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Inventor(s)	Hassler; Michel et al.

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### Intra-articular joint replacement and method

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#### Abstract

Methods of implanting a prosthesis to repair a joint include exposing a first bone of the joint; resecting an end portion of the first bone to form a resected end defining a resection plane; forming a concavity in the resected end portion of the first bone using a shaping tool, the concavity extending at least through a full hemispherical arc; selecting a diameter of the prosthesis to be implanted; and implanting a prosthesis having the selected diameter in the concavity.

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## Field of Classification Search

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## References Cited

### U.S. PATENT DOCUMENTS

Patent No.	Issued Date	Patentee Name	U.S. Cl.	CPC
2666430	12/1953	Altamirano	N/A	N/A
3412733	12/1967	Ross	606/81	A61B 17/1666
3694820	12/1971	Scales et al.	N/A	N/A
3815157	12/1973	Skorecki et al.	N/A	N/A
3842442	12/1973	Kolbel	N/A	N/A
3864758	12/1974	Yakich	N/A	N/A
3869730	12/1974	Skobel	N/A	N/A
3916451	12/1974	Buechel	403/56	A61F 2/3854
3938193	12/1975	Sargunar	N/A	N/A
3978528	12/1975	Crep	N/A	N/A
3979778	12/1975	Stroot	N/A	N/A
3992726	12/1975	Freeman et al.	N/A	N/A
4003095	12/1976	Gristina	N/A	N/A
4023572	12/1976	Weigand	606/81	A61B 17/1666
4030143	12/1976	Elloy	623/19.12	A61F 2/40
4040131	12/1976	Gristina	N/A	N/A
4054955	12/1976	Seppo	N/A	N/A
4126924	12/1977	Akins et al.	N/A	N/A
4131116	12/1977	Hedrick	606/81	A61B 17/1666
4135517	12/1978	Reale	N/A	N/A
4179758	12/1978	Gristina	N/A	N/A
4206517	12/1979	Pappas et al.	N/A	N/A
4261062	12/1980	Amstutz et al.	N/A	N/A
4479271	12/1983	Bolesky et al.	N/A	N/A
4550450	12/1984	Kinnett	N/A	N/A

4662891	12/1986	Noiles	623/22.25	A61F 2/4609
4693723	12/1986	Gabard	N/A	N/A
4822370	12/1988	Schelhas	N/A	N/A
4846840	12/1988	Leclercq et al.	N/A	N/A
4865605	12/1988	Dines et al.	N/A	N/A
4865609	12/1988	Roche	N/A	N/A
4892549	12/1989	Figgie, III et al.	N/A	N/A
4919670	12/1989	Dale et al.	N/A	N/A
4957510	12/1989	Cremascoli	N/A	N/A
4963155	12/1989	Lazzeri et al.	N/A	N/A
4964865	12/1989	Burkhead et al.	N/A	N/A
5030233	12/1990	Ducheyne	N/A	N/A
5032132	12/1990	Matsen, III et al.	N/A	N/A
5053050	12/1990	Itay	N/A	N/A
5080673	12/1991	Burkhead et al.	N/A	N/A
5080685	12/1991	Bolesky et al.	N/A	N/A
5127920	12/1991	MacArthur	N/A	N/A
5135529	12/1991	Paxson et al.	N/A	N/A
5163961	12/1991	Harwin	N/A	N/A
5181928	12/1992	Bolesky et al.	N/A	N/A
5192329	12/1992	Christie et al.	N/A	N/A
5201882	12/1992	Paxson	N/A	N/A
5206925	12/1992	Nakazawa et al.	N/A	N/A
5222984	12/1992	Forte	N/A	N/A
5261914	12/1992	Warren	N/A	N/A
5314479	12/1993	Rockwood, Jr. et al.	N/A	N/A
5314487	12/1993	Schryver et al.	N/A	N/A
5330531	12/1993	Capanna	N/A	N/A
5358526	12/1993	Tornier	N/A	N/A
5383936	12/1994	Kubein-Meesenburg et al.	N/A	N/A
5425779	12/1994	Schlosser et al.	N/A	N/A
5435722	12/1994	Mandell	433/165	A61C 1/052
5443515	12/1994	Cohen et al.	N/A	N/A
5443519	12/1994	Averill et al.	N/A	N/A
5462563	12/1994	Shearer et al.	N/A	N/A
5507817	12/1995	Craig et al.	N/A	N/A
5507818	12/1995	McLaughlin	N/A	N/A
5507819	12/1995	Wolf	N/A	N/A
5507824	12/1995	Lennox	N/A	N/A
5534033	12/1995	Simpson	N/A	N/A
5549682	12/1995	Roy	N/A	N/A
5571203	12/1995	Masini	N/A	N/A
5580352	12/1995	Sekel	N/A	N/A
5702447	12/1996	Walch et al.	N/A	N/A
5702457	12/1996	Walch	623/19.13	A61F 2/4014
5702486	12/1996	Craig et al.	N/A	N/A
5723018	12/1997	Cyprien	623/19.13	A61F 2/40

