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Maxson

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(54) **TIBIAL TUBERCULE OSTEOTOMY**

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(56) **References Cited**

U.S. PATENT DOCUMENTS

1,480,285	A	1/1924	Moore
2,181,746	A	11/1939	Siebrandt
2,407,845	A	9/1946	Orisan

(Continued)

FOREIGN PATENT DOCUMENTS

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

(Continued)

OTHER PUBLICATIONS

"3D-Implantatplanung and StereolithographieImplantatbohrschablonen", Stomatologie 101.3, (2004), 55-59.

(Continued)

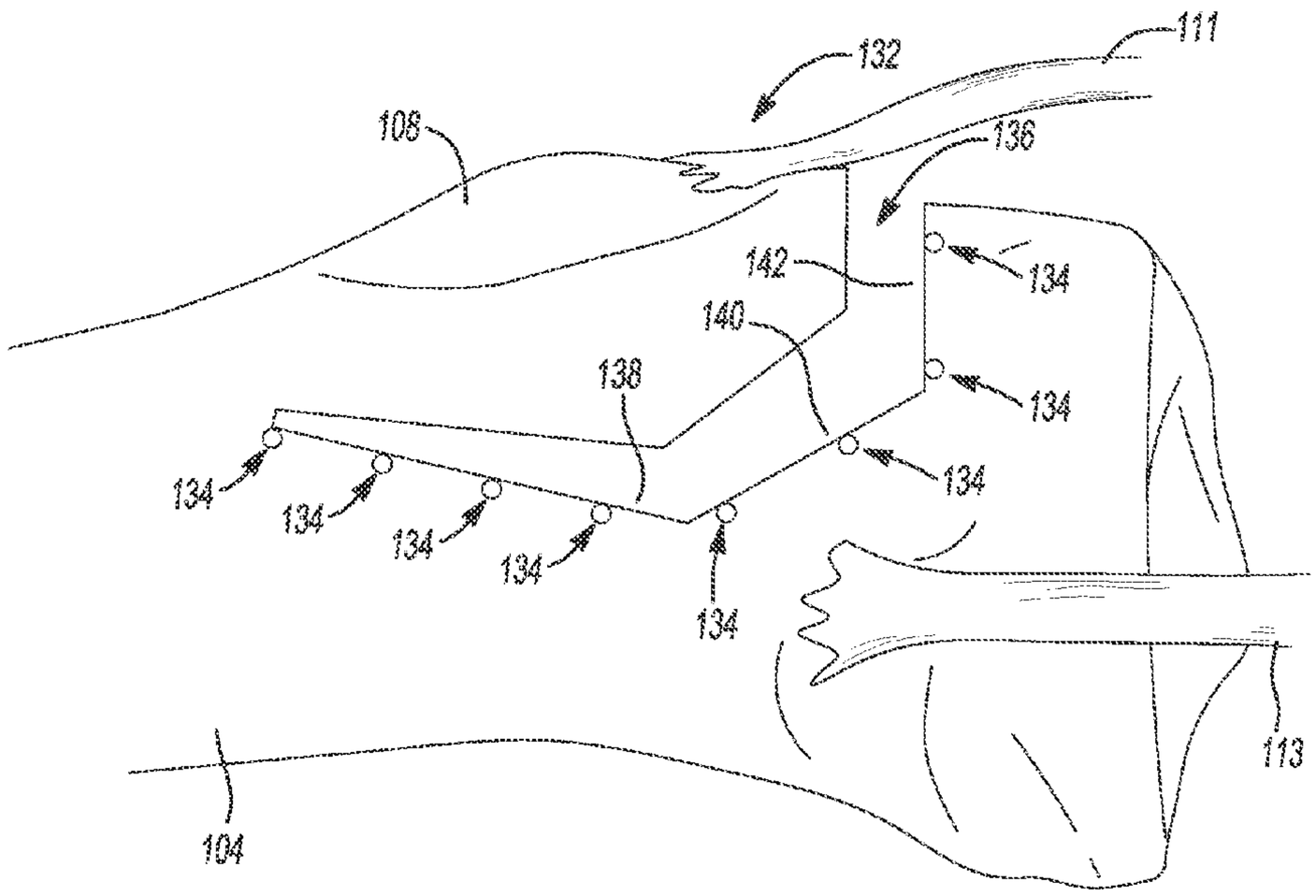
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(57) **ABSTRACT**

Patient-specific guides for a tibial tubercle osteotomy are provided. The guides include a guide body defining a portion with a bone-engaging surface that conforms as a negative surface to a corresponding surface of a specific patient's tibia, and a guide portion that guides a surgical instrument to a specific location on the specific patient's tibia, wherein the bone-engaging surface and guide portion are configured during a pre-operative planning stage. Methods for performing a tibial tubercle osteotomy with the patient-specific guides are also provided.

6 Claims, 6 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

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	A61B 17/152 606/87
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.	
4,677,973	A	*	7/1987	Slocum	A61B 17/1637 606/60
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.	
5,108,425	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	
5,133,760	A		7/1992	Petersen et al.	
5,140,777	A		8/1992	Ushiyama 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.	
5,246,444	A	*	9/1993	Schreiber	A61B 17/152 606/87
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	
5,320,529	A		6/1994	Pompa	
5,320,625	A		6/1994	Bertin	
5,323,697	A		6/1994	Schrock	
5,342,366	A		8/1994	Whiteside et al.	
5,344,423	A		9/1994	Dietz 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.	
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	
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	A61B 17/1714 606/206
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	Elliot 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	

(56) **References Cited**

U.S. PATENT DOCUMENTS

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.	
5,824,083	A	10/1998	Draenert	
5,835,619	A	11/1998	Morimoto et al.	
5,843,085	A *	12/1998	Graser	A61B 17/15 606/87
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	A61B 17/68 623/20.14
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	
6,066,175	A	5/2000	Henderson et al.	
6,086,593	A	7/2000	Bonutti	
6,099,531	A *	8/2000	Bonutti	A61B 17/562 606/87
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.	
6,187,010	B1	2/2001	Masini	
6,190,390	B1 *	2/2001	McAllister	A61B 17/1604 606/54
6,195,615	B1	2/2001	Lysen	
6,203,546	B1 *	3/2001	MacMahon	A61B 17/152 606/87
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.	
6,302,913	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	
6,423,061	B1 *	7/2002	Bryant	A61B 17/152 606/54
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.	
6,533,737	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	
6,591,581	B2	7/2003	Schmieding	
6,605,293	B1	8/2003	Giordano et al.	
6,610,067	B2	8/2003	Tallarida et al.	
6,622,567	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.	
6,682,567	B1	1/2004	Schroeder	
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.	
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	A61B 17/1714 128/898
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.	

(56) **References Cited**

U.S. PATENT DOCUMENTS

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.	
6,953,480	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.	
7,169,185	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.	
7,239,908	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.	
7,294,133	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	
7,364,581	B2 *	4/2008	Michalowicz	A61B 17/157 606/87
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	
7,427,200	B2	9/2008	Noble et al.	
7,427,272	B2	9/2008	Richard 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.	
7,591,821	B2	9/2009	Kleman	
7,601,155	B2	10/2009	Petersen	
7,603,192	B2	10/2009	Martin 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.	
7,682,398	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.	
7,704,253	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.	
7,837,690	B2	11/2010	Metzger	
7,846,165	B2 *	12/2010	Aram	A61B 17/17 606/86 R
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	A61B 17/1615 606/87
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	Roßner 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.	
8,170,641	B2	5/2012	Belcher	
8,182,489	B2	5/2012	Horacek	
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.	
8,221,430	B2	7/2012	Park et al.	
8,241,292	B2 *	8/2012	Collazo	A61B 17/8095 606/87
8,241,293	B2 *	8/2012	Stone	A61B 17/152 606/87
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	
8,282,646	B2	10/2012	Schoenfeld et al.	
8,298,237	B2	10/2012	Schoenfeld et al.	
8,303,596	B2	11/2012	Plaßky et al.	
8,313,491	B2	11/2012	Green, II et al.	
D672,038	S	12/2012	Frey	

(56) **References Cited**

U.S. PATENT DOCUMENTS

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.	
8,398,646	B2	3/2013	Metzger 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	A61B 34/10 606/88
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.	
8,771,279	B2 *	7/2014	Philippon	A61B 17/68 606/87
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.	
8,858,602	B2 *	10/2014	Weiner	A61B 17/151 606/282
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	
8,926,618	B2 *	1/2015	Collazo	A61B 17/1764 606/87
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.	
9,055,954	B2 *	6/2015	Aram	A61B 17/17
9,427,240	B2 *	8/2016	Von Zabern	A61B 17/1637
9,833,245	B2 *	12/2017	Maxson	A61B 17/1764
10,335,162	B2 *	7/2019	Maxson	A61B 17/152
2001/0005797	A1	6/2001	Barlow et al.	
2001/0011190	A1	8/2001	Park	
2001/0021876	A1	9/2001	Terrill-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	
2002/0165552	A1 *	11/2002	Duffner	A61B 17/152 606/87
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	A61F 2/28 623/16.11
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	
2004/0158255	A1	8/2004	Justin et al.	
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	
2004/0220583	A1	11/2004	Pieczynski, II et al.	
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	
2005/0027303	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.	

(56) **References Cited**

U.S. PATENT DOCUMENTS

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
2005/0148843 A1 7/2005 Roose
2005/0149042 A1 7/2005 Metzger
2005/0169893 A1* 8/2005 Koblish A61L 27/54 424/93.7
2005/0171545 A1 8/2005 Walsh et al.
2005/0177245 A1 8/2005 Leatherbury et al.
2005/0203536 A1 9/2005 Laffargue et al.
2005/0203540 A1 9/2005 Broyles
2005/0209597 A1 9/2005 Long et al.
2005/0209605 A1 9/2005 Grimm et al.
2005/0216023 A1* 9/2005 Aram ..... A61B 17/1637 606/86 R
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.
2005/0267485 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.
2006/0161165 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
2006/0235421 A1 10/2006 Rosa et al.
2006/0241635 A1 10/2006 Stumpo et al.
2006/0241636 A1 10/2006 Novak et al.
2006/0241775 A1 10/2006 Buss
2006/0241776 A1 10/2006 Brown 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
2007/0118055 A1 5/2007 Mccombs
2007/0118138 A1 5/2007 Seo et al.
2007/0118243 A1 5/2007 Schroeder 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.
2007/0162038 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.
2007/0226986 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.
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

(56) **References Cited**

U.S. PATENT DOCUMENTS

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.	
2008/0114370	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.	
2008/0154267	A1	6/2008	Merchant et al.	
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	A61B 17/152 606/70
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.	
2008/0243257	A1*	10/2008	Taber	A61B 17/152 623/20.16
2008/0255674	A1	10/2008	Rahaman et al.	
2008/0257363	A1	10/2008	Schoenefeld et al.	
2008/0262500	A1*	10/2008	Collazo	A61B 17/8095 606/88
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	
2008/0287954	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.	
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	
2009/0118769	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.	
2009/0149964	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.	
2009/0187193	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.	
2009/0259312	A1	10/2009	Shterling et al.	
2009/0270868	A1	10/2009	Park et al.	
2009/0274350	A1	11/2009	Pavlovskaia et al.	
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.	
2009/0318924	A1*	12/2009	Helenbolt	A61B 17/151 606/88
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	

(56) **References Cited**

U.S. PATENT DOCUMENTS

2010/0082067	A1	4/2010	Kondrashov	
2010/0087829	A1*	4/2010	Metzger	A61B 17/154 606/96
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.	
2010/0145343	A1	6/2010	Johnson et al.	
2010/0145344	A1	6/2010	Jordan et al.	
2010/0152782	A1*	6/2010	Stone	A61B 17/809 606/280
2010/0160917	A1	6/2010	Fitz et al.	
2010/0160919	A1	6/2010	Axelson, Jr. 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	
2010/0228257	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.	
2011/0046735	A1	2/2011	Metzger et al.	
2011/0054478	A1	3/2011	Vanasse et al.	
2011/0054479	A1*	3/2011	Aram	A61B 17/1637 606/87
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	A61B 17/155 606/88
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	A61B 17/1764 606/88
2011/0172672	A1*	7/2011	Dubeau	A61B 17/152 606/87
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	A61B 17/151 606/88
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	
2011/0245835	A1	10/2011	Dodds et al.	
2011/0251617	A1	10/2011	Ammann et al.	
2011/0257657	A1	10/2011	Turner et al.	
2011/0269100	A1	11/2011	Furrer et al.	
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	A61B 17/1746 606/96
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	
2012/0089595	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	A61F 2/4607 606/87
2012/0130383	A1*	5/2012	Budoff	A61B 17/152 606/87
2012/0136365	A1	5/2012	Iannotti et al.	
2012/0141034	A1	6/2012	Iannotti et al.	
2012/0143197	A1	6/2012	Lang et al.	
2012/0143267	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	
2012/0184962	A1	7/2012	Merchant	
2012/0192401	A1	8/2012	Pavlovskaia et al.	
2012/0197410	A1*	8/2012	Horan	A61B 17/68 623/20.32
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	

(56) **References Cited**

U.S. PATENT DOCUMENTS

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.	
2012/0303004	A1	11/2012	Uthgenannt et al.	
2012/0303033	A1*	11/2012	Weiner	A61B 17/8061 606/87
2012/0310364	A1	12/2012	Li et al.	
2012/0310399	A1	12/2012	Metzger	
2012/0316564	A1*	12/2012	Serbousek	A61B 17/1675 606/80
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.	
2013/0030540	A1	1/2013	Leibinger	
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	
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	A61B 17/58 606/88
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	A61B 34/10 606/88
2014/0163564	A1	6/2014	Bollinger	
2014/0163565	A1	6/2014	Bollinger	
2014/0172116	A1*	6/2014	Maxson	A61F 2/2846 623/23.53
2014/0180341	A1*	6/2014	Kang	A61B 17/8095 606/281
2014/0188119	A1	7/2014	Catanzarite et al.	
2014/0208578	A1*	7/2014	Linderman	A61B 17/155 29/592
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.	
2014/0288562	A1*	9/2014	Von Zabern	A61D 1/00 606/88
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	A61B 17/1764 606/96
2014/0378979	A1	12/2014	Stone et al.	
2015/0038974	A1*	2/2015	Harbison	A61B 17/151 606/88
2015/0071885	A1*	3/2015	Saw	A61B 17/157 424/93.7
2015/0088293	A1	3/2015	Metzger	
2015/0305752	A1*	10/2015	Eash	A61B 17/151 606/82
2015/0335367	A1*	11/2015	Austin	A61F 2/28 606/87
2016/0089166	A1*	3/2016	Maxson	A61B 17/8095 606/88
2018/0049750	A1*	2/2018	Maxson	A61B 17/1764
2019/0314038	A1*	10/2019	Maxson	A61B 17/1764

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
CN	107072672	A	8/2017
DE	04219939	A1	12/1993
DE	4421153	A1	12/1995
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

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

EP	2502582	A1	9/2012
EP	2709568	A1	3/2014
FR	2659226	A1	9/1991
FR	2721195	A1	12/1995
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
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
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-2002026145	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-06060795	A1	6/2006
WO	WO-2006058057	A2	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-07041375	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-2012158917	A1	11/2012
WO	WO-2012173929	A1	12/2012
WO	WO-2012174008	A1	12/2012
WO	WO-2013179142	A1	12/2013
WO	WO-2016053843	A1	4/2016

OTHER PUBLICATIONS

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

"U.S. Appl. No. 14/500,019, Non Final Office Action dated Apr. 18, 2017", 19 pgs.

