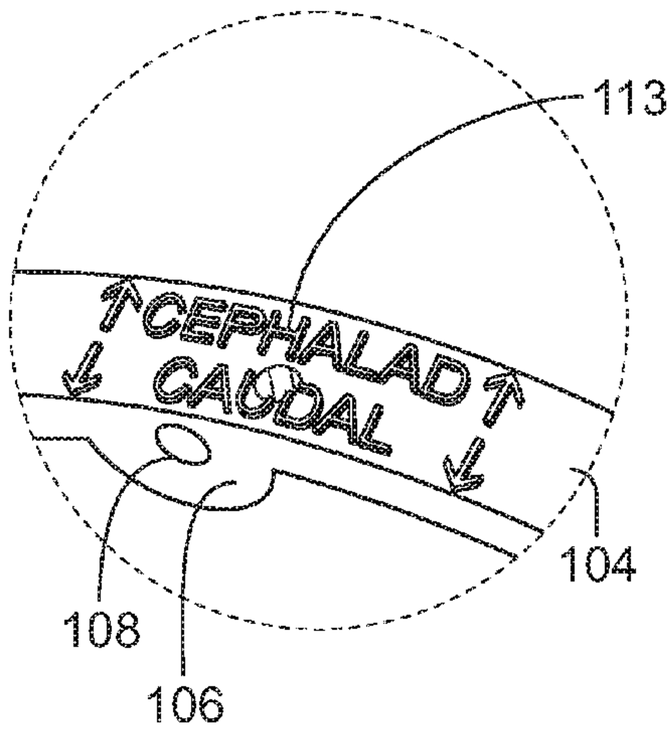


FIG. 4E

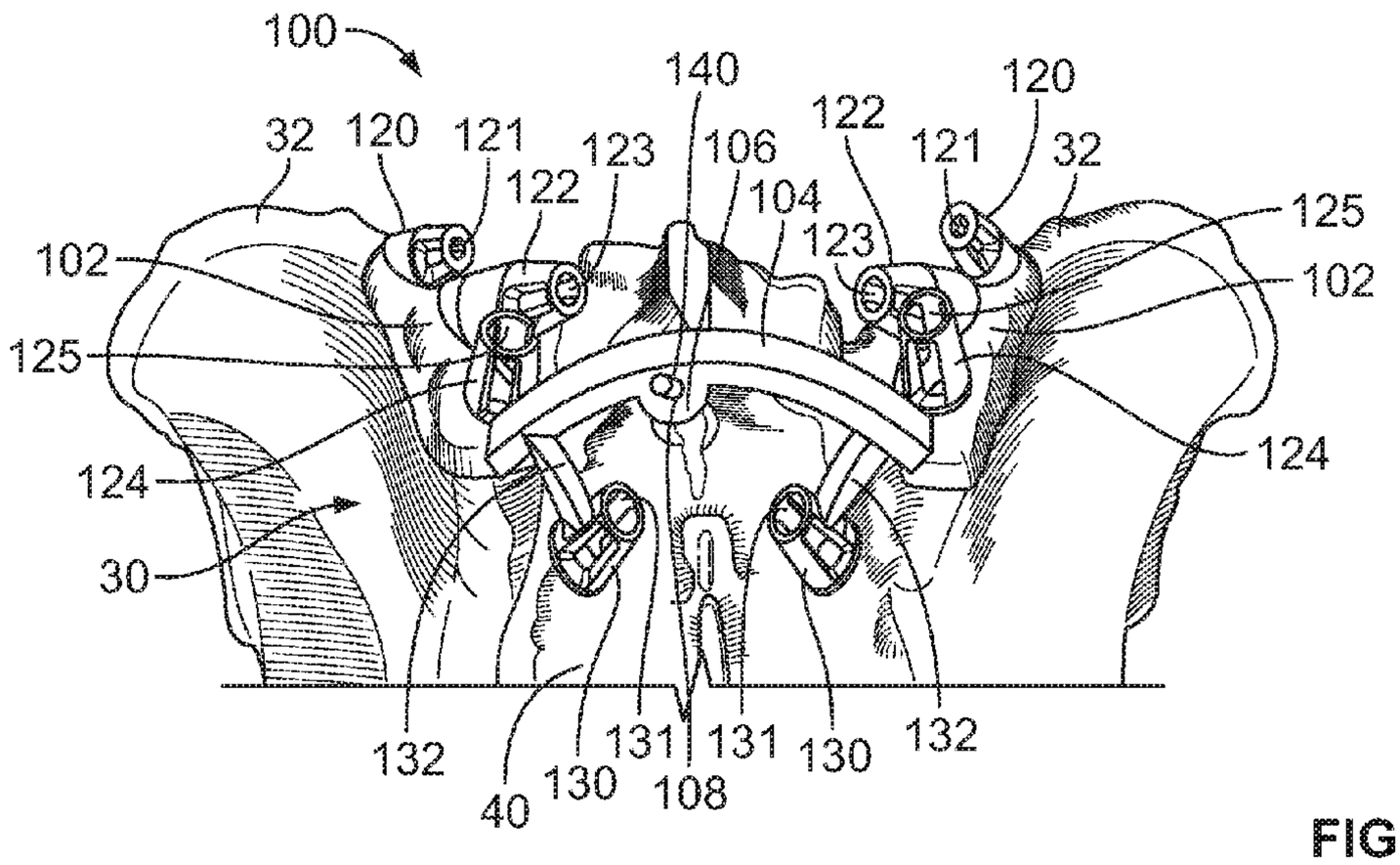

100
140
120
32
120
121
123
106
122
121
32
122
104
125
123
102
102
125
124
124
30
132
40
130
131
108
131
130
132

FIG. 5

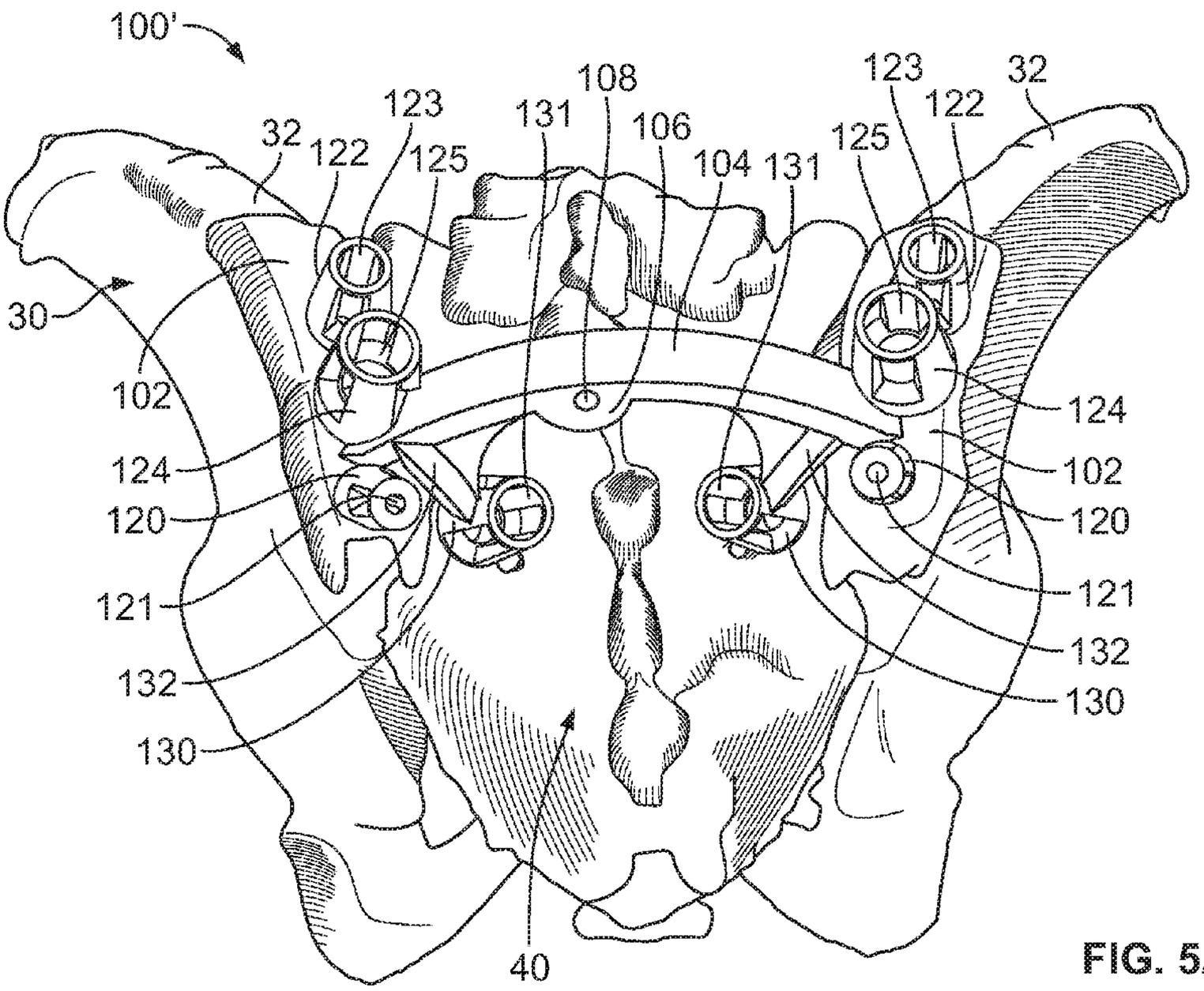

100'
108
123
123
122
32
131
32
122
106
125
125
104
131
30
102
124
124
120
102
120
121
121
132
132
130
130
40