5728161	12/1997	Camino et al.	N/A	N/A
5741335	12/1997	Gerber et al.	N/A	N/A
5755719	12/1997	Frieze	606/81	A61B 17/1666
5755807	12/1997	Anstaett et al.	N/A	N/A
5779709	12/1997	Harris, Jr. et al.	N/A	N/A
5800551	12/1997	Williamson et al.	N/A	N/A
5800557	12/1997	Elhami	N/A	N/A
5879355	12/1998	Ullmark	606/92	A61F 2/4601
5879405	12/1998	Ries et al.	N/A	N/A
5902340	12/1998	White et al.	N/A	N/A
5910171	12/1998	Kummer et al.	N/A	N/A
5928285	12/1998	Bigliani et al.	N/A	N/A
5941706	12/1998	Ura	433/165	A61C 3/02
5944758	12/1998	Mansat et al.	N/A	N/A
5961555	12/1998	Huebner	N/A	N/A
5972368	12/1998	McKay	N/A	N/A
5984927	12/1998	Wenstrom, Jr. et al.	N/A	N/A
6015437	12/1999	Stossel	N/A	N/A
6027503	12/1999	Khalili	606/81	A61B 17/1666
6033439	12/1999	Camino et al.	N/A	N/A
6045302	12/1999	Orr	408/83	B23B 51/0426
6045582	12/1999	Prybyla	N/A	N/A
6045583	12/1999	Gross et al.	N/A	N/A
6090145	12/1999	Hassler	623/23.14	A61F 2/30721
6096084	12/1999	Townley	N/A	N/A
6102953	12/1999	Huebner	N/A	N/A
6129764	12/1999	Servidio	N/A	N/A
6165224	12/1999	Tornier	N/A	N/A
6171341	12/2000	Boileau et al.	N/A	N/A
6197062	12/2000	Fenlin	N/A	N/A
6197063	12/2000	Dews	N/A	N/A
6203575	12/2000	Farey	N/A	N/A
6206925	12/2000	Tornier	N/A	N/A
6221076	12/2000	Albrektsson	407/62	A61B 17/1666
6228120	12/2000	Leonard et al.	N/A	N/A
6245074	12/2000	Allard	606/80	A61B 17/1684
6267767	12/2000	Strobel et al.	N/A	N/A
6283999	12/2000	Rockwood, Jr.	623/19.12	A61F 2/40
6312467	12/2000	McGee	N/A	N/A
6334874	12/2001	Tornier et al.	N/A	N/A
6364910	12/2001	Shultz et al.	N/A	N/A
6368352	12/2001	Camino et al.	N/A	N/A
6368353	12/2001	Arcand	N/A	N/A

6383227	12/2001	Baroud et al.	N/A	N/A
6398812	12/2001	Masini	N/A	N/A
6406495	12/2001	Schoch	N/A	N/A
6406496	12/2001	Rüter	N/A	N/A
6436144	12/2001	Ahrens	N/A	N/A
6436146	12/2001	Hassler	623/18.11	A61F 2/4261
6436147	12/2001	Zweymüller	N/A	N/A
6454811	12/2001	Sherwood et al.	N/A	N/A
6458136	12/2001	Allard et al.	N/A	N/A
6475221	12/2001	White	404/54	A61B 17/1666
6475243	12/2001	Sheldon et al.	N/A	N/A
6494913	12/2001	Huebner	N/A	N/A
6506214	12/2002	Gross	N/A	N/A
6508840	12/2002	Rockwood, Jr. et al.	N/A	N/A
6511511	12/2002	Slivka et al.	N/A	N/A
6514287	12/2002	Ondrla et al.	N/A	N/A
6520994	12/2002	Nogarin	N/A	N/A
6530957	12/2002	Jack	N/A	N/A
6541022	12/2002	Murphy et al.	N/A	N/A
6558425	12/2002	Rockwood, Jr.	N/A	N/A
6569202	12/2002	Whiteside	N/A	N/A
6589281	12/2002	Hyde, Jr.	N/A	N/A
6605117	12/2002	Kuberasampath et al.	N/A	N/A
6620197	12/2002	Maroney et al.	N/A	N/A
6626946	12/2002	Walch et al.	N/A	N/A
6673114	12/2003	Hartdegen et al.	N/A	N/A
6673115	12/2003	Resch et al.	N/A	N/A
6679916	12/2003	Frankle et al.	N/A	N/A
6692563	12/2003	Zimmermann	N/A	N/A
6730252	12/2003	Teoh et al.	N/A	N/A
6736851	12/2003	Maroney et al.	N/A	N/A
6746487	12/2003	Scifert et al.	N/A	N/A
6749637	12/2003	Bähler	N/A	N/A
6755866	12/2003	Southworth	N/A	N/A
6761740	12/2003	Tornier	N/A	N/A
6767928	12/2003	Murphy et al.	N/A	N/A
6780190	12/2003	Maroney	N/A	N/A
6783549	12/2003	Stone	623/18.11	A61B 17/1684
6790234	12/2003	Frankle	623/19.12	A61F 2/40
6797006	12/2003	Hodorek	N/A	N/A
6863690	12/2004	Ball et al.	N/A	N/A
6875234	12/2004	Lipman et al.	N/A	N/A
6887277	12/2004	Rauscher et al.	N/A	N/A
6890358	12/2004	Ball et al.	N/A	N/A
6902584	12/2004	Kwan et al.	N/A	N/A
6942699	12/2004	Stone et al.	N/A	N/A