"U.S. Appl. No. 14/500,019, Notice of Allowance dated Aug. 4, 2017", 9 pgs.

"U.S. Appl. No. 14/500,019, Response filed Jun. 30, 2017 to Non Final Office Action dated Apr. 18, 2017", 13 pgs.

"U.S. Appl. No. 15/800,399, Non Final Office Action dated Nov. 6, 2018", 11 pgs.

"U.S. Appl. No. 15/800,399, Notice of Allowance dated Feb. 28, 2019", 7 pgs.

"U.S. Appl. No. 15/800,399, Response filed Jan. 31, 2019 to Non Final Office Action dated Nov. 6, 2018", 12 pgs.

"U.S. Appl. No. 15/800,399, Response filed Apr. 18, 2018 to Restriction Requirement dated Mar. 19, 2018", 6 pgs.

"U.S. Appl. No. 15/800,399, Restriction Requirement dated Mar. 19, 2018", 6 pgs.

"Ascent Total Knee System", Biomet, Inc., (Oct. 31, 1999), 16 pgs.

"Australian Application Serial No. 2013222609, First Examiner Report dated Feb. 16, 2015", 5 pgs.

"Chinese Application Serial No. 201580060122.2, Office Action dated Jan. 16, 2019", (W/ English Translation), 16 pgs.

"Chinese Application Serial No. 201580060122.2, Response filed Apr. 17, 2019 to Office Action dated Jan. 16, 2019", (W/ English Claims), 10 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.

(56) **References Cited**

OTHER PUBLICATIONS

"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) dated Jan. 22, 2015", 6 pgs.
"European Application Serial No. 07809326.7, Extended European Search Report dated Nov. 15, 2011", 6 pgs.
"European Application Serial No. 09731923.0, Examination Notification Art. 94(3) dated Feb. 10, 2015", 7 pgs.
"European Application Serial No. 10705064.3, Examination Notification Art. 94(3) dated Feb. 4, 2015", 6 pgs.
"European Application Serial No. 12724475.4, Examination Notification Art. 94(3) dated Nov. 24, 2014", 7 pgs.
"European Application Serial No. 15775589.3, Response filed Dec. 19, 2017 to Communication pursuant to Rules 161(1) and 162 EPC dated Jun. 9, 2017", 14 pgs.
"Great Britain Application Serial No. 1116054.6, Search Report dated 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 dated Nov. 30, 2010", 3 pgs.
"International Application U.S. Appl. No. PCT/US2007/013223, International Preliminary Report on Patentability dated Dec. 24, 2008", 5 pgs.
"International Application Serial No. PCT/US2007/013223, International Search Report dated Nov. 26, 2007", 3 pgs.
"International Application Serial No. PCT/US2007/013223, Written Opinion dated Nov. 26, 2007", 4 pgs.
"International Application Serial No. PCT/US2009/039507, International Preliminary Report on Patentability dated Oct. 28, 2010", 9 pgs.
"International Application Serial No. PCT/US2009/039507, International Search Report dated Jul. 14, 2009", 6 pgs.
"International Application Serial No. PCT/US2009/039507, Written Opinion dated Jul. 14, 2009", 7 pgs.
"International Application Serial No. PCT/US2009/039578, International Preliminary Report on Patentability dated Oct. 28, 2010", 9 pgs.
"International Application Serial No. PCT/US2009/039578, International Search Report dated Jul. 31, 2009", 6 pgs.
"International Application Serial No. PCT/US2009/039578, Written Opinion dated Jul. 31, 2009", 7 pgs.
"International Application Serial No. PCT/US2009/056670, International Preliminary Report on Patentability dated Mar. 31, 2011", 12 pgs.
"International Application Serial No. PCT/US2009/056670, International Search Report dated Mar. 2, 2010", 7 pgs.
"International Application Serial No. PCT/US2009/056670, Invitation to Pay Additional Fees and Partial Search Report dated Nov. 26, 2009".
"International Application Serial No. PCT/US2009/056670, Written Opinion dated Mar. 2, 2010", 10 pgs.
"International Application Serial No. PCT/US2010/024073, International Preliminary Report on Patentability dated Aug. 25, 2011", 8 pgs.
"International Application Serial No. PCT/US2010/024073, International Search Report dated Jun. 4, 2010", 4 pgs.
"International Application Serial No. PCT/US2010/024073, Written Opinion dated Jun. 4, 2010", 6 pgs.
"International Application Serial No. PCT/US2010/024579, International Preliminary Report on Patentability dated Sep. 1, 2011", 7 pgs.
"International Application Serial No. PCT/US2010/024579, International Search Report dated Apr. 22, 2010", 3 pgs.
"International Application Serial No. PCT/US2010/024579, Written Opinion dated Apr. 22, 2010", 5 pgs.
"International Application Serial No. PCT/US2010/024584, International Preliminary Report on Patentability dated Sep. 1, 2011", 8 pgs.
"International Application Serial No. PCT/US2010/024584, International Search Report dated Aug. 19, 2010", 6 pgs.
"International Application Serial No. PCT/US2010/024584, Written Opinion dated Aug. 19, 2010", 6 pgs.
"International Application Serial No. PCT/US2010/038177, International Preliminary Report on Patentability dated Dec. 22, 2011", 10 pgs.
"International Application Serial No. PCT/US2010/038177, International Search Report dated Aug. 24, 2010", 4 pgs.
"International Application Serial No. PCT/US2010/038177, Written Opinion dated Aug. 24, 2010", 8 pgs.
"International Application Serial No. PCT/US2010/038845, International Preliminary Report on Patentability dated Jan. 5, 2012", 9 pgs.
"International Application Serial No. PCT/US2010/038845, International Search Report dated Oct. 5, 2010", 4 pgs.
"International Application Serial No. PCT/US2010/038845, Written Opinion dated Oct. 5, 2010", 7 pgs.
"International Application Serial No. PCT/US2010/050701, International Preliminary Report on Patentability dated Apr. 12, 2012", 10 pgs.
"International Application Serial No. PCT/US2010/050701, International Search Report dated Dec. 7, 2010", 6 pgs.
"International Application Serial No. PCT/US2010/050701, Written Opinion dated Dec. 7, 2010", 8 pgs.
"International Application Serial No. PCT/US2011/026333, International Preliminary Report on Patentability dated Sep. 7, 2012", 10 pgs.
"International Application Serial No. PCT/US2011/026333, International Search Report dated Aug. 9, 2011", 6 pgs.
"International Application Serial No. PCT/US2011/026333, Invitation to Pay Additional Fees dated May 3, 2011".
"International Application Serial No. PCT/US2011/026333, Written Opinion dated Aug. 9, 2011", 8 pgs.
"International Application Serial No. PCT/US2011/026412, International Search Report dated May 9, 2011", 5 pgs.
"International Application Serial No. PCT/US2011/026412, Written Opinion dated May 9, 2011", 6 pgs.
"International Application Serial No. PCT/US2011/057300, International Search Report dated Mar. 5, 2012", 7 pgs.
"International Application Serial No. PCT/US2011/057300, Written Opinion dated Mar. 5, 2012", 9 pgs.
"International Application Serial No. PCT/US2012/026356, International Preliminary Report on Patentability dated Sep. 6, 2013", 8 pgs.
"International Application Serial No. PCT/US2012/026356, International Search Report dated May 8, 2012", 5 pgs.
"International Application Serial No. PCT/US2012/026356, Written Opinion dated May 8, 2012", 6 pgs.
"International Application Serial No. PCT/US2012/038351, International Preliminary Report on Patentability dated Nov. 28, 2013", 9 pgs.
"International Application Serial No. PCT/US2012/038351, Written Opinion dated Jul. 6, 2012", 8 pgs.
"International Application Serial No. PCT/US2012/041893, International Search Report dated Oct. 23, 2012", 5 pgs.
"International Application Serial No. PCT/US2012/042081, International Preliminary Report on Patentability dated Jan. 3, 2014", 7 pgs.
"International Application Serial No. PCT/US2012/042081, Written Opinion dated Sep. 5, 2012", 6 pgs.

(56) **References Cited**

OTHER PUBLICATIONS

"International Application Serial No. PCT/US2012/052853, International Preliminary Report on Patentability dated Mar. 13, 2014", 14 pgs.
"International Application Serial No. PCT/US2012/052853, International Search Report dated Nov. 15, 2012", 6 pgs.
"International Application Serial No. PCT/US2012/052853, Written Opinion dated Nov. 15, 2012", 12 pgs.
"International Application Serial No. PCT/US2012/059189, International Preliminary Report on Patentability dated Apr. 24, 2014", 10 pgs.
"International Application Serial No. PCT/US2012/059189, International Search Report dated Dec. 18, 2012", 6 pgs.
"International Application Serial No. PCT/US2012/059189, Written Opinion dated Dec. 18, 2012", 9 pgs.
"International Application Serial No. PCT/US2012/060842, International Preliminary Report on Patentability dated May 8, 2014", 7 pgs.
"International Application Serial No. PCT/US2012/060842, International Search Report dated Feb. 6, 2013", 4 pgs.
"International Application Serial No. PCT/US2012/060842, Written Opinion dated Feb. 6, 2013", 5 pgs.
"International Application Serial No. PCT/US2012/060848, International Preliminary Report on Patentability dated May 8, 2014", 11 pgs.
"International Application Serial No. PCT/US2012/060848, Invitation to Pay Additional Fees dated Feb. 6, 2013".
"International Application Serial No. PCT/US2012/060848, Written Opinion dated Apr. 12, 2013", 9 pgs.
"International Application Serial No. PCT/US2012/060853, International Preliminary Report on Patentability dated May 8, 2014", 11 pgs.
"International Application Serial No. PCT/US2012/060853, Invitation to Pay Additional Fees dated Feb. 7, 2013", 4 pgs.
"International Application Serial No. PCT/US2012/060853, Written Opinion dated Apr. 9, 2013", 9 pgs.
"International Application Serial No. PCT/US2012/060854, International Preliminary Report on Patentability dated May 8, 2014", 8 pgs.
"International Application Serial No. PCT/US2012/060854, International Search Report dated Feb. 6, 2013", 4 pgs.
"International Application Serial No. PCT/US2012/060854, Written Opinion dated Feb. 6, 2013", 6 pgs.
"International Application Serial No. PCT/US2013/026875, International Preliminary Report on Patentability dated Sep. 4, 2014", 9 pgs.
"International Application Serial No. PCT/US2013/026875, International Search Report dated Jun. 7, 2013", 5 pgs.
"International Application Serial No. PCT/US2013/026875, Written Opinion dated Jun. 7, 2013", 8 pgs.
"International Application Serial No. PCT/US2013/057097, International Preliminary Report on Patentability dated Mar. 12, 2015", 10 pgs.
"International Application Serial No. PCT/US2013/057097, International Search Report dated Oct. 14, 2013", 6 pgs.
"International Application Serial No. PCT/US2013/057097, Written Opinion dated Oct. 14, 2013", 9 pgs.
"International Application Serial No. PCT/US2013/067505, International Search Report dated Apr. 14, 2014", 5 pgs.
"International Application Serial No. PCT/US2013/067505, Invitation to Pay Additional Fees dated Feb. 6, 2014", 6 pgs.
"International Application Serial No. PCT/US2013/067505, Written Opinion dated Apr. 14, 2014", 11 pgs.
"International Application Serial No. PCT/US2013/074288, International Search Report dated May 23, 2014", 7 pgs.
"International Application Serial No. PCT/US2013/074288, Written Opinion dated May 23, 2014", 11 pgs.
"International Application Serial No. PCT/US2014/022000, International Search Report dated Jun. 24, 2014", 3 pgs.
"International Application Serial No. PCT/US2014/022000, Written Opinion dated Jun. 24, 2014", 5 pgs.
"International Application Serial No. PCT/US2014/023655, International Search Report dated Jul. 10, 2014", 4 pgs.
"International Application Serial No. PCT/US2014/023655, Written Opinion dated Jul. 10, 2014", 6 pgs.
"International Application Serial No. PCT/US2015/052591, International Preliminary Report on Patentability dated Apr. 13, 2017", 9 pgs.
"International Application Serial No. PCT/US2015/052591, International Search Report dated Mar. 3, 2016", 8 pgs.
"International Application Serial No. PCT/US2015/052591, Written Opinion dated Mar. 3, 2016", 7 pgs.
"Is Subchondroplasty® Right for Me?", [Online] retrieved from the internet: <http://www.subchondroplasty}'..com/about subchondroplasty}'./is subchondroplasty right for >, (Jul. 1, 2013), 1 pg.
"Japanese Application Serial No. 2014511538, Office Action dated Apr. 7, 2015", (W/ English Translation), 8 pgs.
"Knee tensor combined with laser femoral head locator", Research Disclosure, No. 507, (Jul. 2006), 903.
"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® Porous Titanium Construct", Biomet brochure, (2011), 12 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.
"Signature™ Personalized Patient Care, Surgical Technique Addendum Vanguard® Complete Knee System", Biomet® Orthopedics Brochure, (2011), 1-32.
"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.
"TruMatch™ Personalized knee replacement solutions", SIGMA® DePuy Orthopaedics, Inc, tri-fold brochure, (2009), 2 pgs.
"Vanguard Complete Knee System", Biomet Othopedics, Vanguard, System Summary, (2011), 8 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.