FIG. 5A

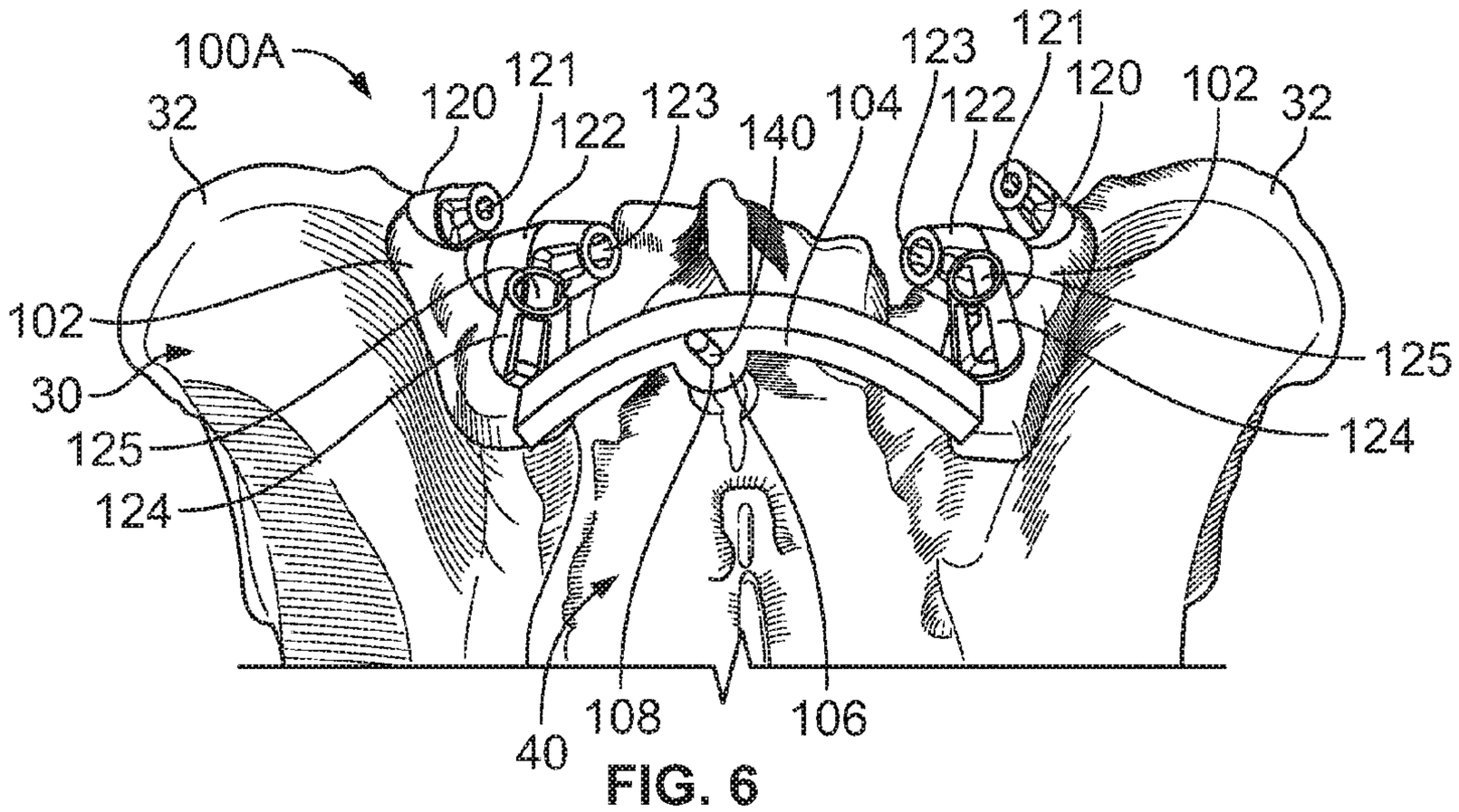


FIG. 6

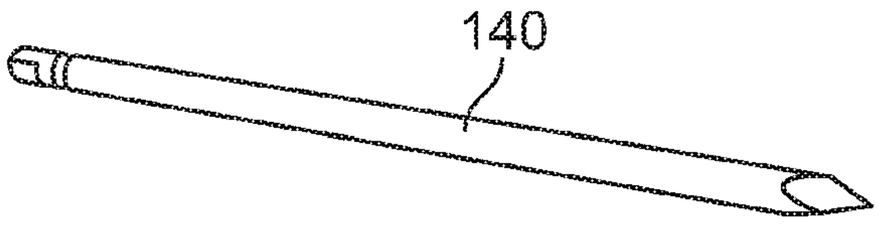


FIG. 6A

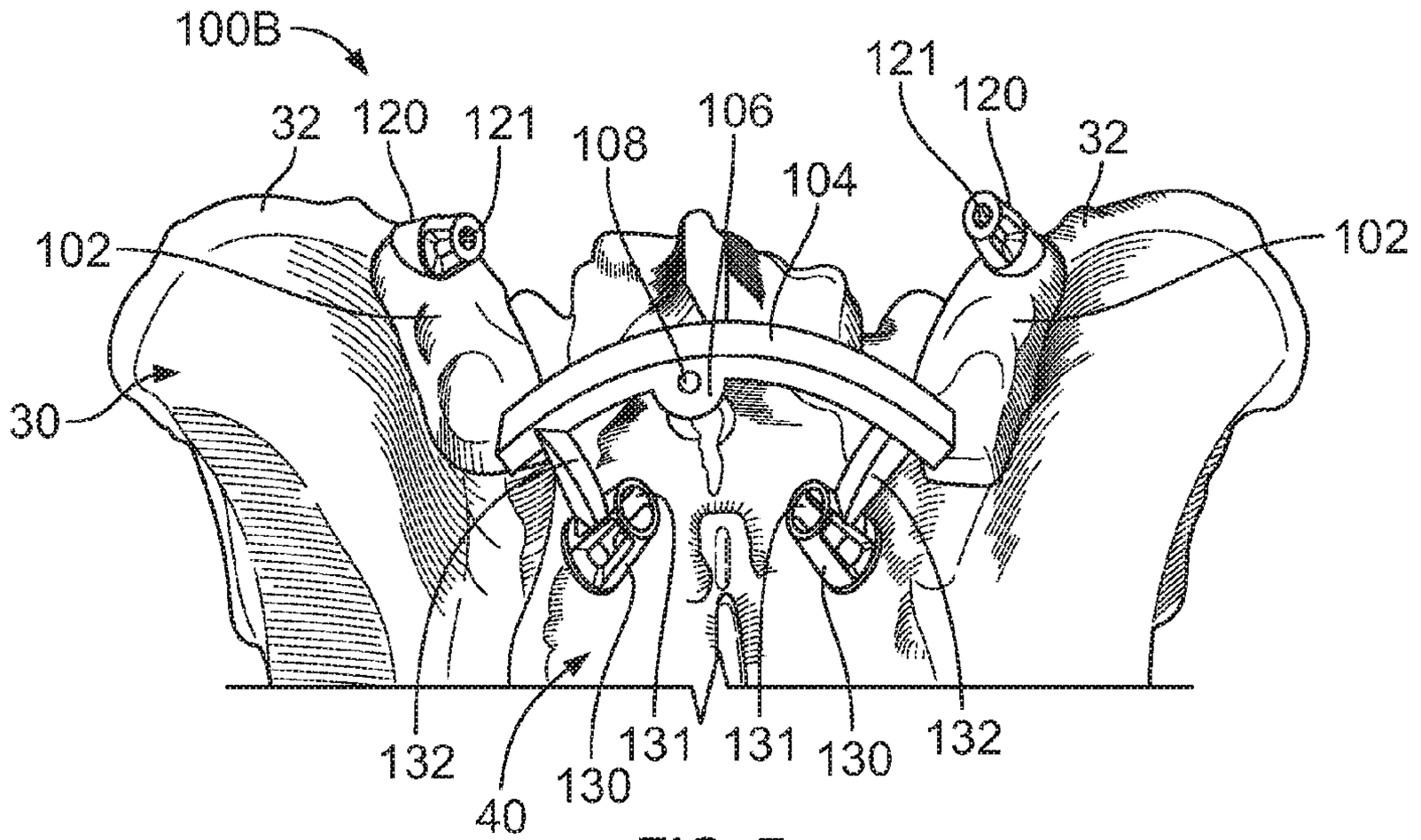


FIG. 7

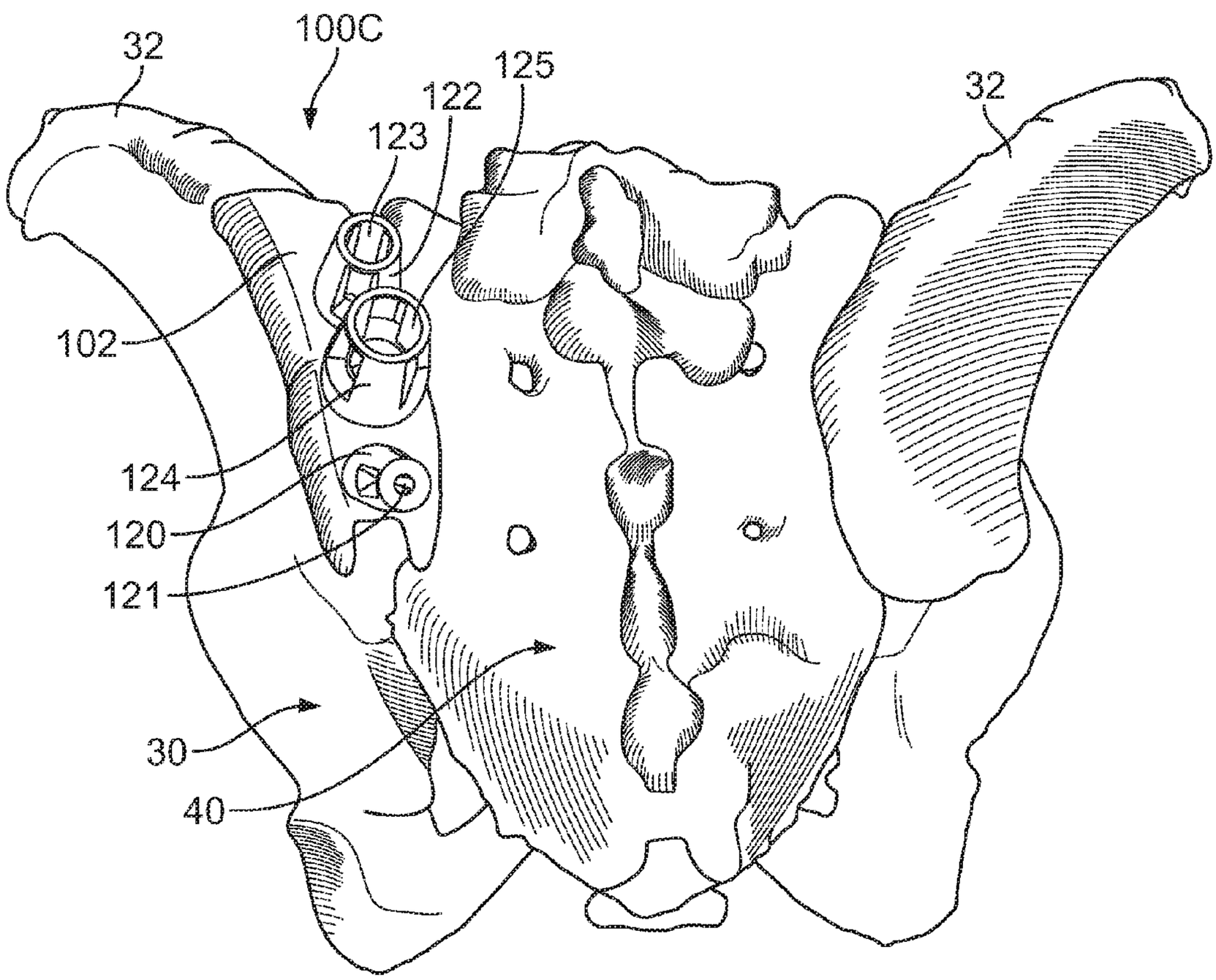


FIG. 8

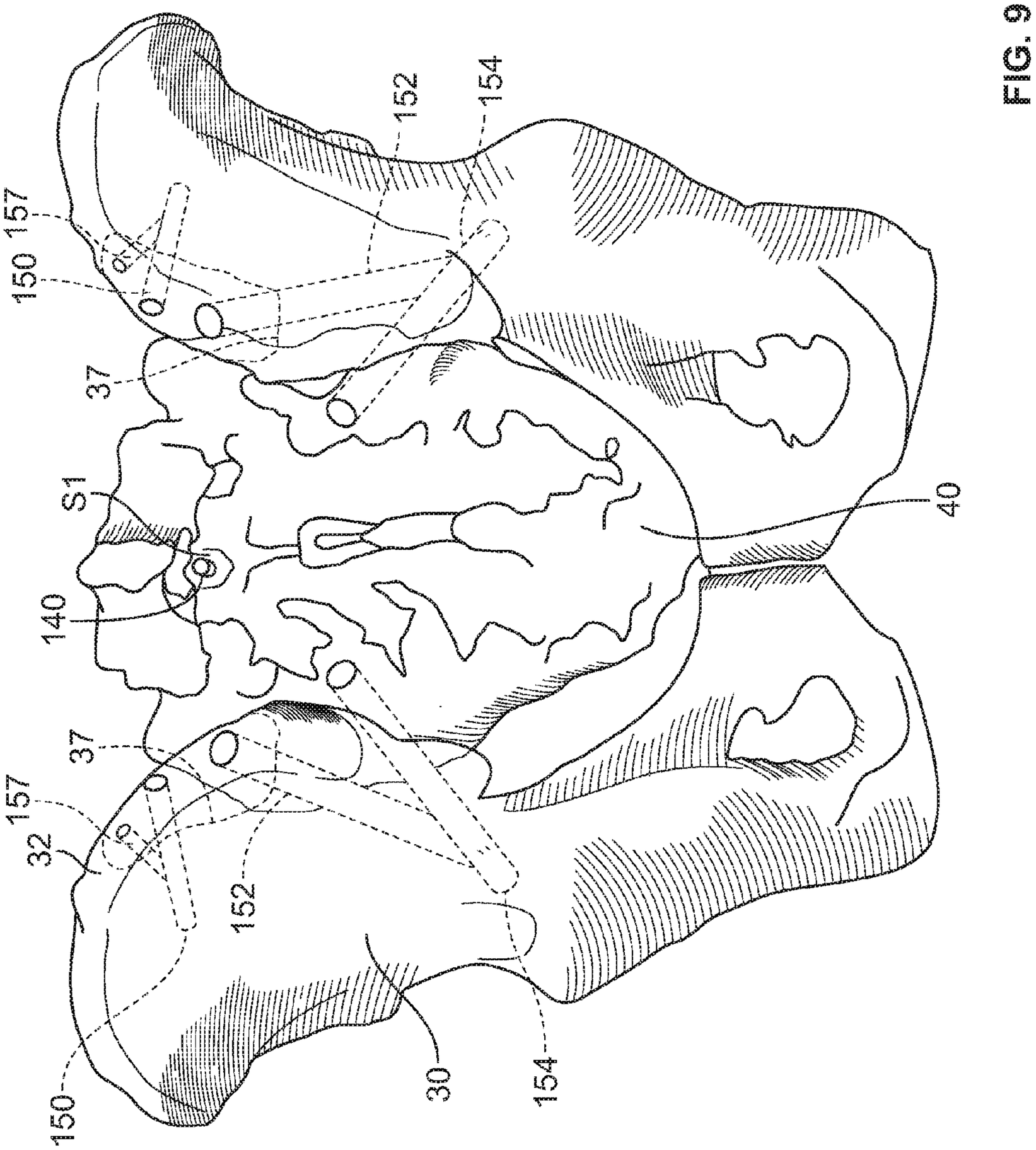


FIG. 9

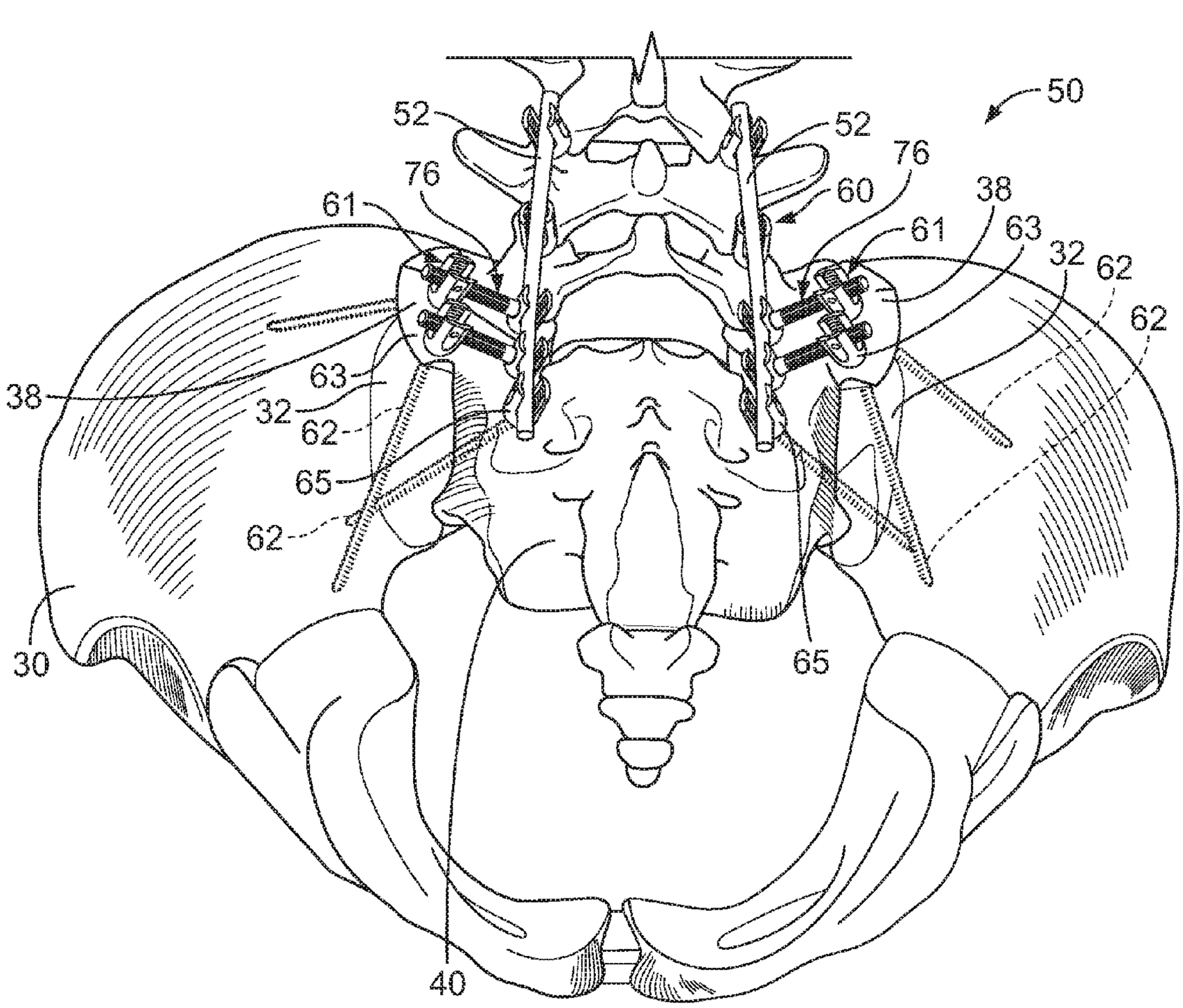


FIG. 10

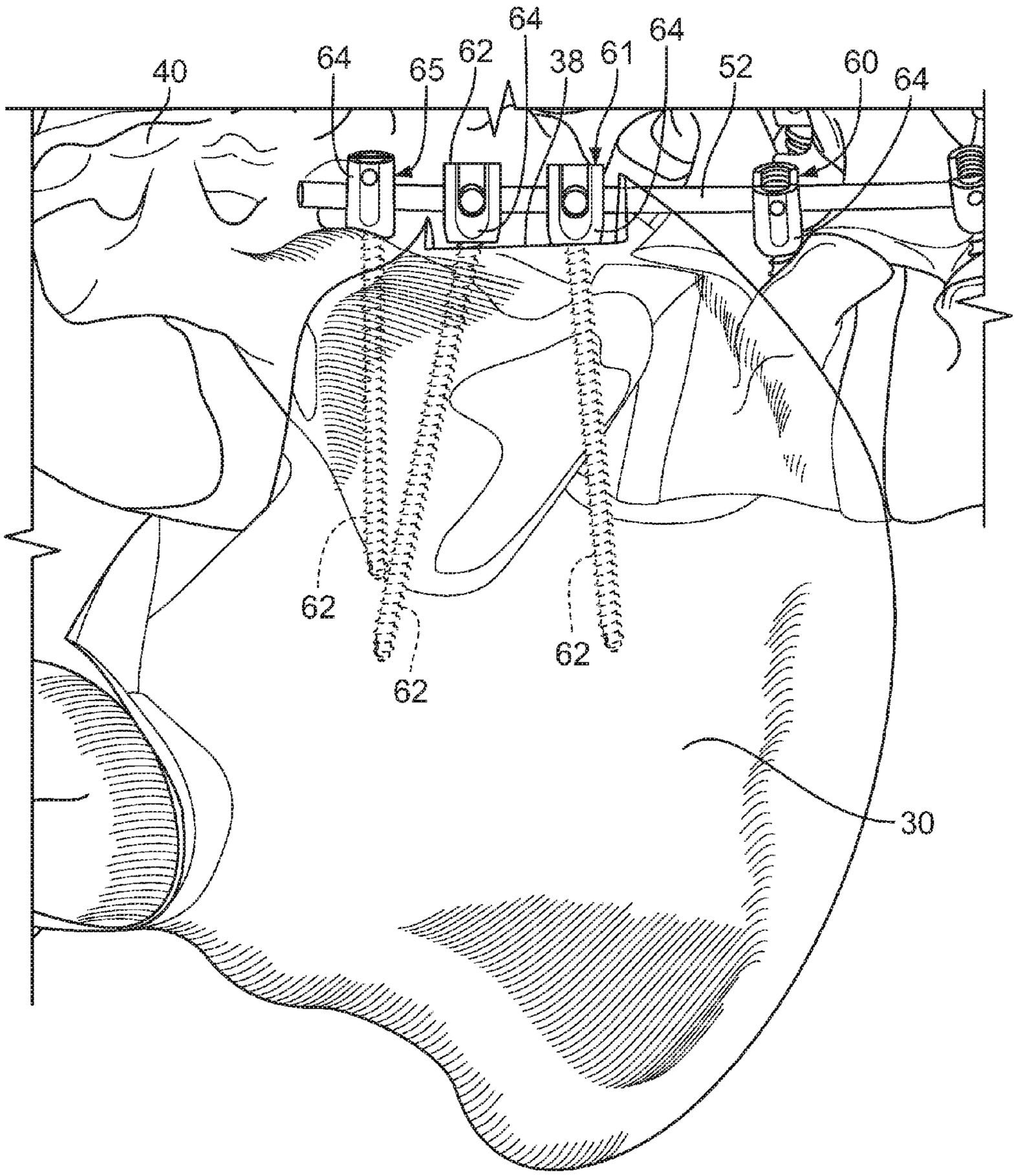


FIG. 11

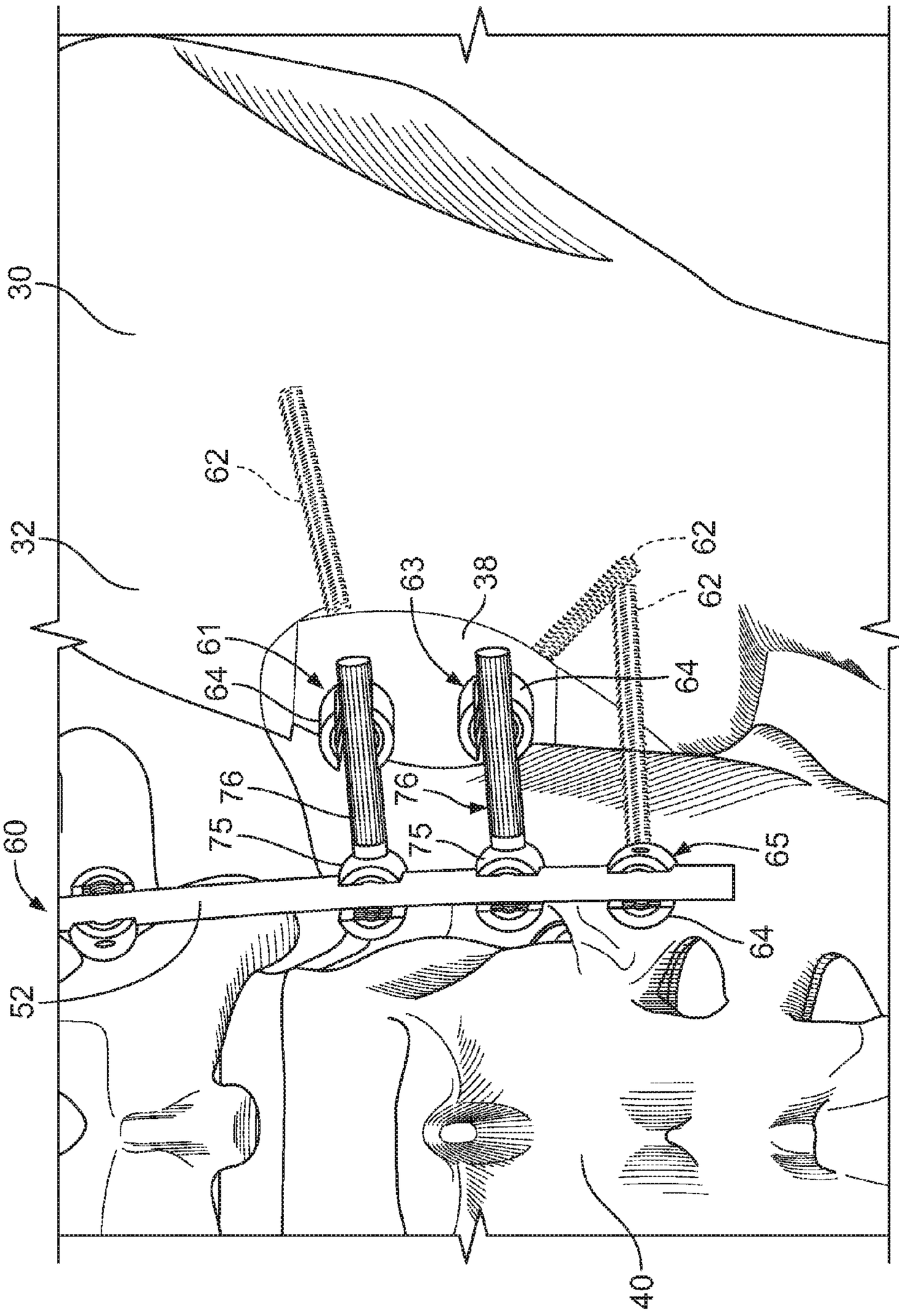


FIG. 12

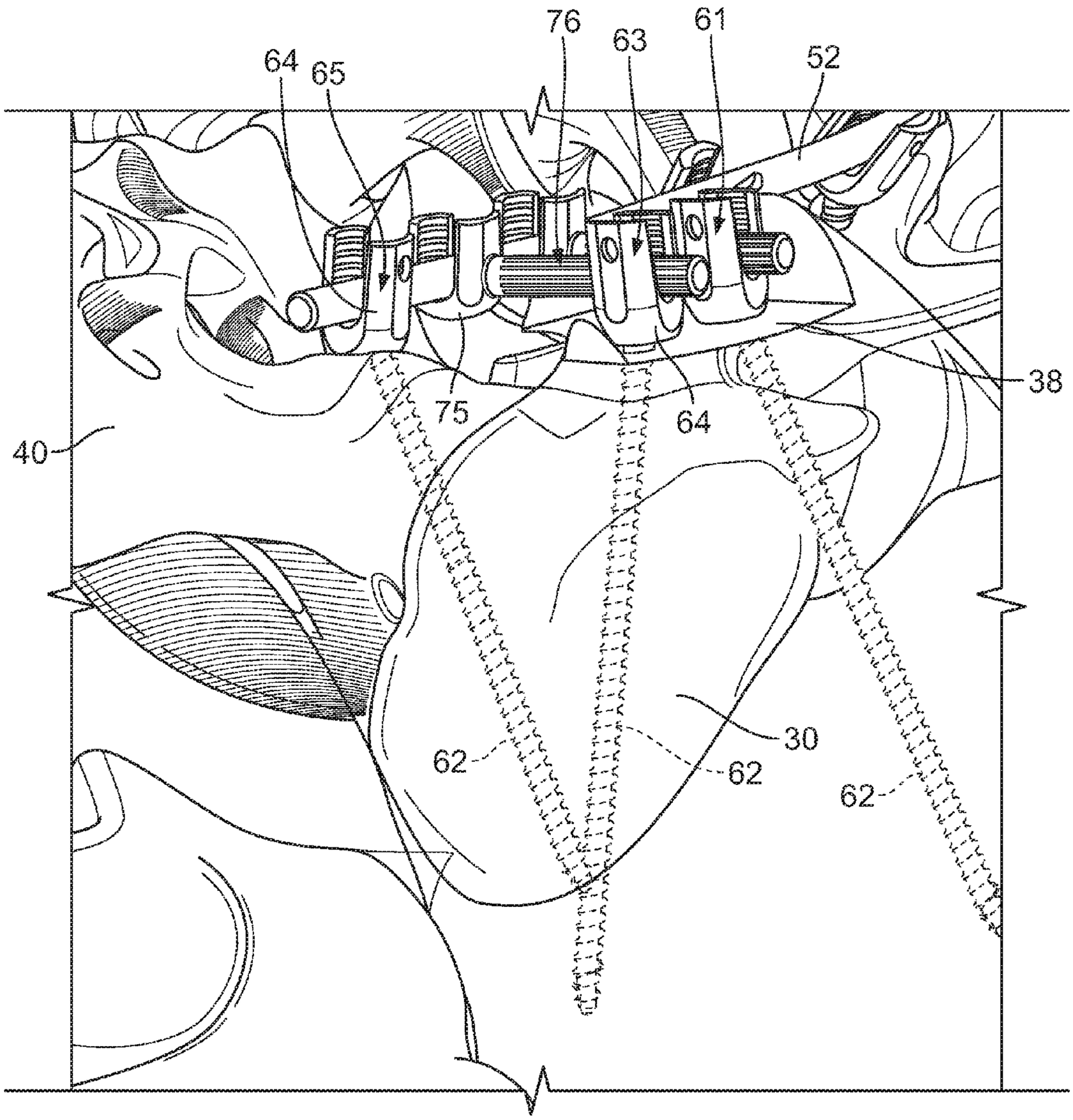


FIG. 13

PATIENT-SPECIFIC SACROILIAC GUIDES AND ASSOCIATED METHODS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 14/753,560 filed Jun. 29, 2015, which is a continuation of U.S. patent application Ser. No. 13/221,968 filed on Aug. 31, 2011 now issued as U.S. Pat. No. 9,066,734. The entire disclosures of the above applications are incorporated herein by reference.

FIELD AND INTRODUCTION

The present teachings provide various patient-specific alignment guides for sacro-pelvic, sacroiliac and/or posterior iliac fixation. The patient-specific alignment guides facilitate more accurate placement of bone screws and other fixation devices that are used in various spinal fixation systems, such as, for example, thoracic and lumbar rod systems. The patient-specific alignment guides are designed and constructed preoperatively based on three-dimensional digital images of portions of the patient's pelvis and spine, including the ilium and the sacrum. The digital images of the patient's anatomy can be reconstructed from medical scans of the patient using commercially available CAD (Computer Aided Design) and/or other imaging software.

SUMMARY

The present teachings provide orthopedic devices that include patient-specific alignment guides for various lumbopelvic fixation procedures. In some embodiments, the patient-specific alignment guide can be preoperatively configured for unilateral fixation, bilateral fixation, sacral fixation and/or sacroiliac fixation and combinations thereof. In some embodiments, the patient-specific alignment guide can be modular and intraoperatively convertible and reconfigurable at the discretion of the operating surgeon.