6953478	12/2004	Bouttens et al.	N/A	N/A
6969406	12/2004	Tornier	N/A	N/A
7011686	12/2005	Ball	623/19.14	A61F 2/4014
7033395	12/2005	Cauthen	N/A	N/A
7051417	12/2005	Michelson	N/A	N/A
7066959	12/2005	Errico et al.	N/A	N/A
7108719	12/2005	Horber	N/A	N/A
7166132	12/2006	Callaway et al.	N/A	N/A
7169184	12/2006	Dalla Pria	N/A	N/A
7175663	12/2006	Stone	N/A	N/A
7195645	12/2006	DiSilvestro et al.	N/A	N/A
7238207	12/2006	Blatter et al.	N/A	N/A
7238208	12/2006	Camino et al.	N/A	N/A
7250550	12/2006	Overby et al.	N/A	N/A
7297163	12/2006	Huebner	N/A	N/A
7309360	12/2006	Tornier et al.	N/A	N/A
7329284	12/2007	Maroney et al.	N/A	N/A
7338498	12/2007	Long et al.	N/A	N/A
7338528	12/2007	Stone et al.	N/A	N/A
7462197	12/2007	Tornier	623/19.12	A61F 2/4081
7520898	12/2008	Re	623/13.14	A61B 17/1714
7604637	12/2008	Johnson	606/81	A61F 2/30724
8062376	12/2010	Shultz	623/19.12	A61F 2/40
8366713	12/2012	Long	606/80	A61B 17/1675
8414586	12/2012	Cawthan	606/81	A61B 17/1666
8864834	12/2013	Boileau et al.	N/A	N/A
8974536	12/2014	Walch et al.	N/A	N/A
9089435	12/2014	Walch et al.	N/A	N/A
9408652	12/2015	Hassler et al.	N/A	N/A
10251755	12/2018	Boileau et al.	N/A	N/A
10413416	12/2018	Boileau et al.	N/A	N/A
10695195	12/2019	Hassler et al.	N/A	N/A
2001/0032021	12/2000	McKinnon	N/A	N/A
2001/0047210	12/2000	Wolf	N/A	N/A
2001/0049561	12/2000	Dews et al.	N/A	N/A
2002/0032484	12/2001	Hyde, Jr.	N/A	N/A
2002/0099381	12/2001	Maroney	N/A	N/A
2002/0138148	12/2001	Hyde, Jr.	N/A	N/A
2002/0143402	12/2001	Steinberg	N/A	N/A
2002/0151982	12/2001	Masini	N/A	N/A
2002/0177901	12/2001	Howie	N/A	N/A
2003/0009171	12/2002	Tornier	N/A	N/A
2003/0065397	12/2002	Hanssen	623/23.23	A61F 2/34
2003/0097183	12/2002	Rauscher et al.	N/A	N/A

2003/0114933	12/2002	Bouttens et al.	N/A	N/A
2003/0125809	12/2002	Iannotti et al.	N/A	N/A
2003/0149485	12/2002	Tornier	N/A	N/A
2003/0158605	12/2002	Tornier	N/A	N/A
2003/0181916	12/2002	Wolford	606/81	A61B 17/1666
2004/0002765	12/2003	Maroney	623/19.12	A61F 2/4014
2004/0006392	12/2003	Grusin et al.	N/A	N/A
2004/0030394	12/2003	Horber	623/19.12	A61F 2/4014
2004/0034431	12/2003	Maroney et al.	N/A	N/A
2004/0064189	12/2003	Maroney	623/19.13	A61F 2/30734
2004/0064190	12/2003	Ball et al.	N/A	N/A
2004/0068320	12/2003	Robie et al.	N/A	N/A
2004/0133276	12/2003	Lang et al.	N/A	N/A
2004/0138754	12/2003	Lang et al.	N/A	N/A
2004/0148033	12/2003	Schroeder	N/A	N/A
2004/0193168	12/2003	Long	606/80	A61B 17/1684
2004/0193276	12/2003	Maroney et al.	N/A	N/A
2004/0193277	12/2003	Long et al.	N/A	N/A
2004/0193278	12/2003	Maroney et al.	N/A	N/A
2004/0210317	12/2003	Maroney et al.	N/A	N/A
2004/0220673	12/2003	Pria	N/A	N/A
2004/0220674	12/2003	Pria	N/A	N/A
2004/0225367	12/2003	Glien et al.	N/A	N/A
2004/0230197	12/2003	Tornier et al.	N/A	N/A
2004/0249383	12/2003	White	606/80	A61B 17/1666
2004/0267370	12/2003	Ondrla	N/A	N/A
2005/0008672	12/2004	Winterbottom et al.	N/A	N/A
2005/0010304	12/2004	Jamali	N/A	N/A
2005/0015154	12/2004	Lindsey et al.	N/A	N/A
2005/0033443	12/2004	Blatter et al.	N/A	N/A
2005/0043805	12/2004	Chudik	N/A	N/A
2005/0049709	12/2004	Tornier	N/A	N/A
2005/0060039	12/2004	Cyprien	N/A	N/A
2005/0065612	12/2004	Winslow	N/A	N/A
2005/0085919	12/2004	Durand-Allen et al.	N/A	N/A
2005/0085921	12/2004	Gupta et al.	N/A	N/A
2005/0090902	12/2004	Masini	N/A	N/A
2005/0107882	12/2004	Stone et al.	N/A	N/A
2005/0113837	12/2004	Salyer	606/80	A61B 17/1666
2005/0113931	12/2004	Horber	N/A	N/A
2005/0119531	12/2004	Sharratt	N/A	N/A
2005/0143818	12/2004	Yuan et al.	N/A	N/A
2005/0143829	12/2004	Ondrla et al.	N/A	N/A