(56) **References Cited**

OTHER PUBLICATIONS

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.
Genant, H K, et al., "Advanced CT bone imaging in osteoporosis", Rheumatology, 47, (2008), 8 pgs.
Guldberg, et al., "3D Imaging of Tissue Integration with Porous Biomaterials", Biomaterials, 29, (Oct. 2008), 3757-3761.
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.
Hajan, Eric, "Computer-Assisted Orthopaedic Sugery, 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.
Patsch, J M, et al., "Noninvasive imaging of bone microarchitecture", Annals ofthe NY Academy of Sciences, (2011), 77-87.
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.
Tripp, et al., "A Nondestructive Prescreening Method for Bone Collagen Content Using Micro-Computed Tomography", Radiocarbon, vol. 52, (2010), 612-619.

* cited by examiner

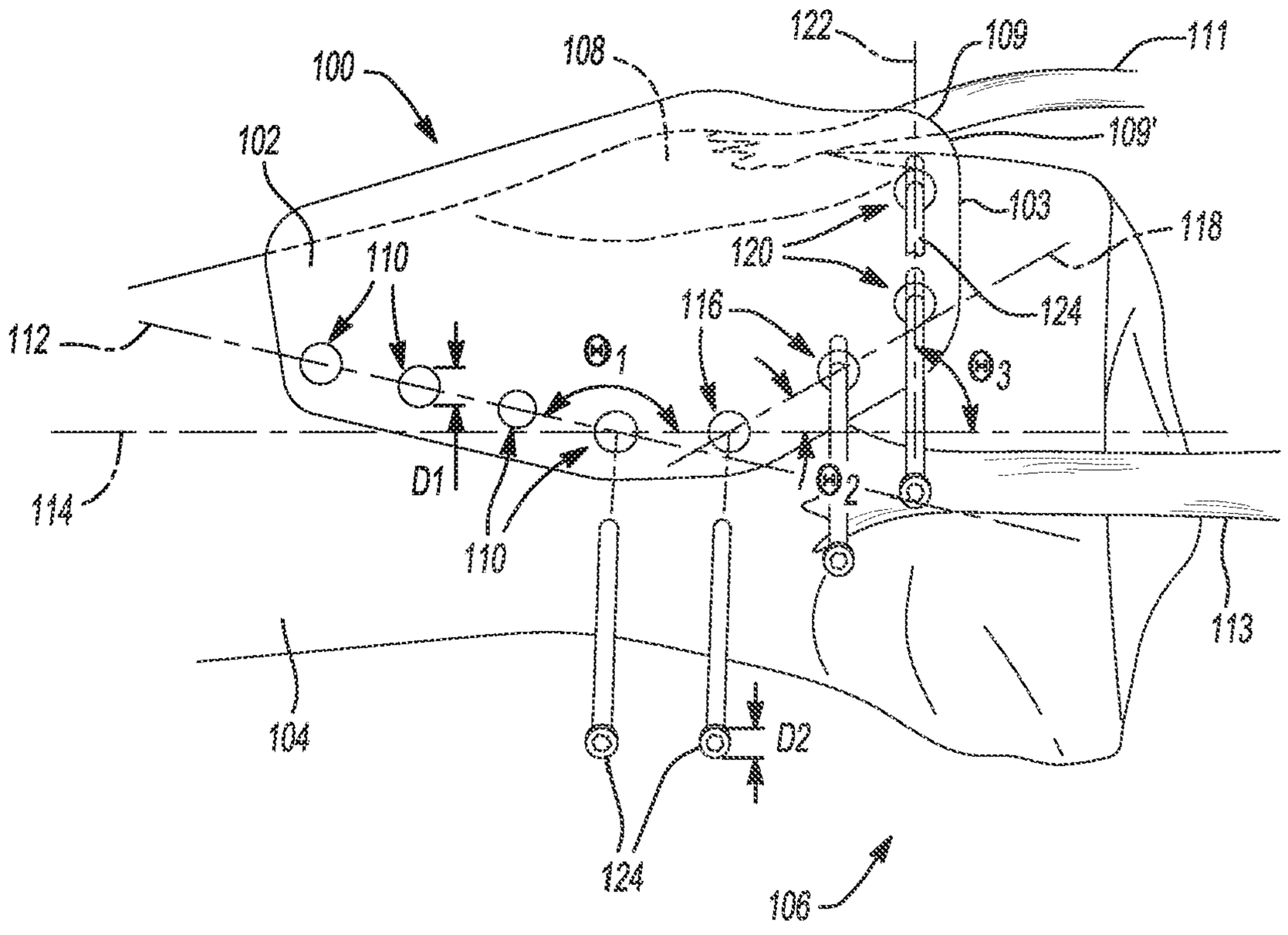

100
102
104
106
108
109
109'
110
111
112
113
114
116
118
120
122
124
103
D1
D2
Θ1
Θ2
Θ3

Fig-1

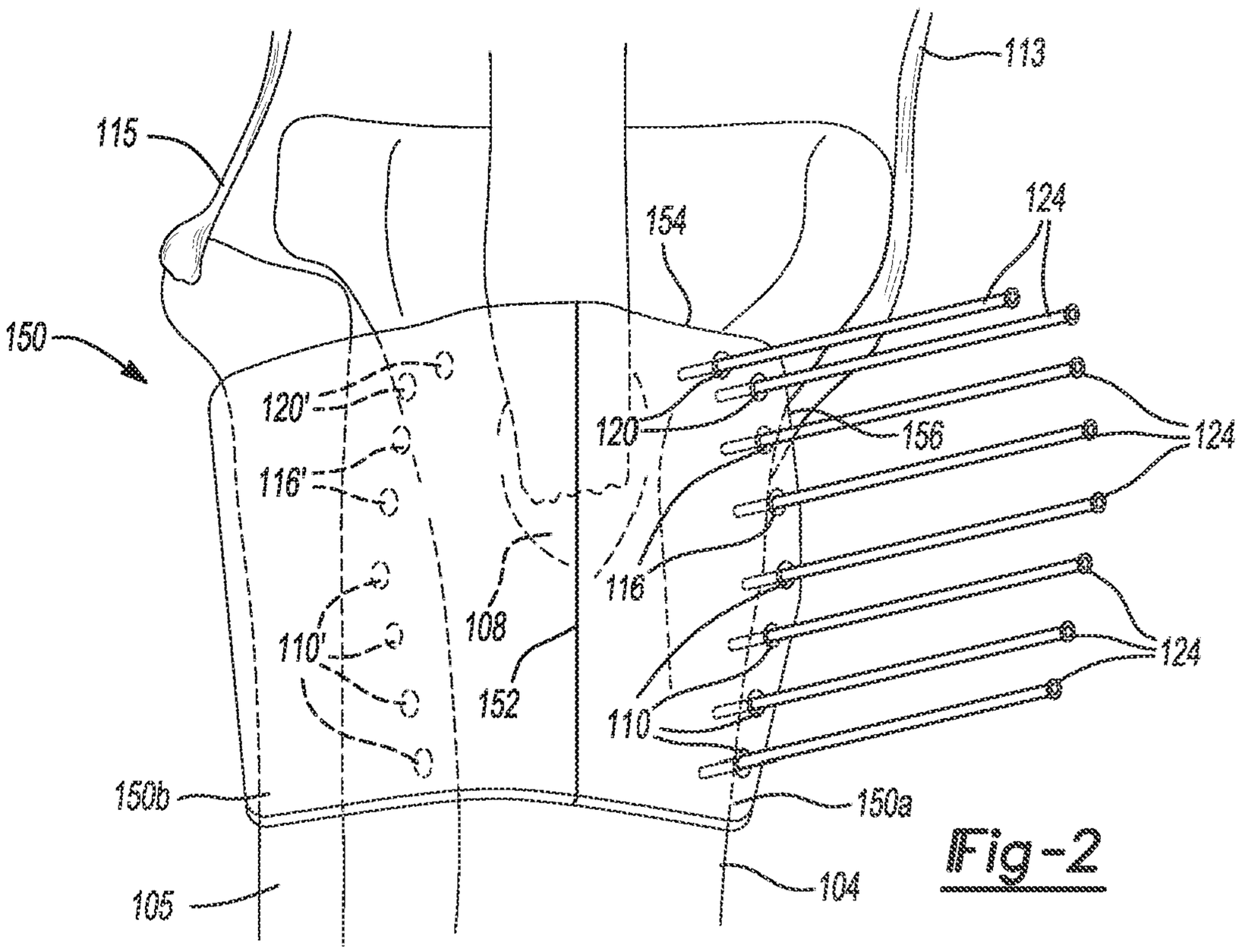

113
115
154
124
150
120'
120
156
124
116'
116
108
110'
110
152
124
150b
150a
105
104