In some embodiments, the patient-specific alignment guide includes a patient-specific portion and a guiding element having a through opening. The patient-specific portion has a patient-specific surface preoperatively configured to nestingly mate as a negative of a portion of an iliac crest of a pelvis of a specific patient and mate to the iliac crest only in one position. The guiding element has a preoperatively configured orientation and location relative to the patient-specific portion for preparing a bore in the bone of the patient to direct a bone screw at the preoperatively configured orientation and location for sacroiliac fixation.

In some embodiments, the patient-specific alignment guide includes first and second patient-specific portions coupled by an arcuate bridge. The first patient-specific portion has a patient-specific surface preoperatively configured to nestingly mate to a portion of a first iliac crest of a pelvis of a specific patient and mate to the first iliac crest only in one position. The second patient-specific portion is similarly constructed for a second iliac crest of the patient. The bridge is configured to span a posterior contour of the pelvis of the patient. The patient-specific alignment guide can include first and second iliac guiding elements coupled to the corresponding first and second patient-specific portions, and first and second sacral guiding elements coupled to the bridge. Each of the first and second iliac and sacral guiding elements has a through opening and a preoperatively configured orientation and location relative to one of the first and second patient-specific portions for preparing a corresponding bore in the bone of the patient to direct a corresponding bone screw for sacroiliac fixation.