2005/0159751	12/2004	Berthusen	606/80	A61B 17/1666
2005/0165490	12/2004	Tornier	N/A	N/A
2005/0177241	12/2004	Angibaud et al.	N/A	N/A
2005/0186247	12/2004	Hunter et al.	N/A	N/A
2005/0197708	12/2004	Stone et al.	N/A	N/A
2005/0209700	12/2004	Rockwood, Jr. et al.	N/A	N/A
2005/0216092	12/2004	Marik et al.	N/A	N/A
2005/0240267	12/2004	Randall et al.	N/A	N/A
2005/0245934	12/2004	Tuke et al.	N/A	N/A
2005/0251263	12/2004	Forrer et al.	N/A	N/A
2005/0256584	12/2004	Farrar	N/A	N/A
2005/0267590	12/2004	Lee	N/A	N/A
2005/0278030	12/2004	Tornier et al.	N/A	N/A
2005/0278031	12/2004	Tornier et al.	N/A	N/A
2005/0278032	12/2004	Tornier et al.	N/A	N/A
2005/0278033	12/2004	Tornier et al.	N/A	N/A
2005/0288681	12/2004	Klotz et al.	N/A	N/A
2005/0288791	12/2004	Tornier et al.	N/A	N/A
2006/0004462	12/2005	Gupta	N/A	N/A
2006/0009852	12/2005	Winslow et al.	N/A	N/A
2006/0020344	12/2005	Shultz et al.	N/A	N/A
2006/0025796	12/2005	Merced-O	N/A	N/A
2006/0030946	12/2005	Ball et al.	N/A	N/A
2006/0111787	12/2005	Bailie	623/908	A61F 2/4081
2006/0122705	12/2005	Morgan	623/19.11	A61F 2/4081
2006/0195110	12/2005	White	606/81	A61B 17/1684
2006/0235539	12/2005	Blunn	623/23.11	A61B 17/1666
2006/0241775	12/2005	Buss	N/A	N/A
2007/0078516	12/2006	Emami	N/A	N/A
2007/0142916	12/2006	Olson, Jr. et al.	N/A	N/A
2007/0156250	12/2006	Seitz, Jr. et al.	N/A	N/A
2007/0173945	12/2006	Wiley et al.	N/A	N/A
2007/0179562	12/2006	Nycz	N/A	N/A
2007/0198087	12/2006	Coleman et al.	N/A	N/A
2007/0225817	12/2006	Reubelt et al.	N/A	N/A
2007/0225818	12/2006	Reubelt et al.	N/A	N/A
2007/0225821	12/2006	Reubelt et al.	N/A	N/A
2007/0244564	12/2006	Ferrand et al.	N/A	N/A
2007/0250174	12/2006	Tornier et al.	N/A	N/A
2007/0276509	12/2006	Ratcliffe et al.	N/A	N/A
2008/0183297	12/2007	Boileau	623/16.11	A61B 17/1637
2009/0125113	12/2008	Guederian et al.	N/A	N/A
2009/0270993	12/2008	Maisonneuve	623/19.14	A61B 17/1778



2009/0287309	12/2008	Walch	623/18.11	A61B 17/1739
2009/0292364	12/2008	Linares	623/19.13	A61B 17/686
2009/0306782	12/2008	Schwyzer	623/19.12	A61F 2/4003
2010/0280517	12/2009	Cawthan	606/81	A61B 17/1666
2010/0280518	12/2009	Gary	606/84	A61B 17/1666
2011/0098822	12/2010	Walch et al.	N/A	N/A
2011/0166661	12/2010	Boileau et al.	N/A	N/A
2011/0213372	12/2010	Keefer	606/85	A61B 17/1735
2011/0264153	12/2010	Hassler et al.	N/A	N/A
2014/0058523	12/2013	Walch et al.	N/A	N/A
2015/0297354	12/2014	Walch et al.	N/A	N/A
2019/0358045	12/2018	Boileau et al.	N/A	N/A

## FOREIGN PATENT DOCUMENTS

Patent No.	Application Date	Country	CPC
426096	12/1965	CH	N/A
507704	12/1970	CH	N/A
1950937	12/1965	DE	N/A
19630298	12/1997	DE	N/A
0257359	12/1990	EP	N/A
0299889	12/1991	EP	N/A
0524857	12/1992	EP	N/A
0617934	12/1993	EP	N/A
0549480	12/1996	EP	N/A
0599429	12/1996	EP	N/A
0797964	12/1996	EP	N/A
0679375	12/1997	EP	N/A
0864306	12/1997	EP	N/A
0712617	12/1998	EP	N/A
0715836	12/2000	EP	N/A
0664108	12/2001	EP	N/A
0809986	12/2001	EP	N/A
0927548	12/2002	EP	N/A
0807426	12/2002	EP	N/A
1062923	12/2003	EP	N/A
1380274	12/2003	EP	N/A
0903128	12/2003	EP	N/A
1195149	12/2004	EP	N/A
1064890	12/2004	EP	N/A
1477120	12/2006	EP	N/A
0903127	12/2006	EP	N/A
1570816	12/2007	EP	N/A
1652482	12/2007	EP	N/A