Fig-2

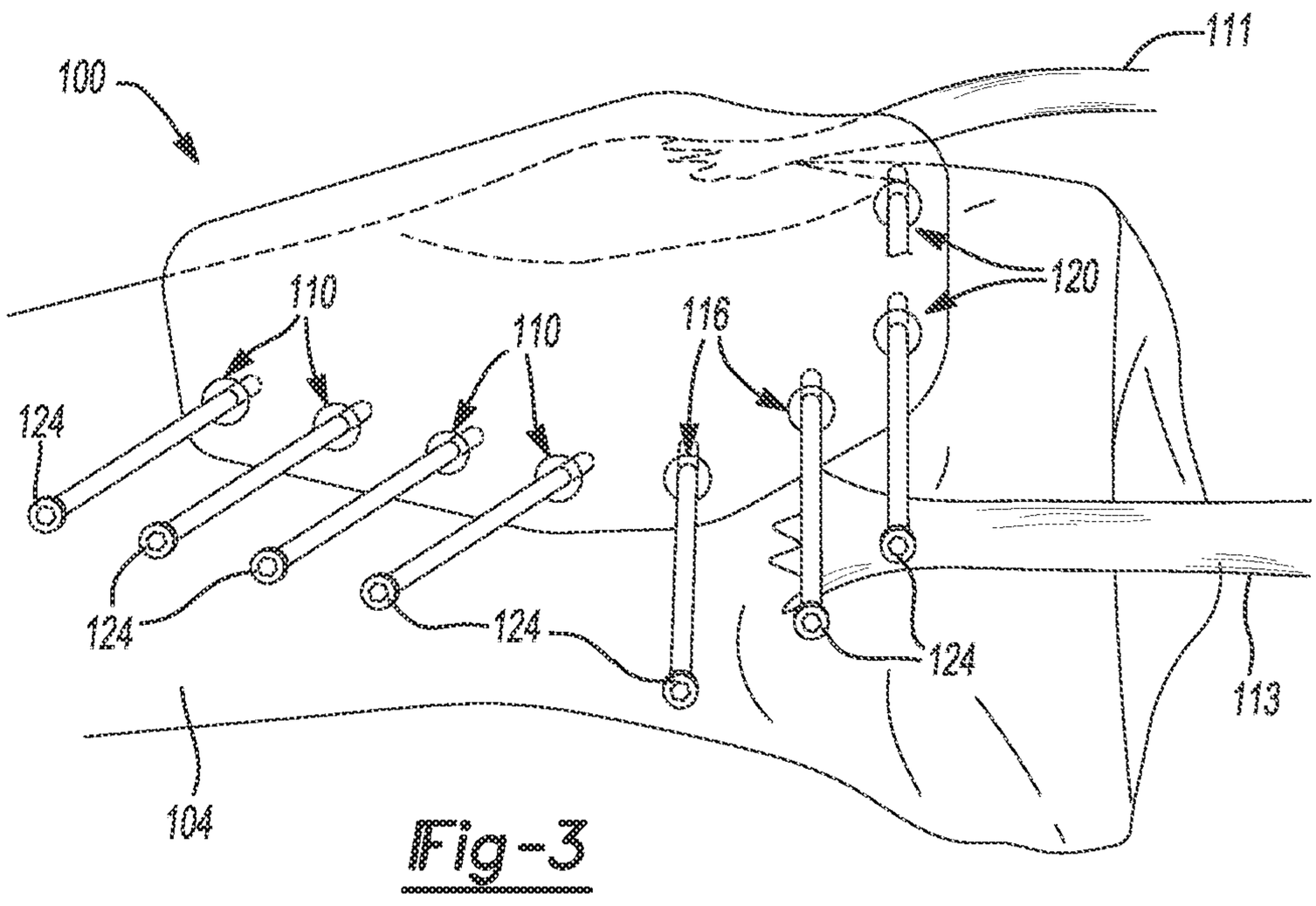

111
100
110
110
116
120
124
124
124
124
124
113
104

Fig-3

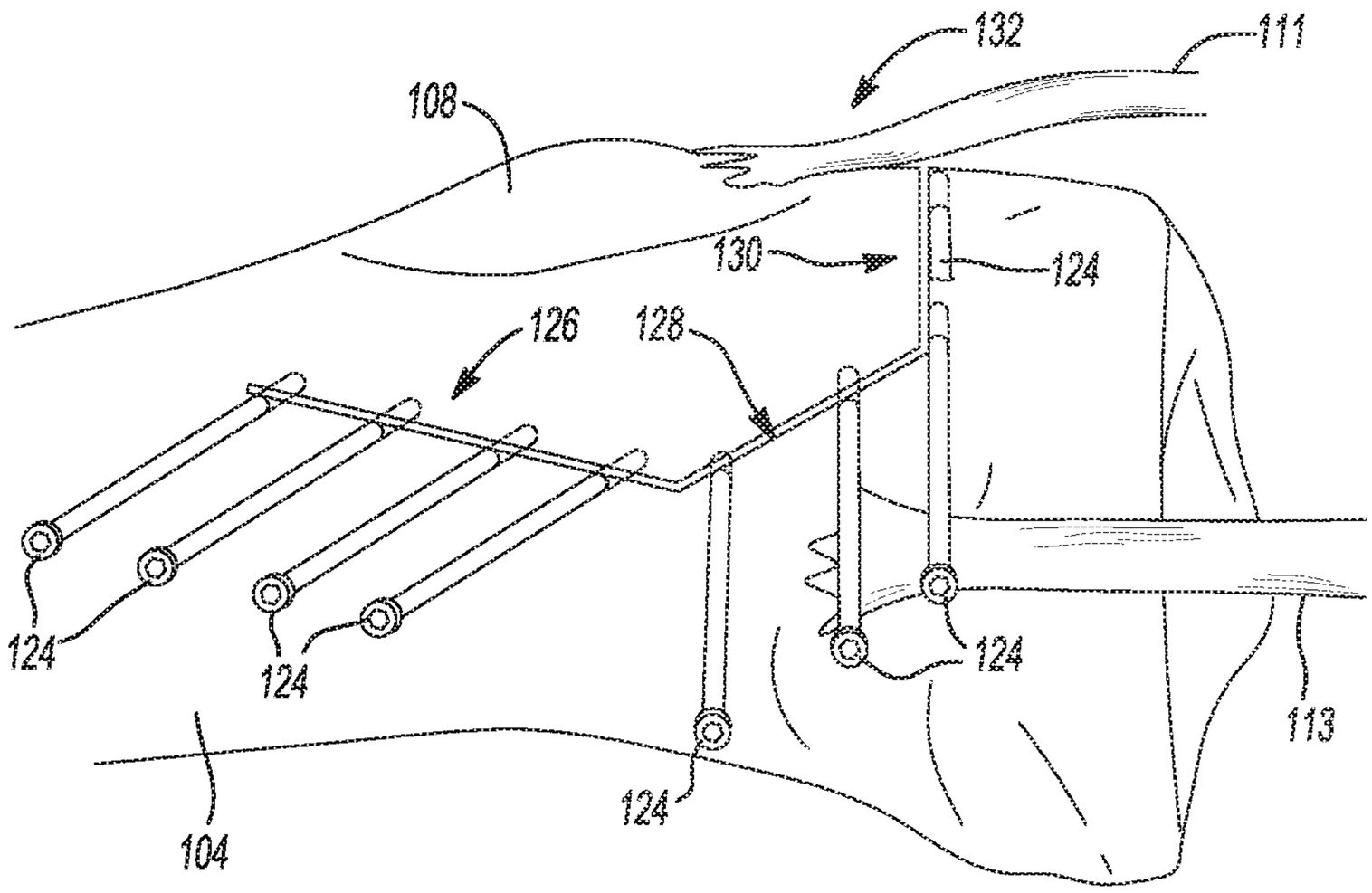

132
111
108
130
124
126
128
124
124
124
124
104
113

Fig-4

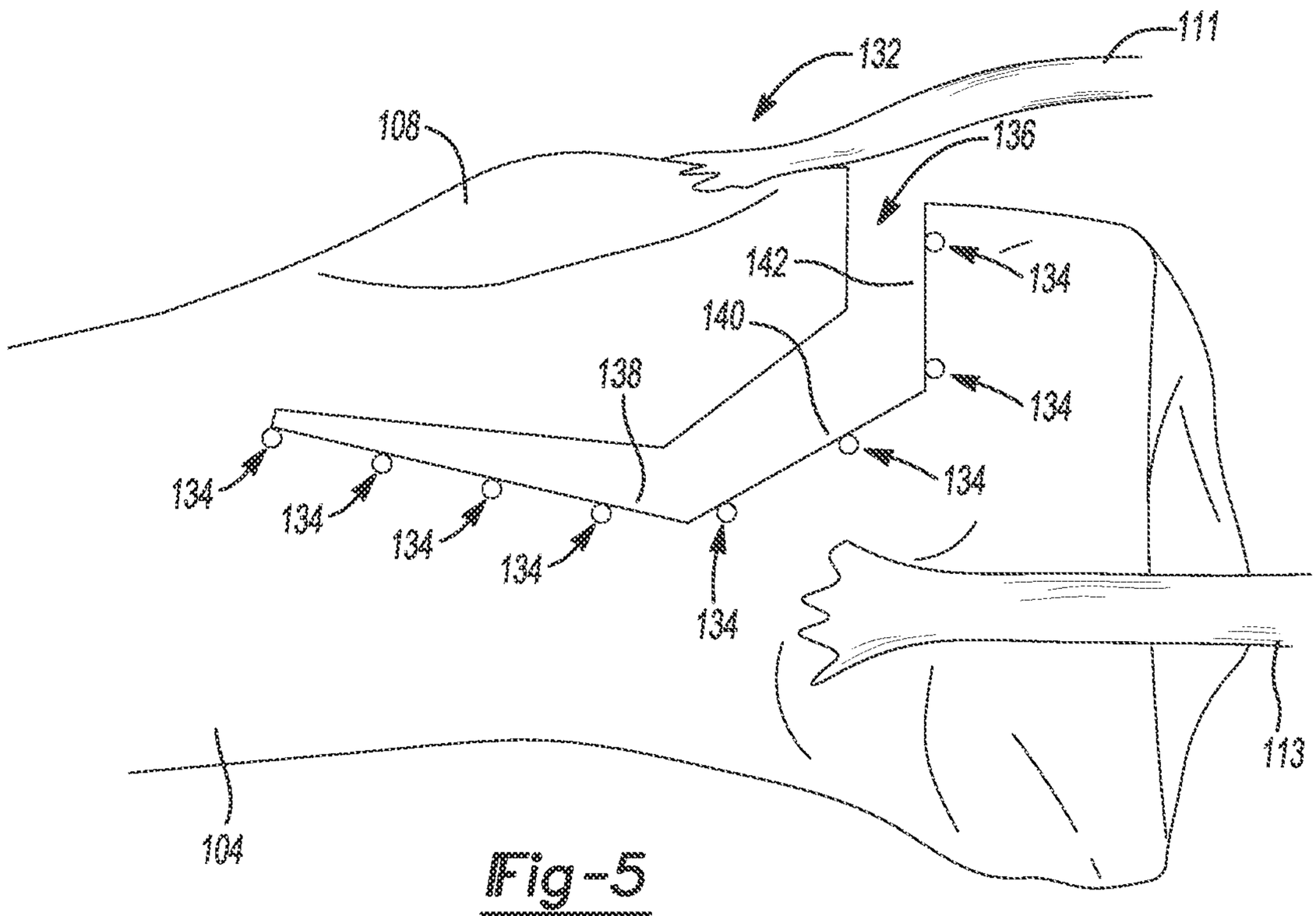

111
132
108
136
142
134
140
138
134
134
134
134
134
134
134
104
113

Fig-5

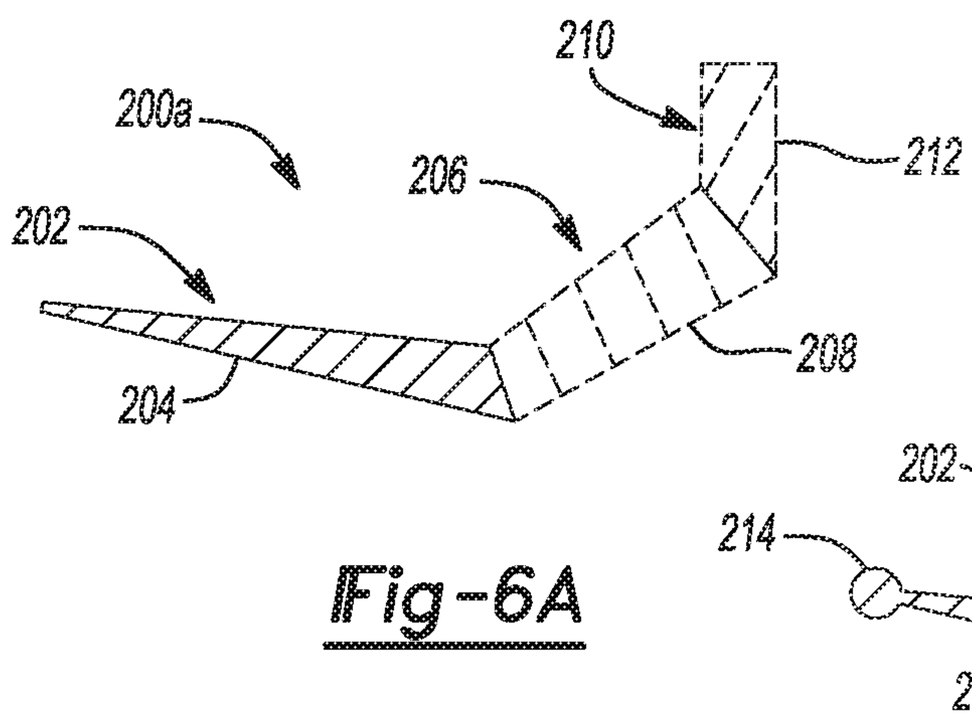


Fig-6A

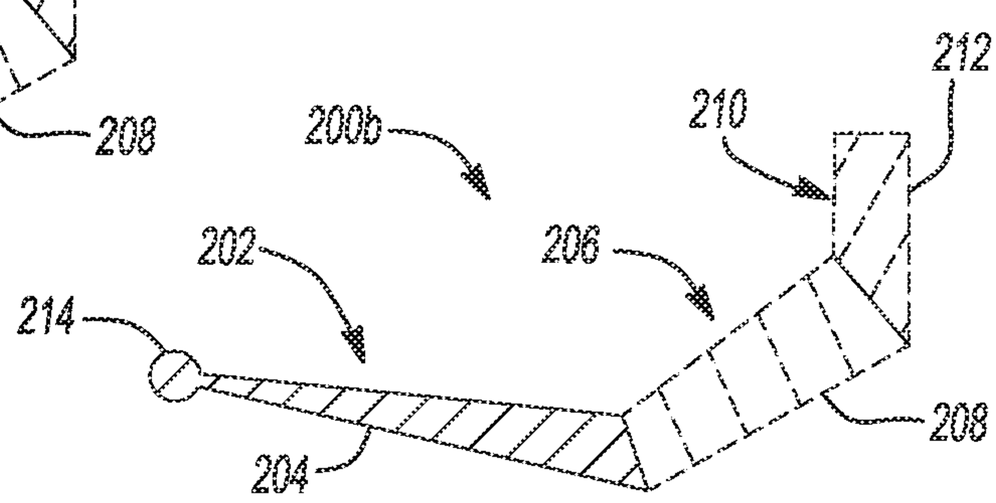


Fig-6B

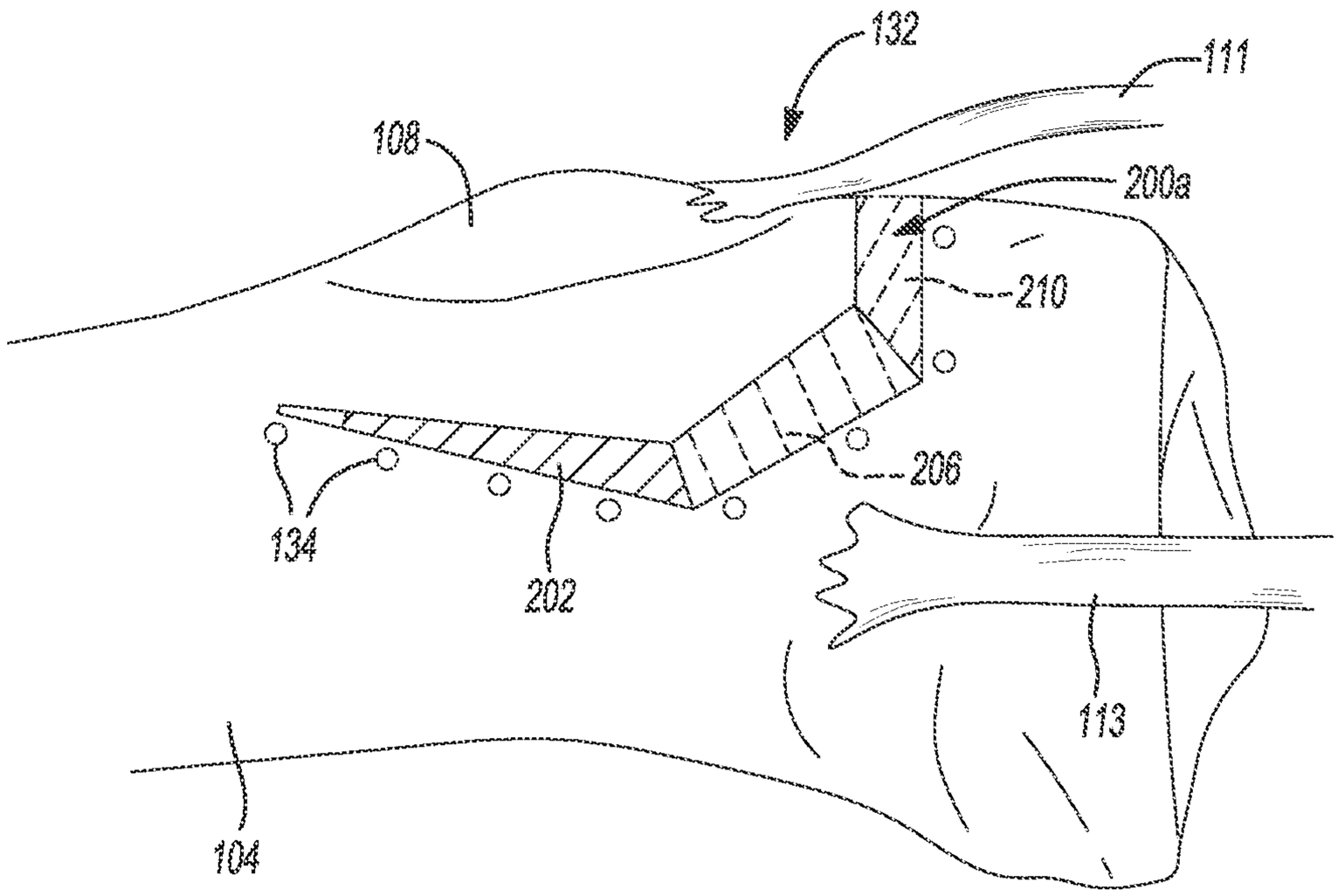


Fig-7

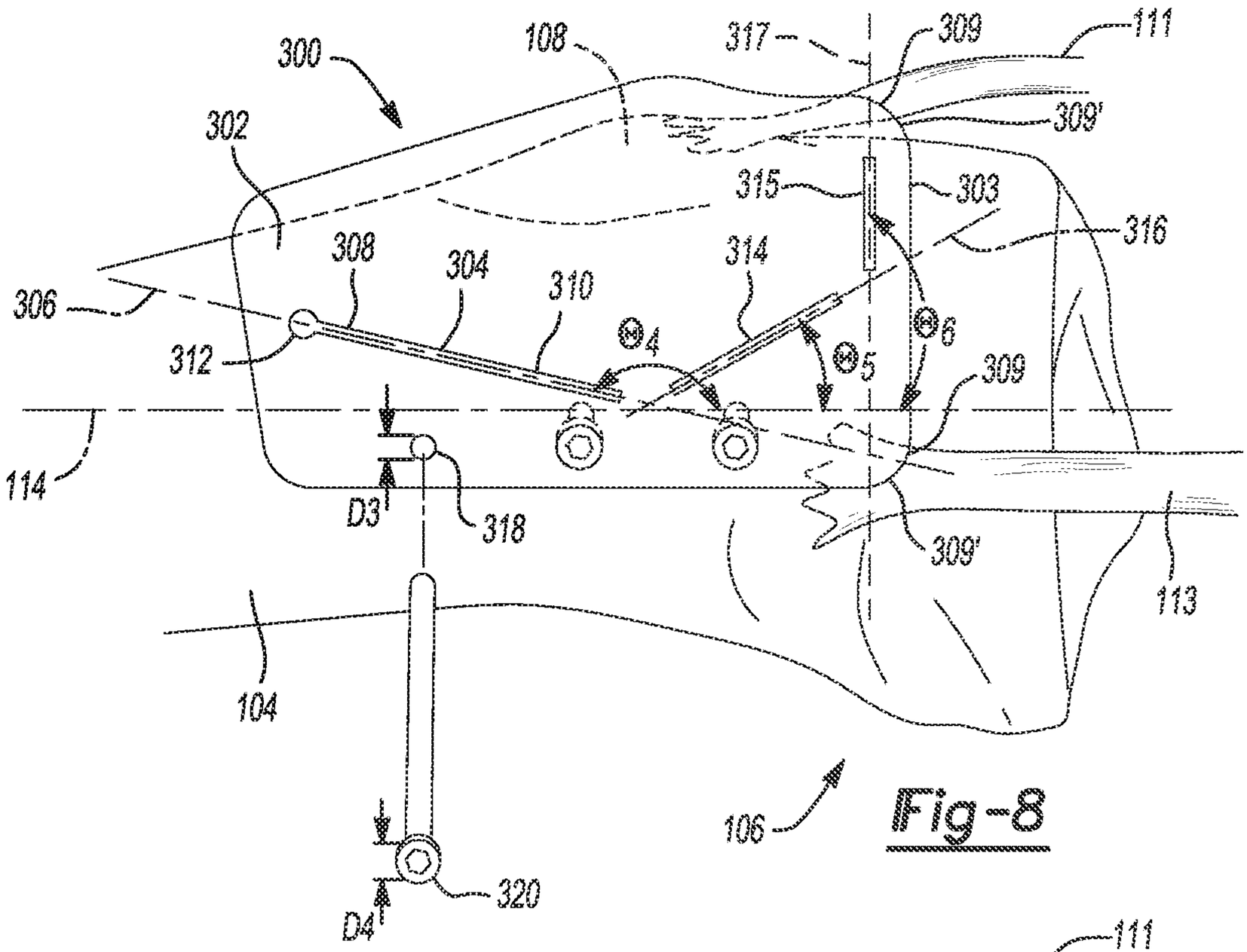

300
108
317
309
111
309'
302
315
303
316
308
304
310
314
306
312
4
5
6
309
114
D3
318
309'
113
104
106
320
D4

Fig-8

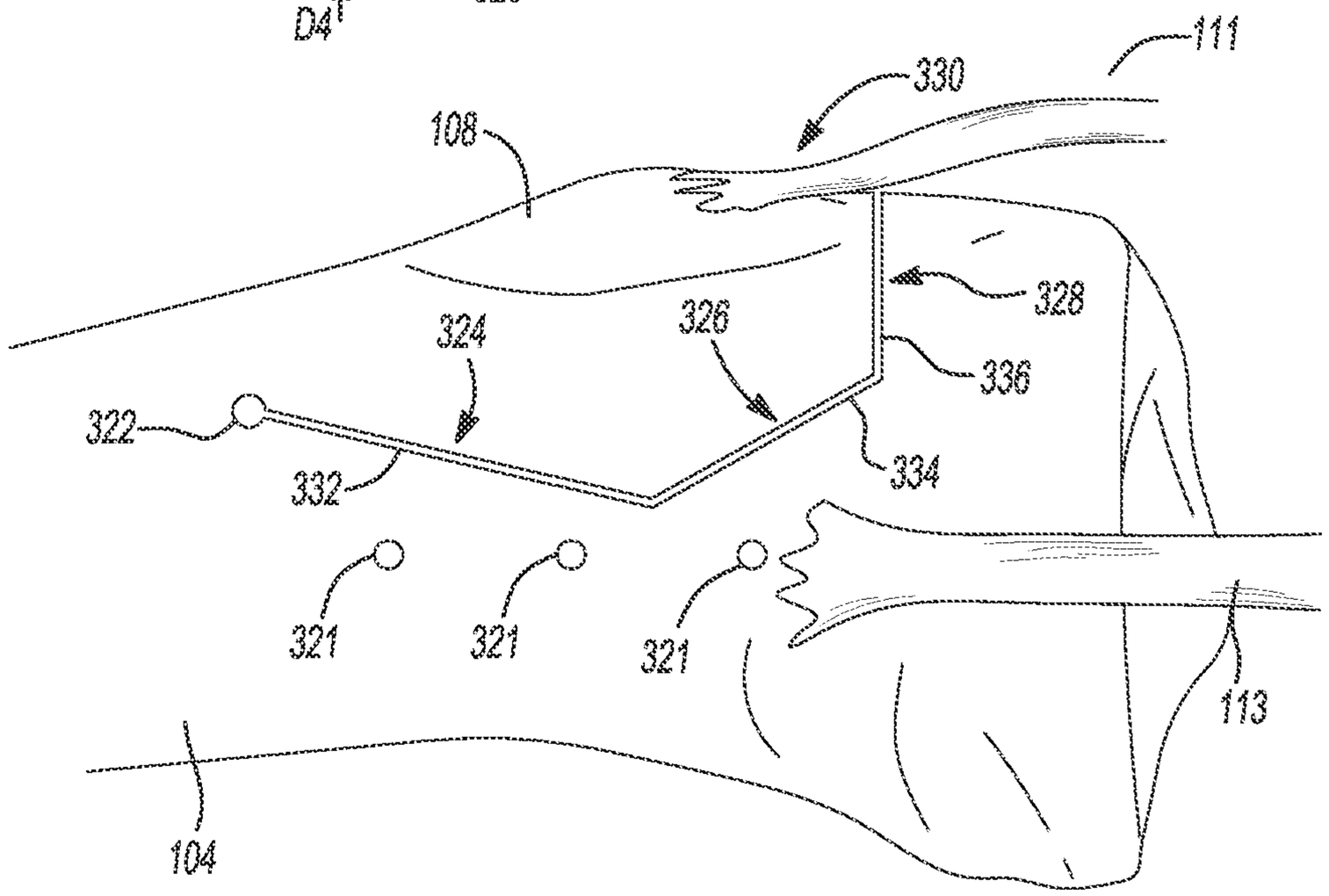

111
330
108
328
324
326
336
322
332
334
321
321
321
113
104

Fig-9

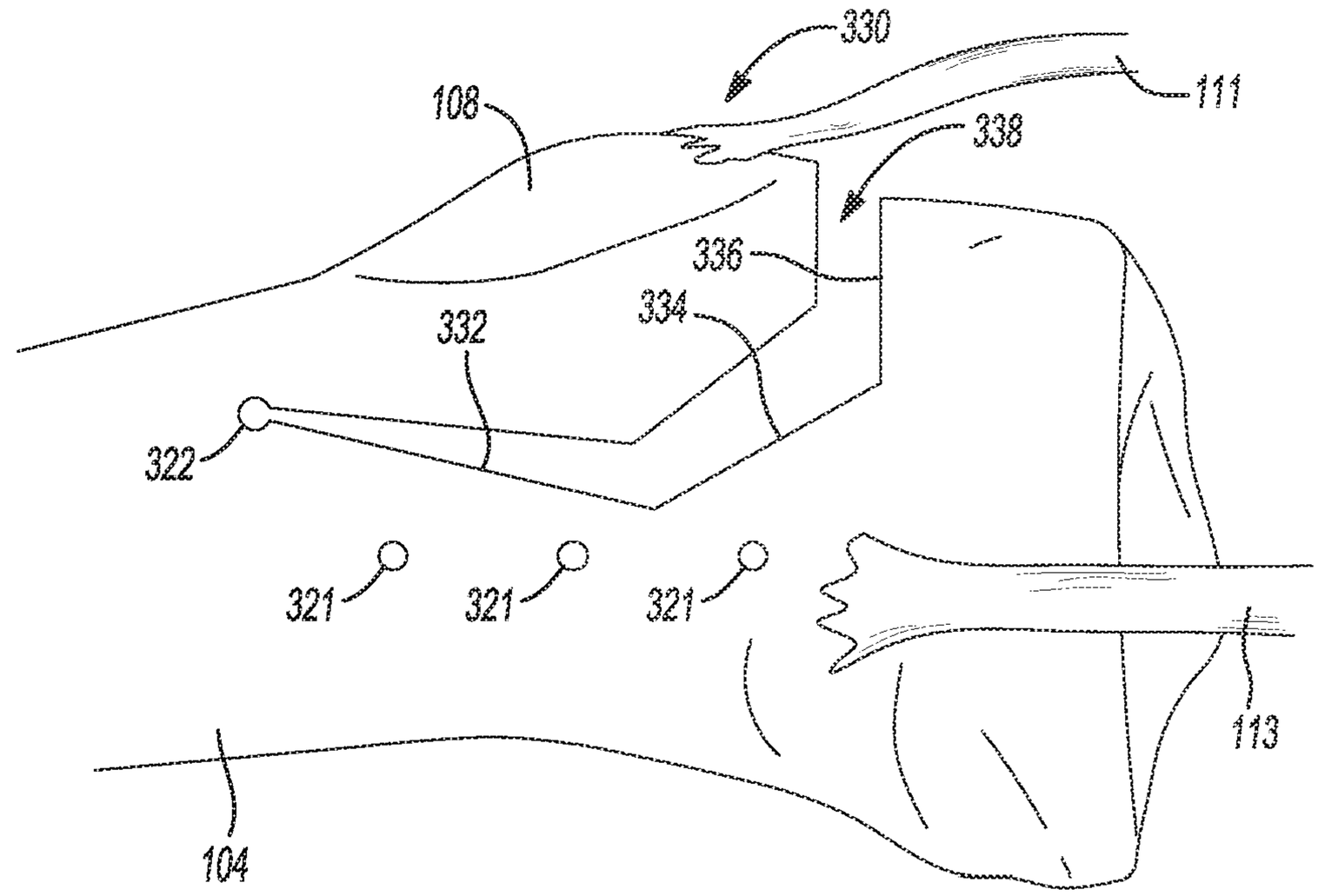

330
108
111
338
336
334
332
322
321
321
321
113
104

Fig-10

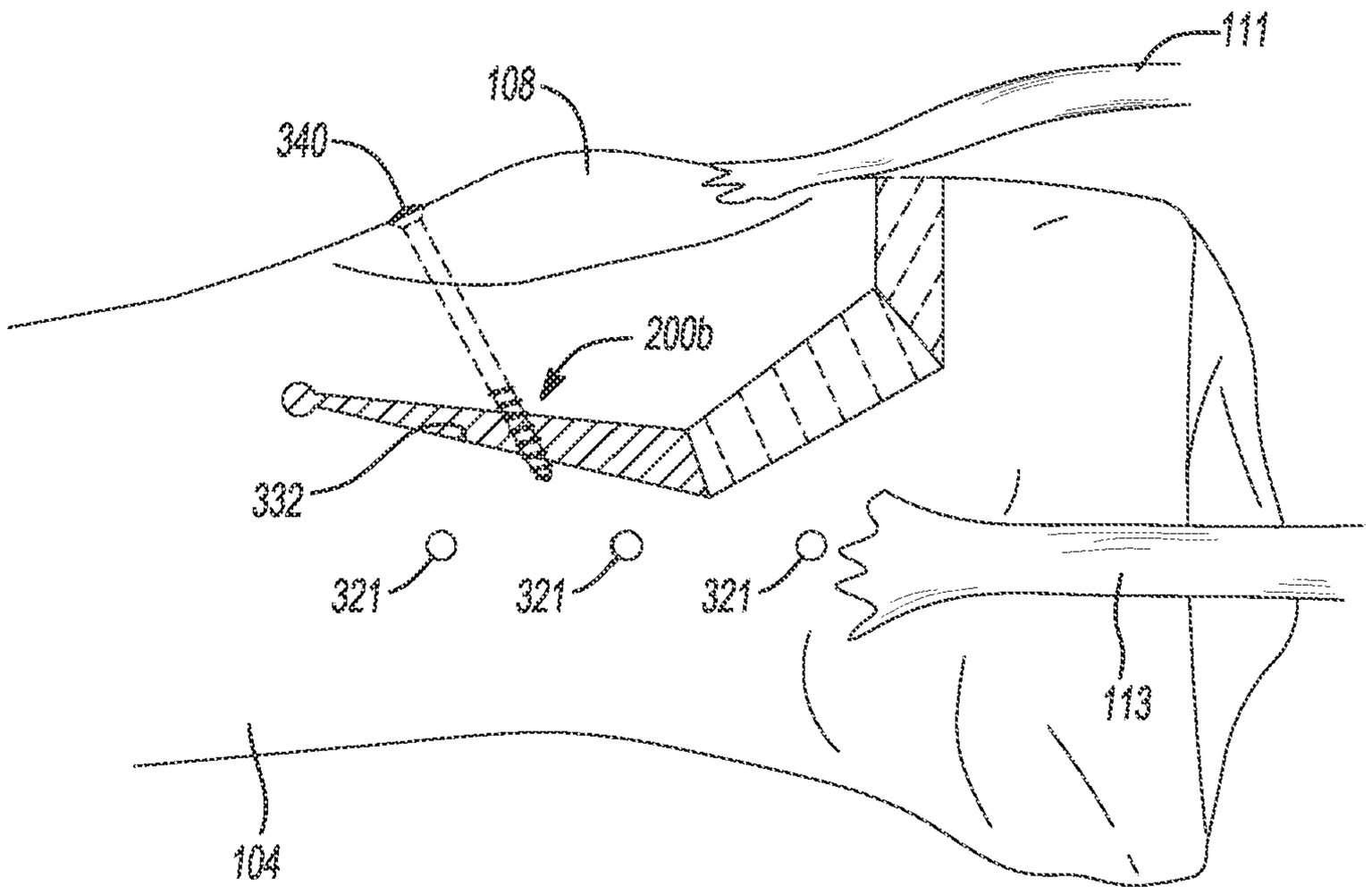

111
108
340
200b
332
321
321
321
113
104

Fig-11

TIBIAL TUBERCULE OSTEOTOMY

RELATED APPLICATIONS

This application is a divisional of U.S. application Ser. No. 15/800,399, filed Nov. 1, 2017, which is a divisional of U.S. application Ser. No. 14/500,019, filed Sep. 29, 2014, now issued as U.S. Pat. No. 9,833,245, the benefit of priority of each of which is claimed hereby, and each of which are incorporated by reference herein in its entirety.

BACKGROUND

This section provides background information related to the present disclosure which is not necessarily prior art.

A tibial tubercle osteotomy is a surgical procedure which is performed to treat patellofemoral conditions, such as patellar instability, patellofemoral pain and chondrosis, and osteoarthritis. Such an osteotomy is typically performed when nonoperative measures, such as physical therapy, have failed. During a tibial tubercle osteotomy an incision is made in the anterior of a patient's leg just inferior to the patella, and a proximal and anterior portion of a tibia is partially resected to generate a tubercle flap. The tubercle flap is then repositioned in anterior and medial-lateral directions and held in place with screws. Typically, a tibial tubercle osteotomy results in anteromedialization (AMZ) of the tubercle. This repositioning alters the position of the patella in a patient to remove a pain-causing load, resulting in alleviation of a patellofemoral condition characterized by malalignment of the patella relative to asymptomatic individuals.

Many tibial tubercle osteotomies are performed with the aid of commercially available osteotomy systems. However, these systems generally comprise multiple units that are complicated to use. Moreover, the commercially available systems are mass produced, and are not tailored to a specific patient's anatomy. Therefore, there remains a need to develop new guide systems that are easier to use than currently available systems, and that are custom manufactured to match the anatomy of a specific patient.

SUMMARY

This section provides a general summary of the disclosure, and is not a comprehensive disclosure of its full scope or all of its features.

The present teachings provide a patient-specific guide for a tibial osteotomy. The guide includes a guide body defining a portion with a bone-engaging surface that conforms as a negative surface to a corresponding surface of a specific patient's tibia, and a guide portion that guides a surgical instrument to a specific location on the specific patient's tibia, wherein the bone-engaging surface and guide portion are configured during a pre-operative planning stage.

The present teachings also provide a patient-specific guide for a tibial osteotomy that includes a guide body defining a portion with a bone-engaging surface configured during a pre-operative planning stage of a tibial osteotomy to conform as a negative surface to a corresponding surface of a specific patient's tibia; and a plurality of apertures positioned in a straight line that defines a predetermined angle relative to a proximal-distal axis of the specific patient's tibia that is selected during the pre-operative planning stage of the tibial osteotomy. The plurality of apertures are configured to guide the insertion of a plurality of pins into the tibial. The plurality of apertures have a diameter that