The present teachings also provide a method for lumbopelvic fixation. The method includes providing a convertible patient-specific alignment guide for a patient's pelvis and intraoperatively selecting one of unilateral fixation, iliac fixation, sacral fixation and bilateral sacroiliac fixation procedure for the patient. The convertible patient-specific alignment guide is reconfigured intraoperatively to a corresponding patient-specific alignment guide for the selected procedure. The convertible patient-specific alignment guide includes first and second patient-specific portions coupled by a bridge.

Further areas of applicability of the present teachings will become apparent from the description provided hereinafter. It should be understood that the description and specific examples are intended for purposes of illustration only and are not intended to limit the scope of the present teachings.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings described herein are for illustrative purposes only of selected embodiments and not all possible implementations, and are not intended to limit the scope of the present disclosure.

FIG. **1** is an environmental view of a portion of a spinal rod system;

FIG. **2** is an environmental view of a portion of another spinal rod system;

FIG. **3** is a detail of a multi-axial screw assembly of the spinal rod system shown in FIG. **2**;

FIG. **4** is a perspective view of a patient-specific universal alignment guide according to the present teachings;

FIG. **4**A is a detail of another embodiment of the patient-specific universal alignment guide of FIG. **4**;

FIG. **4**B is a detail of another embodiment of the patient-specific universal alignment guide of FIG. **4**;