1607069	12/2008	EP	N/A
1402853	12/2009	EP	N/A
1402854	12/2009	EP	N/A
1323395	12/2015	EP	N/A
1952771	12/2015	EP	N/A
1952788	12/2017	EP	N/A
3335676	12/2017	EP	N/A
2248820	12/1975	FR	N/A
2216981	12/1978	FR	N/A
2574283	12/1988	FR	N/A
2545352	12/1989	FR	N/A
2699400	12/1994	FR	N/A
2704747	12/1994	FR	N/A
2726994	12/1996	FR	N/A
2737107	12/1996	FR	N/A
2652498	12/1996	FR	N/A
2664809	12/1996	FR	N/A
2721200	12/1998	FR	N/A
2835425	12/2003	FR	N/A
2836039	12/2003	FR	N/A
749392	12/1979	SU	N/A
1991007932	12/1990	WO	N/A
1993009733	12/1992	WO	N/A
1996017553	12/1995	WO	N/A
1998046172	12/1997	WO	N/A
1999049792	12/1998	WO	N/A
1999065413	12/1998	WO	N/A
2000015154	12/1999	WO	N/A
2000041653	12/1999	WO	N/A
2000062718	12/1999	WO	N/A
2001047442	12/2000	WO	N/A
2002039931	12/2001	WO	N/A
2002039933	12/2001	WO	N/A
2002049516	12/2001	WO	N/A
2002067821	12/2001	WO	N/A
2003005933	12/2002	WO	N/A
2003092513	12/2002	WO	N/A
2003094806	12/2002	WO	N/A
2006039483	12/2005	WO	N/A
2007109291	12/2006	WO	N/A
2007109319	12/2006	WO	N/A
2007109340	12/2006	WO	N/A
2008015724	12/2007	WO	N/A

## OTHER PUBLICATIONS

“Aequalis-Fracture Shoulder Prosthesis—Surgical Technique,” Tornier, Inc., in 32 pages. cited by applicant

“Aequalis-Fracture Suture Technique in 5 Steps,” Tornier, Inc., in 2 pages. cited by applicant

“Aequalis-Glenoid Keeled and Pegged—Surgical Technique,” Tornier, Inc., in 12 pages. cited by applicant

“Aequalis Press-Fit Shoulder Prosthesis—Surgical Technique,” Tornier, Inc., in 27 pages. cited by applicant

“Aequalis Resurfacing Head”, retrieved from <http://www.tornier-us.com/upper/shoulder/shorec004/index.php?pop+1> on Apr. 14, 2010. cited by applicant

“Aequalis-Reversed™ Shoulder Prosthesis, Surgical Technique,” Tornier, Inc., in 24 pages. cited by applicant

“Anatomic Glenoid, Surgical Technique,” Smith & Nephew, Inc., Feb. 2000 in 6 pages. cited by applicant

“Anatomical Shoulder™—Cemented Shoulder Prosthesis Product Information and Surgical Technique,” Sulzer Medica, 2000, in 30 pages. cited by applicant

“Anatomical Shoulder™ System—The new removable head option,” Zimmer Inc., 2004 in 6 pages. cited by applicant

“Anatomical Shoulder™ System Surgical Technique—Removable head option for improved surgical results,” Zimmer, Inc., 2004, in 33 pages. cited by applicant

Apoil, A., “A Condyle for the Rotator Cuff Muscles: The Total Shoulder Prosthesis,” Aesculap—ICP S.A., Feb. 1994, in 4 pages. cited by applicant

Bigliani/Flatow®—The Complete Shoulder Solution, Designed by Shoulder Surgeons for Shoulder Surgery, Zimmer, Inc., 2001 in 6 pages. cited by applicant

“Bigliani/Flatow®—The Complete Shoulder Solution, Total Shoulder Arthroplasty Surgical Technique,” Zimmer, Inc., 2003, in 30 pages. cited by applicant

Bigliani/Flatow®—The Complete Shoulder Solution, 4-Part Fracture of the Humerus Surgical Technique, Zimmer, Inc., 2001. cited by applicant

“Bio-Modular®/ Bi-Polar Shoulder Arthroplasty,” Biomet, Inc., 1997, in 2 pages. cited by applicant

“Bio-Modular® Choice—Shoulder System—Surgical Technique,” Biomet Orthopedics, Inc., 2004, in 16 pages. cited by applicant

“Bio-Modular Total Shoulder Surgical Technique,” Biomet Orthopedics, Inc., 2001. cited by applicant