is larger than the diameter of the pins, which allows for the guide to be removed while leaving the pins in the tibia. The pins are used as a saw guide for resecting the specific-patient's tibia.

The present teachings further provide for a patient-specific guide for a tibial osteotomy that includes a guide body that defines: (a) a portion with a bone-engaging surface, wherein the bone-engaging surface is configured during a pre-operative planning stage of a tibial osteotomy to conform as a negative surface to a corresponding surface of a specific patient's tibia; (b) a first planar slot oriented at a first predetermined angle and at a first predetermined position relative to a proximal-distal axis of the specific patient's tibia that is selected during the pre-operative planning stage of the tibial osteotomy; (c) a second planar slot oriented at a second predetermined angle and at a second predetermined position relative to the proximal-distal axis of the specific patient's tibia that is selected during the pre-operative planning stage of the tibial osteotomy; and (d) a plurality of apertures. The plurality of apertures are configured to accept pins for removeably anchoring the guide to the specific patient's tibia.

Additionally, the present teachings provide a method for performing a tibial tubercle osteotomy on a patient's tibia. The method includes positioning a patient-specific guide on the patient's tibia, wherein the guide comprises a guide body defining a portion with a bone-engaging surface configured during a pre-operative planning stage of a tibial osteotomy to conform as a negative surface to a corresponding surface of the patient's tibia, and a plurality of apertures; inserting a plurality of pins through the apertures and into the patient's tibia; removing the guide; and resecting the tibia by using the pins inserted into the tibia as a saw guide and sawing the tibia adjacent to the pins from pin to pin to generate a tubercle flap adjacent to a resected surface of the tibia. The method also includes repositioning the tubercle flap in an anterior direction or in both anterior and medial-lateral directions to form a gap between the tubercle flap and the resected surface of the tibia; and implanting a wedge in the gap, wherein the wedge has a predetermined shape configured during the pre-operative planning stage and wherein the wedge is composed of a material that promotes bone ingrowth.

Further, the present teachings provide a method for performing a tibial tubercle osteotomy on a patient's tibia. The method includes positioning a patient-specific guide on the patient's tibia, wherein the guide includes: (i) a portion with a bone-engaging surface, wherein the bone-engaging surface is configured during a pre-operative planning stage of a tibial osteotomy to conform as a negative surface to a corresponding surface of a specific patient's tibia; (ii) a first planar slot oriented at a first predetermined angle and at a first predetermined position relative to a proximal-distal axis of the specific patient's tibia that is selected during the pre-operative planning stage of the tibial osteotomy, wherein the first planar slot defined by the guide body has a distal end and a proximal end, and wherein the guide body further defines a circular slot in communication with the first distal end; (iii) a second planar slot oriented at a second predetermined angle and at a second predetermined position relative to the proximal-distal axis of the specific patient's tibia that is selected during the pre-operative planning stage of the tibial osteotomy; and (iv) a plurality of apertures. The method also includes anchoring the guide to the patient's tibia by inserting pins through the apertures; inserting a drill bit through the circular slot and drilling a hole through the tibia; inserting a saw blade through the first slot and resect-

ing a first cut from the hole to the proximal end; inserting the saw blade through the second slot and resecting a second cut; removing the pins and the guide; and further resecting the tibia to connect the first cut and the second cut, and to connect the second cut to a surface of the tibia to form a tubercle flap adjacent to a resected surface of the tibia.