FIG. **4**C is a perspective view of a drill guide according to the present teachings;

FIG. **4**D is a side view of the drill guide of FIG. **4**C;

FIG. **4**E is a detail of the patient-specific universal alignment guide of FIG. **4** showing an exemplary marking;

FIG. **5** is an environmental view of the universal alignment guide of FIG. **4**;

FIG. **5**A is an environmental view of another universal alignment guide according to the present teachings;

FIG. **6** is an environmental view of a patient-specific iliac alignment guide according to the present teachings;

FIG. **6**A is a perspective view of a fixation pin shown in FIG. **6**;

FIG. **7** is an environmental view of a patient-specific sacral alignment guide according to the present teachings;

FIG. **8** is an environmental view of a unilateral iliac alignment guide according to the present teachings;

FIG. **9** is an environmental view of a patient's pelvis showing representative bores drilled into the pelvis using the patient-specific alignment guides of FIG. **5**, **5**A, **7** or **8**;

FIG. **10** is an environmental view of a spinal rod system showing sacral and iliac screws positioned with patient-specific alignment guides according to the present teachings; and

FIGS. **11-13** are different environmental perspective views showing placement of sacral and iliac screws according to the present teachings.

Corresponding reference numerals indicate corresponding parts throughout the several views of the drawings.

DESCRIPTION OF VARIOUS ASPECTS

The following description is merely exemplary in nature and is in no way intended to limit the present teachings, applications, or uses. For example, although some of the present teachings are illustrated for sacroiliac fixation, the present teachings can be used for any other lumbopelvic procedure or lumbar and/or pelvic correction including trauma, deformation or disease.