Boileau, P., et al. “Adaptability and modularity of shoulder prosthese,” Maitrise Orthopedique, [https://www.maitriseorthop.com/corpusmaitri/orthopaedic/prothese\\_epaule\\_orthop/boileau\\_us.shtml](https://www.maitriseorthop.com/corpusmaitri/orthopaedic/prothese_epaule_orthop/boileau_us.shtml), downloaded Jan. 3, 2006. cited by applicant

Boileau, P., et al. “Arthroscopic Repair of Full-Thickness Tears of the Supraspinatus: Does the Tendon Really Heal?” The Journal of Bone and Joint Surgery, Inc., Jun. 2005, 87A(6): 1229-1240. cited by applicant

Buechel, F.F., “Buechel-Pappas™ Modular Salvage Shoulder System, Surgical Procedure,” Endotec, Inc., Aug. 2001, in 8 pages. cited by applicant

Buechel, F.F., “Buechel-Pappas™ Resurfacing Shoulder System, Surgical Procedure” Endotec, Inc., Aug. 2000, in 8 pages. cited by applicant

Buechel, F.F., “Buechel-Pappas™ Total Shoulder System, Surgical Procedure,” Endotec, Inc., Aug. 2000, in 16 pages. cited by applicant

Cofield, R.H., “Cofield2 Total Shoulder System, Surgical Technique,” Smith & Nephew, 1997, in 32 pages. cited by applicant

“Copeland™ Humeral Resurfacing Head,” Biomet Orthopedics, Inc., 2001, in 12 pages. cited by applicant

“Delta CTA™ Reverse Shoulder Prosthesis—Surgical Technique,” DePuy International Ltd., revised Aug. 2004, in 28 pages. cited by applicant

“Design Rationale,” Latitude® Total Elbow, pp. 3-38. cited by applicant

Fenlin, Jr., J.M., “Total Glenohumeral Joint Replacement,” Symposium on Surgery of the Shoulder, Orthopedic Clinics of North America, Apr. 1975, 6(2): 565-583. cited by applicant

“Global C.A.P. TM Surgical Technique, Resurfacing Humeral Head Implant,” DePuy International,

Ltd., revised Oct. 2004, in 23 pages. cited by applicant  
Hertel, R., “Technical considerations for implantation of Epoca glenoid components (Leseprobe),” Epoca Newsletter, May 14, 2001, in 1 page. cited by applicant  
Klein, T.J., et al., “Mechanically Favorable Bone Remodeling in Rotator Cuff Arthropathy Patients with Good Function,” Minneapolis Sports Medicine Center and University of Minnesota, in 2 pages. cited by applicant  
Mansat, M., “Neer 3™, Surgical Technique for Fractures,” Smith & Nephew, Sep. 2000, in 19 pages. cited by applicant  
Nicholson, G.P., “Chapter 7: Arthroplasty and Rotator Cuff Deficiency,” Shoulder Arthroplasty, 2005, DD. 149-166. cited by applicant  
“Offset Head: Bio-Modular® Total Shoulder,” Biomet, Inc. 2000 in 2 pages. cited by applicant  
“The Foundation® Total Shoulder System,” Encore Surgical, in 2 pages. cited by applicant  
“The Townley Modular Shoulder—Design by Reason,” Biopro, Inc., in 2 pages. cited by applicant  
“Tornier Surgical Technique Addendum, Tornier Aequalis® Reversed Hemi-Adaptor Technique,” Tornier, Inc., Aug. 8, 2005. cited by applicant  
“Tornier Surgical Technique Addendum, Aequalis® Reversed Shoulder Polyethylene Insert,” Tornier, Inc., Oct. 8, 2005, in 1 page. cited by applicant  
“Zimmer® Shoulder Retractors,” Zimmer, Inc., 2000, in 2 pages. cited by applicant  
On-Final Office Action issued in connection with U.S. Appl. No. 14/754,506, Jul. 19, 2022, 9 pages. cited by applicant  
Final Office Action issued in connection with U.S. Appl. No. 14/574,506, Mar. 18, 2022, 15 pages. cited by applicant  
Non-Final Office Action issued in connection with U.S. Appl. No. 14/754,506, Sep. 23, 2021, 11 pages. cited by applicant

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## **Background/Summary**

CROSS REFERENCE TO RELATED APPLICATIONS (1) This application is a divisional of a co-pending U.S. patent Application Ser. No. 16/875,729, filed on May 15, 2020, which is a continuation of U.S. patent application Ser. No. 15/224,188, filed on Jul. 29, 2016 (U.S. Pat. No. 10,695,195), which is a divisional of U.S. patent application Ser. No. 12/768,154, filed on Apr. 27, 2010 (U.S. Pat. No. 9,408,652), which are all hereby incorporated by reference in their entirety.

### **BACKGROUND**

(1) One type of method used to replace damaged joints (e.g., shoulder joints) is interpositional arthroplasty. The method of interpositional arthroplasty uses tissue from the patient or an artificial replacement to repair a damaged or malformed joint. An interpositional implant is positioned at the joint to act as an engagement surface between two adjacent bone structures to allow articular movement.