The present teachings additionally provide a surgical kit that includes a patient-specific guide having a guide body defining a portion with a bone-engaging surface that conforms as a negative surface to a corresponding surface of a specific patient's tibia, and a guide portion that guides a surgical instrument to a specific location on the specific patient's tibia, wherein the bone-engaging surface and guide portion are configured during a pre-operative planning stage; a patient-specific implantable wedge with a predetermined shape, wherein the wedge is configured during the pre-operative planning stage; and a plurality of pins.

Further areas of applicability will become apparent from the description provided herein. The description and specific examples in this summary are intended for purposes of illustration only and are not intended to limit the scope of the present disclosure.

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 a schematic illustration of a first patient-specific guide positioned relative to a tibia;

FIG. **2** is a schematic illustration of a second embodiment of the first patient-specific guide positioned relative to a tibia;

FIG. **3** is a schematic illustration of the first patient-specific guide positioned relative to the tibia, with pins inserted into the tibia;

FIG. **4** is a schematic illustration of planes cut through a tibia along the pins positioned with the use of the first patient-specific guide to generate a tubercle flap;

FIG. **5** is a schematic illustration of a repositioned tubercle flap generated with the use of the first patient-specific guide;

FIG. **6**A is a schematic illustration of a first patient-specific implant;

FIG. **6**B is a schematic illustration of a second patient-specific implant;

FIG. **7** is a schematic illustration of the patient-specific implant inserted into a gap generated in a tibia with the use of the first patient-specific guide;

FIG. **8** is a schematic illustration of a second patient-specific guide positioned relative to a tibia;

FIG. **9** is a schematic illustration of planes cut through a tibia with the use of the second patient-specific guide to generate a tubercle flap;

FIG. **10** is a schematic illustration of a repositioned tubercle flap generated with the use of the second patient-specific guide; and

FIG. **11** is a schematic illustration of the patient-specific implant inserted into a gap generated in a tibia with the use of the second patient-specific guide.

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

DETAILED DESCRIPTION

Example embodiments will now be described more fully with reference to the accompanying drawings.

The present teachings generally provide patient-specific tibial tubercle osteotomy guides that include a guide body defining a portion with a bone-engaging surface that conforms as a negative surface to a corresponding surface of a specific patient's tibia about the patient's tibial tubercle, and a guide portion that guides a surgical instrument to a specific location on the specific patient's tibia, wherein the bone-engaging surface and guide portion are configured during a pre-operative planning stage, in which a medical professional determines the location of a tibial tubercle osteotomy and amount of correction needed. In various embodiments, the guide body further defines a soft tissue engaging surface, wherein the soft tissue-engaging surface is configured during the pre-operative planning stage of a tibial osteotomy to conform as a negative surface to a corresponding surface of a specific patient's soft tissue. The soft tissue can be the patient's medial collateral ligament, lateral cruciate ligament, or patellar tendon. In other embodiments, the guide body defines a surface that allows for clearance of soft tissue.

In one embodiment, the guide portion comprises a plurality of apertures defined by the guide body. The plurality of apertures are configured to guide pins to the specific-patient's tibia, wherein the pins are used as a saw guide for resecting the specific-patient's tibia. The plurality of apertures are positioned in three straight lines that define three predetermined angles relative to a proximal-distal axis of the patient's tibia that are selected during the pre-operative planning stage of the tibial osteotomy.