The present teachings provide various patient-specific alignment guides for sacro-pelvic, sacroiliac and/or posterior iliac fixation. The patient-specific alignment guides can facilitate and improve the accuracy of the placement of bone screws and other fixation devices that are used in various spinal fixation systems, such as, for example, thoracic, lumbar and lumbopelvic fixation systems.

The patient-specific alignment guides of the present teachings are designed to guide and facilitate lumbopelvic fixation and help mitigate bone screw breaches of bone or neurovascular injury that can sometimes happen during unguided implantation of a lumbopelvic fixation system. Further, unguided implantation can be complicated by the characteristic three-dimensional geometry of the sacroiliac anatomy and/or the difficulty in directing bone screws toward strong bone anchorage, especially in the presence of cortical deficiencies, such as those that can be caused by previous autograft harvest from the posterior superior iliac spine (PSIS). Additionally, the receiver element of a bone screw assembly that is configured to receive a rod of a lumbopelvic fixation system and also support a corresponding bone screw can further complicate the placement of the bone screws connected to the corresponding receiver elements. The patient-specific alignment guides of the present teachings are preoperatively configured to alleviate or reduce some of these complications for each specific patient.

The patient-specific alignment guides are designed and constructed preoperatively based on three-dimensional digital images of portions of the patient's pelvis and spine, including the ilium, iliac wings and iliac crests and the sacrum. The three-dimensional digital images of the patient's anatomy can be reconstructed preoperatively from MRI, CT, ultrasound, X-ray, or other imaging and medical scans of the patient's anatomy using computer-assisted image methods. Various CAD programs and/or software can be utilized for three-dimensional image reconstruction, such as, for example, software commercially available by Materialise USA, Plymouth, Mich.

Various pre-operative planning procedures and patient-specific alignment guides are described in commonly assigned and co-pending U.S. patent application Ser. No. 11/756,057, filed May 31, 2007, now U.S. Patent Publication No. 2007/0288030; U.S. patent application Ser. No. 12/025,414, filed Feb. 4, 2008, now U.S. Patent Publication No. 2008/0114370; U.S. patent application Ser. No. 12/103,824, filed Apr. 16, 2008, now U.S. Patent Publication No. 2008/0257363; U.S. patent application Ser. No. 12/371,096, filed Feb. 13, 2009, now U.S. Patent Publication No. 2009/0151736; U.S. patent application Ser. No. 12/483,807, filed Jun. 12, 2009, now U.S. Patent Publication No. 2009/0254367; U.S. patent application Ser. No. 12/872,663, filed Aug. 31, 2010, now U.S. Patent Publication No. 2010/0324692; U.S. patent application Ser. No. 12/973,214, filed Dec. 20, 2010, now U.S. Patent Publication No. 2011/0092804; and, U.S. patent application Ser. No. 12/978,069, filed Dec. 23, 2010, now U.S. Patent Publication No. 2011/0093086. The disclosures of the above applications are incorporated herein by reference.

In the preoperative planning stage for lumbopelvic fixation, a preoperative surgical plan is formulated for a specific patient with interactive input from the patient's surgeon or other medical professional. Imaging data of the relevant anatomy of a patient can be obtained at a medical facility or doctor's office, using any of the medical imaging methods described above. The imaging data can include, for example, various medical scans of a relevant joint portion or other relevant portion of the patient's anatomy, as needed for the particular surgical procedure. The imaging data thus obtained and other associated information can be used to construct a three-dimensional computer (digital) image of a relevant portion of the anatomy of the patient, such as, in the present application, portions of the patient's pelvis and spine, including the sacral and iliac regions. The three-dimensional digital image of the patient's anatomy can be used to formulate a preoperative surgical plan specific to the patient. The preoperative surgical plan can include the design and construction of implants, patient-specific alignment guides and other instruments according to selected methods of surgical preparation and implantation. The preoperative surgical plan can also include planning for the location and orientation of bone modifications and/or resections and trajectory paths for various implant components, including, for example bone screws.

Generally, the patient-specific alignment guides of the present teachings are configured to match portions of the iliac and/or sacral anatomy of a specific patient and are generally designed and configured using computer modeling based on the reconstructed three-dimensional digital image of the patient's corresponding anatomy, as discussed above. The patient-specific alignment guides have a patient-specific anatomy-engaging surface that is configured as a mirror or negative or complementary surface that can conformingly contact and match a corresponding bone surface of the patient (with or without cartilage or other soft tissue). In this respect, a patient-specific alignment guide can register to and nestingly mate with the corresponding bone surface, such as, for example, a portion of the iliac crest, of the specific patient in only one position. The patient-specific alignment guides of the present teachings can be configured for use in any surgical procedure, such as open, mini-open and minimally invasive procedure.

The three-dimensional model of the patient's anatomy can be viewed on a computer display or other electronic screen and can also be reproduced as a hard copy on film or other medium and viewed by direct or indirect or backlight illumination. The model can be sized for viewing on any appropriate screen size and may be cropped, rotated, etc., as selected by the individual (e.g., the surgeon) viewing the screen.

The patient-specific alignment guides can be manufactured by rapid prototyping methods, such as stereolithography or other similar methods, or by CNC milling, or other automated or computer-controlled machining or robotic methods. The patient-specific alignment guides can be manufactured from any biocompatible materials, including metals, polymers and combinations thereof. The patient-specific alignment guides, the implants for the surgical procedure and, optionally, other disposable instruments can be sterilized, packaged and forwarded to the surgeon or the surgeon's medical facility for the surgical procedure.

As a brief overview, and referring to FIGS. **1-13**, prior art spinal fixation systems are briefly described in reference to

FIGS. **1-3**. Various embodiments of patient-specific alignment guides are described in reference to FIGS. **4-8**. For example, FIG. **6** illustrates a patient-specific "iliac" guide **100**A for inserting fixation screws starting from and into the ilium of the patient, according to the present teachings. FIG. **7** illustrates a patient-specific "sacral" guide **100**B for inserting fixation screws from the sacrum and into the ilium, according to the present teachings. FIGS. **4**, **5** and **5**A illustrate "universal" patient-specific guides **100**, **100'** for inserting bilaterally or unilaterally fixation screws from and into the ilium and/or from the sacrum and into the ilium according to the present teachings. FIG. **8** illustrates a patient-specific unilateral iliac guide **1000** for inserting fixation screws into the left ilium according to the present teachings. FIG. **9** illustrates screw bores prepared in the bone using an alignment guide of the present teachings and shown after the alignment guide is removed. Post implantation details of the lumbopelvic fixation system implanted using the bores pre-drilled with the alignment guides of the present teachings are shown in FIGS. **8-13**.

Referring to FIGS. **1-3**, portions of prior art spinal fixation systems (or rod systems) are illustrated. Various spinal and/or lumbopelvic fixation systems are commercially available from Biomet Manufacturing Corp., Warsaw, Ind., and include, for example, the Polaris® fixation system and the Array® system. An exemplary spinal fixation system **50** can include elongated fixation members or rods **52** that can be attached to the patient's anatomy with bone screw assemblies **60** inserted into thoracic pedicles, lumbar pedicles **45**, sacrum **40** and/or iliac wings **30** or iliac crest **32** of a patient's pelvis depending on the surgical technique and the corrective procedure selected for the patient. The bone screw assembly **60** can include a bone screw **62** with a bone anchoring portion inserted into the bone, a U-shaped ("tulip") receiver **64**, and a securing cap **66**. The receiver **64** is configured to receive or support the head of the bone screw **62** and optionally allow multi-axial pivoting of the bone screw **62**. The receiver **64** is also configured to transversely hold the rod **52**. The securing cap **66** is received and/or engaged to the receiver **64** and locks the rod **52** and the bone screw **62**. In other embodiments, the bone screw assembly **60** can include fixed, rather than polyaxial, bone screws.

With continued reference to FIGS. **1-3**, cross-connectors **70** between two rods **52** can be used to provide additional stability to the spinal fixation system **50** along the spine. Further, lateral connectors **76** can be used to provide iliac fixation and extend the spinal fixation system **50** over the iliac wings, as shown in FIG. **1**. The lateral connector **76** shown in FIG. **1** includes, for example, a receiver portion **75** coupled to the rod **52** and an elongated shaft **78** coupled to a bone screw assembly **60** that is positioned through the iliac crest **32**. Exemplary embodiments of the spinal fixation system **50** and associated instruments and implants, including the bone screw assembly **60** with the optional cross connectors **70** and lateral connectors **76** are commercially available from Biomet Manufacturing Corp., Warsaw, Ind. It will be appreciated, however, that other spinal fixation systems can be used according to the present teachings including, for example, the spinal fixation systems, bone screw assemblies, cross connectors and lateral connectors described in U.S. Pat. Nos. 7,294,129, 6,302,888, 6,616,668 and 7,699,876, the disclosures of which are incorporated herein by reference.