### **SUMMARY**

(2) Some embodiments relate to a method of implanting a prosthesis to repair a joint. The method includes displacing a first bone from the joint formed by an intersection between the first bone and a second bone. An end portion of the first bone is resected to define a resected end. A concavity is formed into the resected end using a shaping tool. The bone is compacted to form a support layer lining the concavity. The prosthesis is implanted in the concavity against the support layer without

attaching the prosthesis to the support layer, the prosthesis including a first surface and a second surface opposite the first surface, each of the first and second surfaces being substantially convex in shape. The joint is reformed with the prosthesis such that the prosthesis remains unattached to the support layer and the first and second bones articulate about the prosthesis.

(3) Some embodiments relate to a bone recess forming tool. The tool includes a forming head having a forming surface defining a convex hemispherical portion and an upswept portion extending beyond the convex hemispherical portion, the forming surface being adapted to form a recess into a bone.

(4) Still other embodiments relate to a surgical kit of parts for implanting joint prostheses available in a plurality of graduating diameters. The kit includes a plurality of test prostheses each graduating in diameter such that each one of the test prostheses has a diameter corresponding to one of the available graduating diameters of the joint prosthesis. The kit also includes a plurality of reamers each graduating in diameter such that each one of the reamers has a diameter corresponding to one of the available graduating diameters of the joint prosthesis. The kit also includes a plurality of compactors each graduating in diameter such that each one of the compactors has a diameter corresponding to one of the available graduating diameters of the joint prosthesis. Each one of the test prostheses, reamers, and compactors having the same diameter forms an operational tool set for implanting a joint prosthesis of the same diameter, and further wherein each of the test prostheses, reamers, and compactors include colored indicia indicating to which operational tool set a particular test prosthetic, reamer, and compactor belongs.

(5) While multiple embodiments are disclosed, still other embodiments of the present invention will become apparent to those skilled in the art from the following detailed description, which shows and describes illustrative embodiments of the invention. Accordingly, the drawings and detailed description are to be regarded as illustrative in nature and not restrictive.

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## Description

### BRIEF DESCRIPTION OF THE DRAWINGS

- (1) FIG. 1 shows a joint system, according to some embodiments.
- (2) FIG. 2 shows an interpositional implant, according to some embodiments.
- (3) FIG. 3 shows another interpositional implant, according to some embodiments.
- (4) FIG. 4 shows another joint system, according to some embodiments.
- (5) FIG. 5 shows a surgical kit, according to some embodiments.
- (6) FIG. 6 shows a reamer of the surgical kit of FIG. 5, according to some embodiments.
- (7) FIG. 7 shows a test implant and handle of the surgical kit of FIG. 5, according to some embodiments.
- (8) FIG. 8 shows a starter compactor of the kit of FIG. 5, according to some embodiments.
- (9) FIG. 9 shows an initial compactor of the kit of FIG. 5, according to some embodiments.
- (10) FIG. 10 shows a final compactor of the kit of FIG. 5, according to some embodiments.
- (11) FIGS. 11-14 are illustrative of a method of implanting and forming the joint system of FIG. 1, according to some embodiments.
- (12) While the invention is amenable to various modifications, permutations, and alternative forms, specific embodiments have been shown by way of example in the drawings and are described in detail below. The intention, however, is not to limit the invention to the particular embodiments described. On the contrary, the invention is intended to cover all modifications, equivalents, and alternatives falling within the scope of the invention as defined by the appended claims.

### DETAILED DESCRIPTION

- (13) FIG. 1 is a schematic view of a joint system 10 (e.g., a glenohumeral joint system) including an interpositional implant 12, a first bony structure, or bone (e.g., a humerus H) and a second

boney structure, or bone (e.g., a glenoid G), where the first and second boney structures articulate about the interpositional implant **12**. As shown in FIG. **1**, in some embodiments, the interpositional implant **12** is interposed between the two boney structures—the humerus H and the glenoid G—to help repair joint function. Although the implant **12** is primarily discussed as being implanted in a human patient's shoulder, the implant **12** may also be modified and implanted in other locations. For example, the implant **12** is optionally modified to be implanted between a variety of boney structures in a hip, ankle, hand, foot, or other joint, for example, whether human or other animal.

(14) Generally, the interpositional implant **12**, also described as an interpositional prosthesis, is formed as a single piece, or monolithic unit, and includes at least two convex surfaces, although implants formed of separate, connected parts are contemplated. As shown, the implant **12** includes a convex first surface **18** and a convex second surface **20** opposed to the first surface **18**, though the interpositional implant **12** is optionally non-spherical and the surfaces **18**, **20** optionally have different radii of curvature from one other. As shown, the first surface **18** is in direct contact with the glenoid G, and in particular the glenoid cavity, and the second surface **20** is in direct contact with a portion of the humerus H.

(15) The implant **12** generally defines a midline M between the first and second convex surfaces **18**, **20**. For example, while FIG. **1** shows a generally spherical, or spheroid shape for the interpositional implant **12**, while FIG. **2** shows an interpositional implant **12A** having an upper, spheroid portion above a midline M.sub.A and a lower, spherical portion below the midline M.sub.A having a different radius of curvature. FIG. **3** shows an interpositional implant **12B** having a more symmetrical spheroid shape (e.g., a prolate spheroid shape) above and below a midline M.sub.B. In still other embodiments, the convexities of the first and/or second surfaces **18**, **20** are complex, including multiple radii, including the shapes described in U.S. Patent Application Publication 2007/0225818, filed Mar. 21, 2007, and titled “Non-Spherical Articulating Surfaces in Shoulder and Hip Replacement,” the entire contents of which are incorporated herein by reference for all purposes. Moreover, although some shapes for the implant **12** have been described, a variety of shapes are contemplated, such as an egg-shaped implant, for example.