In another embodiment, the guide portion comprises a first planar slot defined by the guide body oriented at a first predetermined angle and at a first predetermined position relative to a proximal-distal axis of the specific patient's tibia that is selected during the pre-operative planning stage of the tibial osteotomy; and a second planar slot defined by the guide body oriented at a second predetermined angle and at a second predetermined position relative to the proximal-distal axis of the specific patient's tibia that is selected during the pre-operative planning stage of the tibial osteotomy. The first planar slot defined by the guide body has a distal end and a proximal end, wherein the guide body further defines a circular slot in communication with the first distal end.

The patient-specific alignment guides can be used either with conventional or patient-specific implant components prepared with computer-assisted image methods. Computer modeling for obtaining three dimensional images of the patient's anatomy using x-ray, MRI or CT scans of the patient's anatomy, the patient specific prosthesis components, and the patient-specific guides can be provided by various CAD programs and/or software available, for example, by Materialise USA, Plymouth, Mich. The guide will allow a surgeon to precisely cut an osteotomy, which ensures that an implant will match the native bone anatomy and provide the proper amount of adjustment.

The patient-specific alignment guides and associated patient-specific implants disclosed herein can be generally formed using computer modeling based on the patient's 3-D anatomic image generated from image scans. The patient-specific alignment guides can have a three-dimensional patient-specific engagement surface that is made to conformingly contact, mate with, and match a three-dimensional image of the patient's bone surface (selectively with or without soft tissue), by the computer methods discussed above. The patient-specific alignment guides can include custom-made guiding formations, such as, for example, guiding bores or guiding apertures, cannulated guiding

extensions or receptacles that can be used for supporting or guiding other instruments, such as drill guides, reamers, cutters, and cutting guides or for inserting pins or other fasteners according to a surgeon-approved pre-operative plan.

In various embodiments, the patient-specific alignment guide can include one or more patient-specific cutting guides for receiving and guiding a cutting blade at corresponding patient-specific cutting plane orientations relative to a selected anatomic axis for the specific patient. The patient-specific alignment guides can also include guiding formations for guiding the implantation of patient-specific or off-the-shelf implants associated with the osteotomy procedure, such as implantable wedges and implantable fixation plates. The geometry, shape and orientation of the various features of the patient-specific alignment guide, as well as various patient-specific implants and other patient-specific tools can be determined during the pre-operative planning stage of the procedure in connection with the computer-assisted modeling of the patient's anatomy. During the pre-operative planning stage, patient-specific alignment guides, implants and other tools, can be designed and manufactured for a specific patient with input from a surgeon or other professional associated with the surgical procedure, as described in U.S. Pat. No. 8,632,547, issued on Jan. 21, 2014 to Maxson et al., U.S. Pat. No. 8,241,293, issued on Aug. 14, 2012 to Stone et al., and U.S. application Ser. No. 14/262,105 to Eash, filed on Apr. 25, 2014, all of which are incorporated herein by reference.

In the following discussion, the terms "patient-specific", "custom-made" or "customized" are defined to apply to components, including tools, implants, portions or combinations thereof, which include certain geometric features, including surfaces, curves, or other lines, and which are made to closely conform as mirror-images or negatives of corresponding geometric features of a patient's anatomy during a pre-operative planning stage based on 3-D computer images of the corresponding anatomy reconstructed from image scans of the patient by computer imaging methods. Further, patient-specific guiding features, such as, guiding apertures and guiding slots, or other holes or openings that are included in alignment guides or in implants are defined as features that are made to have positions, orientations, dimensions, shapes and/or define cutting planes specific to the particular patient's anatomy based on the computer-assisted pre-operative plan associated with the patient.

The current technology provides a patient-specific tibial osteotomy guide **100** as shown in FIG. **1**. The guide **100** comprises a guide body **102** that defines a portion with a bone-engaging surface **103** configured during a pre-operative planning stage of a tibial osteotomy to conform as a negative surface to a corresponding surface of a specific patient's tibia **104**. As shown in FIG. **1**, the guide **100** is positioned on the specific patient's tibia **104** about a tubercle **108** on a medial face of the tibia **104**. In other embodiments, the guide **100** can be configured to be positioned on a lateral face of the specific patient's tibia **104**. The bone engaging surface **103** is custom made during the preoperative planning stage to match a specific patient's anatomy and allows for placement of the guide **100** at a specific location at a proximal portion **106** of the patient's tibia **104**. Typically, the guide **100** is configured to fit on and nest with only one position on the specific patient's tibia **104** at, around, or near the tubercle **108**, which is to be repositioned during an osteotomy.

In some embodiments, the guide body **102** also defines a soft tissue-clearing portion **109** that allows for clearance of soft tissue, such as ligaments and tendons. The soft tissue-clearing portion **109** has an outer convex surface and an inner concave surface, wherein the inner concave surface provides a recess for accommodating soft tissue. As shown in FIG. **1**, the soft tissue-clearing portion **109** accommodates the patient's patellar tendon **111**. However, in various embodiments, the tissue-clearing portion **109** accommodates a medial collateral ligament (MCL) **113** or a lateral cruciate ligament (LCL, not shown). In this regard, the bone-engaging surface **103** mates with and conforms to a specific boney region of the tibia **104**, and the patellar soft tissue-clearing portion **109** allows for the guide to simultaneously be placed about the patient's soft tissue, such as the patellar tendon **111**. In other embodiments, the guide **100** comprises a plurality of tissue-clearing portions **109** for simultaneously accommodating the LCL and patellar tendon, or MCL and patellar tendon.

In additional embodiments, the guide body **102** further defines a soft tissue engaging surface **109'**, wherein the soft tissue-engaging surface **109'** is configured during the pre-operative planning stage of a tibial osteotomy to conform as a negative surface to a corresponding surface of a specific patient's soft tissue at, around, or near the tubercle **108**. The soft tissue can be, for example, the patient's MCL, LCL, or patellar tendon. In various embodiments, the guide **100** comprises a plurality of soft tissue engaging surfaces **109'** for simultaneously accommodating the LCL and patellar tendon, or MCL and patellar tendon. In other embodiments, the guide **100** has both a soft tissue-clearing portion **109** and a soft tissue engaging surface **109'**.

The guide body **102** further defines a first plurality of apertures **110** positioned along a first straight line **112** that defines a first predetermined angle θ_1 relative to a proximal-distal axis **114** of the specific patient's tibia **104**. The first straight line **112** is selected during the pre-operative planning stage of the tibial osteotomy. In many embodiments, a second plurality of apertures **116** is positioned along a second straight line **118** that defines a second predetermined angle θ_2 relative to the proximal-distal axis **114** of the specific patient's tibia **104** that is selected during the pre-operative planning stage of the tibial osteotomy, wherein the second line **118** intersects the first line **112**. In yet other embodiments, a third plurality of apertures **120** is positioned along a third straight line **122** that defines a third predetermined angle θ_3 relative to the proximal-distal axis **114** of the specific patient's tibia **104** that is selected during the pre-operative planning stage of the tibial osteotomy, wherein the third line **122** intersects the second line **118**.

The first, second, and third plurality of apertures **110**, **116**, **120** are configured to guide a plurality of pins **124** to the tibia **104** for insertion. The plurality of apertures **110**, **116**, **120** have a diameter D_1 and the pins **124** have a diameter D_2, wherein D_1 is larger than D_2. Because the apertures **110**, **116**, **120** have a larger diameter than the pins **124**, the guide **100** can be removed from the tibia **104** by simply sliding the guide **100** off from the implanted pins **124**. When the guide **100** is removed, the pins **124** provide a saw guide for resecting planes in the tibia **104** adjacent to the pins **124**, from pin **124** to pin **124**, to generate a tubercle flap **132** as shown in FIGS. **3**, **4**, and **6**. Accordingly, the saw guide is adjacent to the pins **124** and matches the lines **112**, **118**, **122**, configured during the preoperative planning stage. In other words, the pins **124** give visual indicia to a physician for making three intersecting planar cuts through the tibia **104**.

As shown in FIG. **2**, in various embodiments, the present technology provides for a bifurcated patient-specific alignment guide **150** comprising a first guide half **150***a* removeably coupled to a second guide half **150***b* at a seam **152**. The first half of the bifurcated patient-specific alignment guide **150***a* has similar features as the alignment guide **100** shown in FIGS. **1** and **3**, such as a plurality of apertures **110**, **116**, **120** for guiding a plurality of pins **124** to the tibia **104**. Optionally, the second half of the guide **150***b* can also have a plurality of apertures **110'**, **116'**, and **120'** for guiding pins **124** to the tibia **104**. The bifurcated guide **150** has at least one bone-engaging surface **154** that nests with and conforms to a boney structure. The boney structure can be a structure on the tibia **104** or on the fibula **105**. In other embodiments, the bifurcated guide **150** has at least one soft tissue engaging surface **156** that either nests with and conforms to or provides clearance for at least one soft tissue, such as a soft tissue selected from the group consisting of the patient's MCL **113**, LCL **115**, patellar tendon **111**, and combinations thereof. In yet other embodiments, the bifurcated guide **150** has both at least one bone-engaging surface **154** and at least one soft tissue-engaging surface **156**. The second guide half **150***b* allows for the guide **150** to nest with and conform to more boney structures and/or soft tissue structures than a guide that does not comprise two halves. After the pins **124** have been positioned into the tibia **104**, the bifurcated guide **150** can be separated at the seam **152**, which permits both the first half **150***a* and the second half **150***b* to slide over the pins **124** and away from the tibia **104**. With reference to FIG. **6**A, the present technology provides a patient-specific implant or wedge **200***a* that is configured during a pre-operative planning stage of a tibial tubercle osteotomy to be wedged in a gap generated from a resection guided by the patient-specific guide **100** to maintain the position of a patient's tibial tubercle **108** relative to the tibia **104**. The patient-specific implant **200** comprises a first portion **202** that has a first surface **204** that corresponds to the line **112** shown in FIG. **1**. Because the first surface **204** corresponds to the line **112**, the implant **200***a* is custom designed to fit in a gap generated from a resection guided by the patient specific guide **100**. In some embodiments, the implant **200***a* further comprises an optional second portion **206** that has a second surface **208** that corresponds to the line **118** shown in FIG. **1**. Because the first surface **204** corresponds to the line **112**, and because the second surface **208** corresponds to the line **118**, the implant **200***a* with first and second portions **202**, **206** is custom designed to fit in a gap generated from a resection guided by the patient specific guide **100**. In yet other embodiments, the implant **200***a* further comprises an optional third portion **210** that has a third surface **212** that corresponds to the line **122** shown in FIG. **1**. Because the first surface **204** corresponds to the line **112**, the second surface **208** corresponds to the line **118**, and the third surface **212** corresponds to the line **122**, the implant **200***a* with first, second and third portions **202**, **206**, **210** is custom designed to fit in a gap generated from a resection guide by the patient specific guide **100**. The patient-specific implant can be composed of a material that promotes bone in-growth. FIG. **6**B is a second patient-specific implant **200***b* that is similar to the implant **200***a*. However, the second implant **200***b* further comprises a substantially spherical portion **214** coupled to the first portion **202**. The spherical portion **214** is designed to fit in a hinge bore or a stress relief hole, as described further below.

With reference to FIG. **1**, the present technology provides a method for performing a tibial tubercle osteotomy on a patient's tibia **104** with the patient-specific alignment guide **100**. The method comprises positioning the patient-specific guide **100** on the patient's tibia **104** at, near, or around the tubercle **108**, wherein the guide **100** comprises a guide body **102** defining a portion with a bone-engaging surface configured during a pre-operative planning stage of a tibial osteotomy to conform as a negative surface to a corresponding surface of the patient's tibia **104**, and a first plurality of apertures **110** along line **112**. As described above, in some embodiments, the guide body **102** further defines a second plurality of apertures **116** along line **118** and a third plurality of apertures **120** along line **122**. Accordingly, the apertures **110**, **116**, **120** are positioned in three intersecting straight lines **112**, **118**, **122** that define three predetermined angles **81**, **82**, **83** relative to a proximal-distal axis **114** of the patient's tibia **104** that are selected during the pre-operative planning stage of the tibial osteotomy. The guide **100** is custom made to mate with and conform to the specific patient's tibia **104**, at a proximal end **106** at or near the tubercle **108**. The method also includes inserting a plurality of pins **124** through the first plurality of apertures **110**, and into the optional second and third plurality of apertures **116**, **120**, and into the patient's tibia **104**. FIG. **3** shows the guide **100** positioned on the specific-patient's tibia **104**, wherein pins **124** **10** have been placed through the first, second, and third plurality of apertures **110**, **116**, **120** and into the tibia **104**.

After the pins **124** have been inserted into the tibia **104**, the method comprises removing the guide **100** from the tibia **104**. Because the diameter D_1 of the apertures **110**, **116**, **120** is larger than the diameter D_2 of the pins **124**, the guide **100** can be removed by simply sliding the guide **100** over the pines **124**.

With reference to FIG. **4**, when the pins **124** are inserted into the tibia **104**, and the guide **100** has been removed, the method comprises resecting a first plane **126** into the tibia **104** adjacent to the pins **124** that are in line with the first line **112**. Optionally, a bore, such as a hinge bore or a stress relief hole, can be drilled into the tibia **104** adjacent to the most distal pin **124**, wherein the first plane **126** is resected from the bore to the most proximal pin **124** adjacent to the first line **112**. Therefore, the pins **124** provide a saw guide for resecting the first plane **126** in the tibia **104** adjacent to the pins **124**, from pin **124** to pin **124**. Likewise, resecting further comprises resecting a second plane **128** into the tibia **104** adjacent to the pins **124** that are in line with the second line **118**, and resecting a third plane **130** into the tibia **104** adjacent to the pins **124** that are in line with the third line **122**. Resecting is performed, for example, with an oscillating saw. When all three planes **126**, **128**, **130** have been resected, a tubercle flap **132** is generated. Accordingly, the planes **126**, **128**, **130** resected into the tibia **104** are adjacent to and match the lines **112**, **118**, **122** configured during the preoperative planning stage.