Referring to FIGS. **4-5**A, **9** and **10**, two embodiments of a universal patient-specific sacroiliac alignment guide **100**, **100'** ("the universal guide" for short) are illustrated. The universal guide **100**, **100'** is preoperatively configured to guide the drilling of one or more "iliac" (starting at the iliac wing or iliac crest) bores **150**, **152** and one or more "sacral" (starting at the sacrum) bores **154** (see FIG. **9**) to implant corresponding iliac and sacral bone screws **61**, **63**, **65** for a spinal fixation system **50** (see FIG. **10**). As can be seen in FIG. **9**, the iliac bores **150**, **152** are initiated from an iliac crest **32** and are directed into an iliac wing **30**. The sacral bores **154** initiated from the sacrum **40** and are also directed into the iliac wing **30** through a corresponding sacroiliac joint. The two embodiments of the universal guide **100**, **100'** have many similar elements and will be commonly described, except as noted to highlight any differences. Each universal guide **100**, **100'** can include first and second patient-specific portions **102** (right **102**R, left **102**L) that can be either integrally (monolithically) or modularly (removably) connected to one another by an elongated curved or arcuate connector or bridge **104**. The bridge **104** can include a tab portion **106** with a through hole **108** for receiving a locating pin **140** (K-wire or other type of pin) referencing the first sacral process (S1) of the spine, as shown in FIGS. **5** and **9**. The locating pin **140** can be used to confirm the accurate placement of the universal guide **100**, **100** by intraoperatively trialed to confirm contact with the S1 sacral process. The locating pin **140** can also be used for other anatomic landmarks, such as one or more sacral or spinous processes. The arcuate shape of the bridge **104** generally follows the contour of the posterior surface of the pelvis and can facilitate an effortless placement of the universal guide **100**, **100'** on the specified anatomy. The bridge **104** can also function as a handle for holding or guiding the universal guide **100**, **100'** on the pelvis. The bridge **104** can be removably coupled to each patient-specific portion **102** by a taper-to-taper or other releasable connection, as shown in the exemplary illustration of FIG. **4**A.

With continued reference to FIGS. **4-5**A, **9** and **10**, each patient-specific portion **102** is preoperatively configured from a three-dimensional image of the pelvis of the patient that is reconstructed from medical scans of the patient, as discussed above. Specifically, the patient-specific portion **102** has a patient-specific surface **103** configured as a negative or mirror of a portion of the iliac crest **32** and, optionally, adjacent areas. The patient-specific surface **103** tracks the unique anatomy of the specific patient's iliac crest **32** that provides natural referencing landmarks. Accordingly, the patient-specific portion **102** can be positioned intraoperatively with accuracy, and without our intraoperative guidance, in a preoperative determined single location of the iliac crest **32**. The patient-specific portion **102** nests and nestingly mates to the corresponding iliac crest **32**, as shown in FIGS. **5** and **5**A. In some embodiments, the patient-specific portion **102** can snap onto the corresponding iliac crest **32**.

Each patient-specific portion **102** includes one or more "iliac" guiding elements **122**, **124** with corresponding openings **123**, **125** passing through the patient-specific portion **102** for guiding a drill or other cutting instrument and forming corresponding iliac bores **150**, **152** from the iliac crest **32** through the iliac wing **30**. The iliac guiding elements **122**, **124** are configured preoperatively with patient-specific orientations and locations. The openings **123**, **125** of the iliac guiding elements **122**, **124** can be tapered and sized to receive a drill bit either directly or indirectly by receiving a sleeve or other drill guide to stabilize and guide a drill. In other embodiments, the openings **123**, **125** can be cylindrical to limit space requirements. In some embodiments, a metal sleeve may be press-fitted into a corresponding opening **123**, **125** to provide additional rigidity and stability, especially

when the universal guide **100**, **100'** (or any of the patient-specific alignment guides) is made of polymer or other plastic.

In some embodiments, a drill guide can be used to guide a drill, such as the drill guide **200** shown in FIGS. **4**C and **4**D. The drill guide **200** can have a space-saving cylindrical shaft **202** with a cylindrical bore **208** and can be configured to be received into a corresponding opening **123**, **125** of a corresponding iliac element **122**, **124**. Each drill guide **200** can be marked with color-coded and/or raised or embossed marking (e.g., X.Xmm) indicating the size of the corresponding guiding element **122**, **124** with which it can be used. The marking **210** can be placed on an outer surface of a block element **204** that is connected to the shaft **202**. The block element **204** can be used as a handle and can include grooves **206** or other tactile or frictional formations for facilitating secure hand gripping. The block element **204** can be offset relative to the shaft **202** in a direction that avoids interfering with visualization during the surgical procedure.

Similarly, the guiding elements **122**, **124** can be identified with color-coding and/or raised markings indicating size. Embossed or raised markings **113** can also be provided on the bridge **104** to indicate caudal and cephalad directions for the placement of the universal guide **100**, **100'** (and the other patient-specific alignment guides of the present teachings).

With continued reference to FIGS. **4-5**A, **9** and **10**, the universal guide **100**, **100'** can include one or more elongated arms **132** extending from the bridge **104** toward the sacrum **40** (left and right arms **132** are illustrated). In some embodiments, the arm **104** can extend from the patient-specific portion **102**, rather than from the bridge **104**. In some embodiments, the arm **132** can be removably coupled to the patient-specific portion **102** or the bridge **104** by a quick-connect/disconnect coupling, such as snap-fit, tongue and groove, taper-to-taper, etc., as shown in an exemplary illustration of FIG. **4**A. Each arm **132** can support one (or more) sacral guiding elements **130** having corresponding openings **131**. The arm **132** can be curved and oriented such that the sacral guiding element **130** is positioned in a preoperatively determined position and orientation for the specific patient based on the preoperative plan for the patient. The opening **131** of the sacral guiding element **130** can be tapered and sized to receive a drill bit or a sleeve (not shown) for stabilizing and guiding a drill. The sacral guiding element **130** is configured preoperatively with patient-specific orientation and location for guiding a sacral bone screw **65** through a bore **154** drilled from the sacrum **40** into the iliac wing **30** of the patient, as shown in FIGS. **9** and **10**. Additionally, the orientations and positions of the iliac guiding elements **122**, **124** and sacral guiding elements **130** are configured to avoid interference among the trajectories of the corresponding bone screws and provide anchoring in non-deficient cortical bone. In some embodiments, placement of the bone screws at patient-specific distances from the sciatic notch is preoperatively configured by the arrangement of the iliac and sacral guiding elements **122**, **124**, **130**. Further, in some embodiments, all or some of the iliac and/or sacral guiding elements **122**, **124**, **130** can be modular or removable and couplable to the corresponding patient-specific portions **102** with taper-to-taper connections, bayonet connections, threadable connections, snap-fit connections or other removable or releasable connections, as illustrated in FIG. **4**B. The iliac sacral guiding elements **122**, **124**, **130** can be color-coded and marked for size with raised or embossed markings, as discussed above.

Each of the patient-specific portions **102** can also include a fixation guiding element **120** with a corresponding opening **121** for guiding a temporary fixation guiding element such as a trocar pin or the pin **140** shown in FIG. **6**A for temporarily attaching the universal guide **100**, **100'** on the pelvis of the patient. The opening **121** of the fixation guiding element **120** can be smaller in diameter than the openings **123**, **125** and **131** of the corresponding iliac and sacral guiding elements **122**, **124** and **130** that are used for drilling bores for the bone screws **62** of the iliac and sacral screw assemblies, as shown in FIG. **9**. The fixation guiding element **120** is shown as located cephaladly (superiorly) on the patient-specific portion **102** of the universal guide **100** in FIGS. **4** and **5**, and caudally (inferiorly) on the patient-specific portion **102** of the universal guide **100'** shown in FIG. **5**A. In some embodiments, the patient-specific portion **102** of the universal guide **100'** can extend further caudally along the iliac crest **32**, and the bridge **104** of the universal guide **100'** can extend from a position cephalad to the fixation guiding element **120**, as shown in FIG. **5**A. The locations of the temporary fixation pins **140** that are used to support the universal alignment guide **100** on the pelvis are shown at **157** in FIG. **9**.

Referring to FIGS. **9-13**, after the iliac and sacral bores **150**, **152**, **154** have been formed using the universal guide **100**, **100'**, the universal guide **100**, **100'** is removed from the pelvis and preoperatively selected and determined portions **37** of the iliac crests **32** can be resected to create a planar recess or seat **38** to accommodate the receivers **64** of the first and second iliac screw assemblies **61**, **63** shown in FIGS. **11-13**.

Referring to FIGS. **6-8**, the iliac guide **100**A, sacral guide **100**B and unilateral guide **100**C are more specialized versions of the universal guide **100**, **100'**. The iliac guide **100**A, as shown in FIG. **6**, is similar to the universal guide **100** shown in FIG. **5**, but with the sacral guiding elements **130** omitted. It will be appreciated, however, that in other embodiments, the iliac guide **100**A can be arranged as the universal guide **100'** shown in FIG. **5**A, but with the sacral guiding elements **130** omitted.

The sacral guide **100**B, as shown in FIG. **7**, is similar to the universal guide **100** shown in FIG. **5**, but with the iliac guiding elements **122**, **124** omitted. It will be appreciated, however, that in other embodiments, the sacral guide **100**B can be arranged as the universal guide **100'** shown in FIG. **5**A, but with the iliac guiding elements **122**, **124** omitted.

The unilateral guide **100**C, as shown in FIG. **8**, is similar to the one side (left side is shown) of the universal guide **100'** shown in FIG. **5**A, without the bridge **104** and without the sacral guiding element **130**. It will be appreciated, however, that in other embodiments, the unilateral guide **100**C can be arranged as the universal guide **100** shown in FIG. **5**, without the bridge **104** and without the sacral element **130**. The unilateral guide **1000**, as shown in FIG. **8**, is a left side iliac unilateral guide. A right side iliac unilateral guide can be similarly constructed. Additionally, unilateral (left or right side) sacral guides can be constructed by using the arrangement of the sacral guide **100**B shown in FIG. **7** without the bridge **104** and without the opposite side patient-specific portion **102**.