As shown in FIG. **5**, after resecting, the method comprises removing the pins **124** from the tibia **104**. When the pins **124** are removed, holes **134** remain in the tibia **104**. After the tubercle flap **132** has been generated, the method comprises repositioning the tubercle flap **132** in an anterior direction or in both anterior and medial-lateral directions to form a gap **136** between the tubercle flap **132** and the and three resected surfaces **138**, **140**, **142** of the tibia **138**. Repositioning the tubercle flap **132** alters the position of the patient's patella to remove a pain-causing load and results in alleviation of a patellofemoral condition characterized by malalignment of the patella relative to asymptomatic individuals. The tubercle flap **132** is repositioned to a location predetermined during the pre-operative planning stage. After repositioning

the tubercle flap **132** the method comprises implanting or positioning a patient specific implant or wedge **200***a* implant gap **136**, as shown in FIGS. **6**A and **7**. In embodiments where a hinge bore or a stress relief is drilled into the tibia **104**, the implant or wedge **200***b* shown in FIG. **6**B is utilized. As described above, the patient-specific implant **200***a* has a predetermined shape configured during the pre-operative planning stage. The implant **200***a* comprises a first portion **202**, and optionally a second portion **206** or a second **206** and third portion **210**. In some embodiments, the patient-specific implant is composes of a material that promote bone in-growth. In an alternative method, the implant is an off-the-shelf, i.e., non-patient-specific, implantable wedge. Optionally, the method comprises securing the tubercle flap **132** by driving a screw through the tubercle flap **132** and the wedge **200***a*, and into the tibia **104** through one of the resected surfaces **138**, **140**, **142**. The wedge **200***a* maintains the position of the repositioned tubercle flap **132** and prevents the tubercle flap **132** from reverting to its original location.

The current technology provides another patient-specific tibial osteotomy guide **300** as shown in FIG. **8**. The guide **300** comprises a guide body **302** that defines a portion with a bone-engaging surface **303** configured during a pre-operative planning stage of a tibial osteotomy to conform as a negative surface to a corresponding surface of a specific patient's tibia **104**. As shown in FIG. **8**, the guide **300** is positioned on the specific patient's tibia **104** about a tubercle **108** on a medial face of the tibia **104**. In other embodiments, the guide **300** can be configured to be positioned on a lateral face of the specific patient's tibia **104**. The bone engaging surface **303** is custom made during the preoperative planning stage to match a specific patient's anatomy and allows for placement of the guide **300** at a specific location, and in only one position, at a proximal portion **106** of the patient's tibia **104**. Typically, the guide **300** is configured to fit on a specific patient's tibia **104** at, around, or near the tubercle **108**, which is to be repositioned during an osteotomy.

In some embodiments, the guide body **302** also defines a soft tissue-clearing portion **309** that allows for clearance of soft tissue, such as ligaments and tendons. The soft tissue-clearing portion **309** has an outer convex surface and an inner concave surface, wherein the inner concave surface provides a recess for accommodating soft tissue. As shown in FIG. **8**, the soft tissue-clearing portion **309** accommodates the patient's patellar tendon **111**. However, in various embodiments, the tissue-clearing portion **309** accommodates a medial collateral ligament (MCL) **113** or a lateral cruciate ligament (LCL, not shown). In this regard, the bone-engaging surface **303** mates with and conforms to a specific boney region of the tibia **104**, and the patellar soft tissue-clearing portion **309** allows for the guide to simultaneously be placed about the patient's soft tissue, such as the patellar tendon **111**. In other embodiments, the guide **300** comprises a plurality of tissue-clearing portions **309** for simultaneously accommodating the LCL and patellar tendon, or MCL and patellar tendon.

In additional embodiments, the guide body **302** further defines a soft tissue engaging surface **309'**, wherein the soft tissue-engaging surface **309'** is configured during the pre-operative planning stage of a tibial osteotomy to conform as a negative surface to a corresponding surface of a specific patient's soft tissue at, around, or near the tubercle **108**. The soft tissue can be, for example, the patient's MCL, LCL, or patellar tendon. In various embodiments, the guide **300** comprises a plurality of soft tissue engaging surfaces **309'** for simultaneously accommodating the LCL and patellar tendon, or MCL and patellar tendon. In other embodiments, the guide **300** has both a soft tissue-clearing portion **309** and a soft tissue engaging surface **309'**.

The guide body **302** further defines a first planar slot **304** positioned along a fourth straight line **306** that defines a fourth predetermined angle **84** relative to a proximal-distal axis **114** of the specific patient's tibia **104**. The fourth straight line **306** is selected during the pre-operative planning stage of the tibial osteotomy. Therefore, the first planar slot **304** is oriented at a fourth predetermined angle **84** and at a first predetermined position relative to a proximal-distal axis **114** of the specific patient's tibia **104** that is selected during the pre-operative planning stage of the tibial osteotomy. The first planar slot **304** defined by the guide body **302** has a distal end **308** and a proximal end **310**, wherein the guide body **302** further defines a circular slot **312** in communication with the first distal end **308**.

Additionally, the guide body **302** defines a second planar slot **314** positioned along a fifth straight line **316** that defines a fifth predetermined angle θ_5 relative to a proximal-distal axis **114** of the specific patient's tibia **104**. The fifth straight line **316** is selected during the pre-operative planning stage of the tibial osteotomy. Therefore, the second planar slot **314** is oriented at a fifth predetermined angle θ_5 and at a second predetermined position relative to a proximal-distal axis **114** of the specific patient's tibia **104** that is selected during the pre-operative planning stage of the tibial osteotomy

Additionally, the guide body **302** defines a third planar slot **315** positioned along a fifth straight line **317** that defines a sixth predetermined angle θ_6 relative to a proximal-distal axis **114** of the specific patient's tibia **104**. The sixth straight line **317** is selected during the pre-operative planning stage of the tibial osteotomy. Therefore, the third planar slot **315** is oriented at a sixth predetermined angle θ_6 and at a third predetermined position relative to a proximal-distal axis **114** of the specific patient's tibia **104** that is selected during the pre-operative planning stage of the tibial osteotomy

The guide body **302** of the patient specific guide **300** also defines a plurality of apertures **318** for removeably anchoring the guide **300** to the specific patient's tibia **104**. The apertures have a diameter D_3 and the pins have a diameter D_4, wherein D_3 is smaller than D_4. Because the apertures **318** have a smaller diameter than the pins **320**, the guide **300** can be attached to the tibia **104** by way inserting the pins **320** through the apertures **318** and into the tibia **104**. To remove the guide **300** from the tibia **104**, the pins **320** must first be removed.

The present technology also provides a method for performing a tibial tubercle osteotomy on a patient's tibia with the use of the patient-specific guide **300**. As shown in FIG. **8**, the method comprises anchoring the guide **300** to the patient's tibia **104** by inserting pins **320** through the apertures **318** and into the tibia **104**. When the guide **300** is anchored in place, the method comprises inserting a drill bit through the circular slot **312** and drilling a circular hinge bore or stress relief hole **322** through the tibia **104**.

After drilling, the method comprises inserting a saw blade through the first slot **304** and resecting a first plane **324** from the bore **322** to the proximal end **310** of the first slot **304**. Likewise, the method comprises inserting the saw blade through the second slot **314** and resecting a second plane **326** and inserting the saw blade through the third slot **315** and resecting a third plane **328**. Resecting can be performed, for example, with an oscillating saw. After the planes **324**, **326**, **328** have been resected through the tibia **104** via the slots **304**, **314**, **315** in the guide **300**, the method comprises removing the pins **320** from the tibia **104**, which exposes pin

holes **321**, and subsequently removing the guide **300**. As shown in FIG. **9**, after the guide **300** has been removed, the method comprises resecting the tibia **104** to connect the first plane **324** to the second plane **326**, the second plane **326** to the third plane **328**, and the third plane **328** to an anterior surface of the tibia **104** proximal to the tubercle **108** to form a tubercle flap **330** adjacent to a resected surface of the tibia.

As shown in FIG. **10**, after the tubercle flap **330** has been generated, the method comprises repositioning the tubercle flap **330** in an anterior direction or in both anterior and medial-lateral directions to form a gap **338** between the tubercle flap **330** and three resected surfaces **332**, **334**, **336** of the tibia **104**. The hinge bore or stress relief hole **322** ensures that repositioning the tubercle flap **330** does not crack or splinter the tibia **104**. The tubercle flap **330** is repositioned to a location predetermined during the pre-operative planning stage. Repositioning the tubercle flap **132** alters the position of the patient's patella remove a pain-causing load and results in alleviation of a patellofemoral condition characterized by malalignment of the patella relative to asymptomatic individuals. After repositioning the tubercle flap **330** the method comprises implanting or positioning a patient specific implant or wedge **200***a*, **200***b* in gap **338**, as shown in FIGS. **6**A, **6**B, and **11**. As described above, the patient-specific implant **200***a*, **200***b* has a predetermined shape configured during the preoperative planning stage. The implant **200***a*, **200***b* comprises a first portion **202**, and optionally a second portion **206** or a second **206** and third portion **210**. In some embodiments, the patient-specific implant **200***a*, **200***b* is composed of a material that promotes bone in-growth. When the second implant **200***b* is used, the spherical portion **214** is positioned in the stress relief hole **322**. In an alternative method, the implant is an off-the-shelf, i.e., non-patient-specific, implantable wedge. Optionally, the method comprises securing the tubercle flap **330** by driving a screw **340** through the tubercle flap **330** and the wedge **200***a*, **200***b*, and into the tibia **104** through one of the resected surface **332**. The wedge **200***a*, **200***b* maintains the position of the repositioned tubercle flap **330** relative to the tibia **104** and prevents the tubercle flap **330** from reverting to its original location.

The present technology additionally provides for a surgical kit or a system for a tibial osteotomy comprising a patient-specific guide comprising a guide body defining a portion with a bone-engaging surface that conforms as a negative surface to a corresponding surface of a specific patient's tibia, and a guide portion that guides a surgical instrument to a specific location on the specific patient's tibia, wherein the bone-engaging surface and guide portion are configured during a pre-operative planning stage; a patient-specific implantable wedge with a predetermined shape, wherein the wedge is configured during the pre-operative planning stage; and a plurality of pins.

The foregoing description of the embodiments has been provided for purposes of illustration and description. It is not intended to be exhaustive or to limit the disclosure. 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 performing a tibial tubercle osteotomy on a patient's tibia, comprising:

positioning a patient-specific guide on the patient's tibia, wherein the guide comprises a guide body defining a bone-engaging portion with a bone-engaging surface configured during a pre-operative planning stage of a tibial osteotomy to conform as a negative surface to a corresponding surface of the patient's tibia at, around or near the tubercle of the patient's tibia, and a plurality of apertures;

resecting the tibia in three intersecting planes with a saw to generate a tubercle flap, wherein the patient-specific guide provides visual indicia for resecting; and

repositioning the tubercle flap in an anterior direction or in both anterior and medial-lateral directions to form a gap between the tubercle flap and the resected surface of the tibia.

2. The method according to claim **1**, further comprising implanting a wedge in the gap, wherein the wedge has a predetermined shape configured during the pre-operative planning stage and wherein the wedge is composed of a material that promotes bone in-growth.

3. The method according to claim **2**, further comprising securing the tubercle flap relative to a resected surface of the tibia by driving a screw through the tubercle flap and the wedge, and into the tibia through the resected surface.

4. The method according to claim **1**, wherein the plurality of apertures are positioned along three intersecting lines that define three predetermined angles relative to a proximal-distal axis of the patient's tibia that are selected during the pre-operative planning stage of the tibial osteotomy, and wherein the method further comprises:

inserting a plurality of pins through the apertures, the pins having a diameter smaller than a diameter of the apertures; and

removing the patient specific guide,

wherein the pins provide the visual indicia for resecting.

5. The method according to claim **1**, wherein the guide body further defines a first planar slot oriented at a first predetermined angle and at a first predetermined position relative to a proximal-distal axis of the patient's tibia that is selected during the pre-operative planning stage of the tibial osteotomy, wherein the first planar slot defined by the guide body has a distal end and a proximal end, the guide body further defining a circular slot in communication with the first distal end, and wherein the method further comprises:

anchoring the guide to the patient's tibia near the tubercle by inserting pins through the apertures and into the tibia;

inserting a drill bit through the circular slot and drilling a hole through the tibia;

resecting a first plane through the tibia by inserting a saw blade through the first slot;

resecting a second plane through the tibia by inserting a saw blade through a second slot;

removing the pins and the guide;

further resecting the tibia to connect the first plane and the second plane; and

resecting a third plane through the tibia to connect the second plane to an anterior surface of the tibia to form the tubercle flap.

6. The method according to claim **1**, wherein the guide body further defines a soft tissue-clearing portion comprising an outer convex surface and an inner concave surface, and wherein positioning the patient-specific guide on the patient's tibia further comprises nesting the bone-engaging surface of the guide onto a corresponding surface on the tibia, wherein the inner concave surface of the soft tissue-

clearing portion provides a recess for accommodating the patient's medial collateral ligament, lateral cruciate ligament, or patellar tendon.

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