Although various separate patient-specific unilateral, iliac and sacral can be constructed for a specific patient and surgeon, the patient-specific universal guide **100**, **100'** forms a bilateral sacroiliac guide that can be utilized intraoperatively to cover any intraoperative change in plan or intraoperative event for the specific patient. For example, if the surgeon decides to only do a unilateral fixation using sacral and/or iliac bone screws on the left (right) side only, then the corresponding iliac and/or sacral guiding elements of the

opposite right (left) side can simply not be used (no drilling on that side). In this respect, removable plugs or covers can be provided in all or some of the guiding elements, such that attention is directed to which guiding elements should be used by positively removing the plugs and exposing the corresponding guiding openings.

Another option is to decouple the bridge **104** and the right (left) side of the universal guide **100**, **100'** from the left (right) side and completely remove it. Similarly, the universal guide **100**, **100'** can be used for iliac fixation only or for sacral fixation only by not using or by removing those iliac or sacral guiding elements that are not needed. Additionally, the universal guide **100**, **100'** can be fully modular, as described above, and constructed as a bilateral sacroiliac guide with a removable bridge **104** and removable iliac and sacral guiding elements **122**, **124**, **130** and/or arms **132**. The modular universal guide **100**, **100'** is intraoperatively convertible and reconfigurable at the discretion of the operating surgeon. Accordingly, the same universal patient-specific guide **100**, **100'** can be used in several different fixation options of the same patient. As these fixation options are changed or selected intraoperatively, the modular universal guide **100**, **100'** provides the surgeon with intraoperative flexibility, reconfigurability and adaptability to an intraoperative change of plan and surgical procedure informed by intraoperative and possibly unanticipated circumstances. Color-coding and raised or embossed markings indicating size, orientation or other relevant information, such as, for example, patient identification, guide or element type and position, can help streamline intraoperative assembling, positioning and use and help avoid errors. At the same time, and regardless of the fixation option selected, the features and advantages of using a patient-specific guide are retained.

The universal guide **100**, **100'** (or the iliac guide **100**A, or the sacral guide **100**B, or the unilateral guide **100**C) is removed from the pelvis after the bone bores (**150**, **152**, **154**) for the selected fixation procedure have been drilled into the bone. The bone bores (**150**, **152**, **154**) are used to guide corresponding bone screw assemblies of a selected fixation system **50** according to the surgical technique associated with the fixation system.

Example embodiments are provided so that this disclosure is thorough, and fully conveys the scope to those who are skilled in the art. Numerous specific details are set forth, such as examples of specific components, devices, and methods, to provide a thorough understanding of embodiments of the present disclosure.

It will be apparent to those skilled in the art that specific details need not be employed, that example embodiments may be embodied in many different forms and that neither should be construed to limit the scope of the disclosure. In some example embodiments, well-known processes, well-known device structures, and well-known technologies are not described in detail. Accordingly, individual elements or features of a particular embodiment are generally not limited to that particular embodiment, but, where applicable, are interchangeable and can be used in a selected embodiment, even if not specifically shown or described. The same may also be varied in many ways. Such variations are not to be regarded as a departure from the disclosure, and all such modifications are intended to be included within the scope of the disclosure.

What is claimed is:

1. A method for lumbopelvic fixation comprising:

providing a convertible patient-specific alignment guide for a patient's pelvis, the convertible patient-specific alignment guide including first and second patient-specific portions coupled by a bridge;

intraoperatively selecting one of unilateral fixation, iliac fixation, sacral fixation and bilateral sacroiliac fixation procedure for the patient; and

reconfiguring the convertible patient-specific alignment guide to a corresponding patient-specific alignment guide for the selected fixation procedure.

2. The method of claim **1**, further comprising:

selecting a unilateral fixation procedure for a first side of the pelvis;

removing the bridge and the second patient-specific portion;

registering a patient-specific surface of the first patient-specific portion on a first iliac crest of the patient; and

drilling a bone bore for a bone screw through a guiding element of the first patient-specific portion into the first iliac crest.

3. The method of claim **2**, further comprising:

removing the first patient-specific portion; and

resecting a portion of the iliac crest around the bone bore for seating a bone screw assembly.

4. The method of claim **1**, further comprising:

selecting a bilateral fixation procedure for the pelvis;

registering a first patient-specific surface of the first patient-specific portion on a first iliac crest of the patient;

registering a second patient-specific surface of the second patient specific portion on a second iliac crest of the patient; and

drilling first and second bone bores for first and second bone screws through corresponding first and second guiding elements coupled to the corresponding first and second patient-specific portions and into the first and second iliac crests.

5. The method of claim **4**, further comprising:

removing the convertible alignment guide; and

resecting first and second portions of the corresponding first and second iliac crests around the corresponding first and second bone bores for seating corresponding first and second bone screw assemblies.

6. A method for lumbopelvic fixation comprising:

providing a convertible patient-specific alignment guide for a pelvis of a patient, the convertible patient-specific alignment guide including first and second modular portions coupled to each other;

selecting one of unilateral fixation, iliac fixation, sacral fixation and bilateral sacroiliac fixation procedure for the patient; and

configuring the convertible patient-specific alignment guide to arrange the first and second modular portions to correspond to the selected fixation procedure.

7. The method of claim **6**, wherein:

the first and second modular portions comprise:

an iliac guiding element; and

a sacral guiding element; and

selecting one of unilateral fixation, iliac fixation, sacral fixation and bilateral sacroiliac

fixation procedure for the patient comprises:

selecting unilateral fixation; and

selecting one or both of the iliac guiding element and the sacral guiding element for fixation to the pelvis.

8. The method of claim **7**, wherein configuring the convertible patient-specific alignment guide to arrange the first and second modular portions to correspond to the selected fixation procedure includes:

selecting one of the iliac guiding element and the sacral guiding element; and

uncoupling the selected one of the iliac guiding element and the sacral guiding element from the convertible patient-specific alignment guide.

9. The method of claim **8**, further comprising:

registering a first patient-specific surface of the selected one of the iliac guiding element and the sacral guiding element on the pelvis of the patient;

drilling a bone bore for a bone screw through the selected one of the iliac guiding element and the sacral guiding element into the pelvis;

removing the selected one of the iliac guiding element and the sacral guiding element; and

resecting a portion of the pelvis around the bone bore before seating a bone screw assembly.

10. The method of claim **7**, wherein configuring the convertible patient-specific alignment guide to arrange the first and second modular portions to correspond to the selected fixation procedure includes: detaching an arm connecting the iliac guiding element and the sacral guiding element.

11. The method of claim **6**, wherein:

the first and second modular portions comprise:

a first patient-specific iliac guiding element; and

a second patient-specific iliac guiding element; and

selecting one of unilateral fixation, iliac fixation, sacral fixation and bilateral sacroiliac fixation procedure for the patient comprises:

selecting bilateral fixation;

selecting both of the first and second patient-specific iliac guiding elements for fixation to the pelvis.

12. The method of claim **11**, wherein the first patient-specific iliac guiding element and the second patient-specific iliac guiding element include a first sacral guiding element and a second sacral guiding element, respectively.

13. The method of claim **12**, wherein configuring the convertible patient-specific alignment guide to arrange the first and second modular portions to correspond to the selected fixation procedure includes: detaching a first arm and a second arm connecting the first sacral guiding element and the second sacral guiding element to the first patient-specific iliac guiding element and the second patient-specific iliac guiding element, respectively.

14. The method of claim **13**, wherein configuring the convertible patient-specific alignment guide to arrange the first and second modular portions to correspond to the selected fixation procedure includes: detaching the first arm and the second arm from a bridge connecting the first and second patient-specific iliac guiding elements.

15. The method of claim **12**, further comprising uncoupling one or both of the first sacral guiding element from the first patient-specific iliac guiding element and the second sacral guiding element from the second patient-specific iliac guiding element.

16. The method of claim **15**, further comprising:

registering a first patient-specific surface of the first patient-specific iliac guiding element on a first iliac crest of the patient;

registering a second patient-specific surface of the second patient-specific iliac guiding element on a second iliac crest of the patient;

drilling first and second bone bores for first and second bone screws through corresponding first and second guiding elements coupled to the corresponding first and second patient-specific iliac guiding elements and into the first and second iliac crests;

removing the convertible alignment guide; and

resecting first and second portions of the corresponding first and second iliac crests around the corresponding first and second bone bores for seating corresponding first and second bone screw assemblies.

17. A method for lumbopelvic fixation comprising:

evaluating a convertible patient-specific alignment guide for a pelvis of a patient, the convertible patient-specific alignment guide including an iliac guiding element and a sacral guiding element coupled to each other;

selecting between performing one or both of an iliac fixation procedure and a sacral fixation procedure for the patient; and

reconfiguring the convertible patient-specific alignment guide to a corresponding patient-specific alignment guide for the selected fixation procedure.

18. The method of claim **17**, wherein reconfiguring the convertible patient-specific alignment guide comprises uncoupling an arm connecting the iliac guiding element and the sacral guiding element.

19. The method of claim **17**, wherein reconfiguring the convertible patient-specific alignment guide comprises uncoupling a drill guide from a patient-specific base.

20. The method of claim **17**, wherein reconfiguring the convertible patient-specific alignment guide comprises uncoupling a bridge from the convertible patient-specific alignment guide.

* * * * *