(16) In some embodiments, the interpositional implant **12** defines the midline M in an antero-posterior plane and a height perpendicular to the midline M, for example in a supero-inferior plane). In the case of a sphere, the diameter of the sphere corresponds to both the width of the implant **12** along the midline M and the maximum effective height of the sphere perpendicular to the midline M. The implant **12** is formed of an outer layer of pyrocarbon, or pyrolytic carbon, over a graphite substrate or is formed substantially entirely of pyrocarbon, for example. Some examples of pyrolytic carbon implants and associated use for joint repair are described in U.S. Pat. No. 6,436,146, filed Jan. 18, 2000, and titled “Implant for Treating Ailments of a Joint or Bone,” the entire contents of which is incorporated herein by reference for all purposes. In some embodiments, the interpositional implant **12** is characterized by a Young's Modulus of from about 10 GPa to about 35 GPa, for example, or from about 21 to about 28 GPa, for example, which is relatively low compared to the much higher Young's modulus of titanium implants. The interpositional implant **12** is optionally hollow or otherwise defines an internal void V as indicated in FIG. **1** by a broken circle. Although a single, substantially spherical void, or internal hollow portion, is indicated the void V optionally takes a variety of shapes and forms, including multiple voids (e.g., a plurality of larger voids or a plurality of smaller voids similar to a sponge structure) or other forms. By including one or more voids, the weight of the implant **12** is optionally reduced and/or other properties of the implant **12** are adjusted as desired.

(17) As shown in FIG. **1**, the humeral head of the humerus H is removed, or resected, proximate the anatomical neck AN, where the humerus H defines a proximal humerus PH. The humerus defines a recess **22** that is substantially concave in shape, extending at least through a full hemispherical arc, although other shapes are also contemplated. The recess **22**, also described as a concavity or a pocket, has an articulation surface **24**, or reinforcement bed, that lines the recess **22** which, as

described in greater detail below, is optionally formed via compacting and/or reaming methodology. The articulation surface **24** forms a reinforced bed, or liner, for contacting the interpositional implant **12**. As described in greater detail, the recess **22** is formed into epiphyseal/metaphyseal bone of the humerus **H** and optionally extends into the diaphysis in some embodiments, though typically preferential to limit the recess **22** to the metaphyseal bone. Where the recess **22** extends into the diaphysis, or where the metaphyseal bone is thin or has degenerated, a plug or plugs (e.g., made of bone from the humeral head (not shown) or other bone material) are optionally used to reinforce any holes or weak spots in the articulation surface **24** produced during formation. In some embodiments, and as described in greater detail below, the articulation surface **24** is formed of cortical or cortical-like bone **C** that forms over time following surgical insertion of the interpositional implant **12**. Generally, the depth of the recess **22** is measured or otherwise evaluated from the bottom of the recess **22** to a plane of the resected end of the humerus **H**, although other reference planes are employed as appropriate.

(18) Generally, the interpositional implant **12** is not cemented, adhered, or otherwise fixed to the articulation surface **24**, leaving the interpositional implant **12** free to rotate in the recess **22**. In some embodiments, however, there is some frictional engagement between the recess and the interpositional implant **12**—for example, in association with press fitting the interpositional implant **12** into the recess **22** and/or following growth of the humerus **H**.

(19) The glenoid **G** defines an articulation surface **28** and, in some embodiments, the articulation surface **28** corresponds to the natural glenoid cavity where no or very little surface modification is made to the glenoid cavity during implantation. Use of the implant **12** with an unmodified glenoid cavity can be particularly beneficial for partial replacement of a shoulder joint in cases where the rotator cuff is still functional. In other embodiments, the articulation surface **28** is formed into the scapula **S** at the glenoid cavity (e.g., using the reaming and/or compacting methodology similar to that used with the humerus **H** (described in greater detail below) or a glenoid component is attached to the glenoid **G** for interacting with the implant **12** as shown in FIG. 4.

(20) As shown in FIG. 1, and as discussed in greater detail below, the interpositional implant **12** optionally interacts directly with an articulation surface **28** of the glenoid **G**, e.g., without any intermediate components between the interpositional implant **12** and the glenoid cavity. In some embodiments, and as shown in FIG. 1, the interpositional implant **12** also interacts directly with the articulation surface **24**, which is formed in the humerus **H** according to some methods of preparing the humerus **H** for receiving the interpositional implant **12**.

(21) In other embodiments, and as shown in FIG. 4, a joint system **10A** further includes one or both of a glenoid component **30** (e.g., implanted in a scapula **S** of the glenoid **G**) and/or a humeral component **32**, such as those described in U.S. Patent Application Publication 2009/0287309 (“the ‘309 Publication”), filed Dec. 17, 2008, and titled “Intra-Articular Joint Replacement,” the entire contents of which is incorporated herein by reference for all purposes.

(22) The glenoid component **30** includes an articular member **36** with a generally concave articular surface **38** that engages interpositional implant **12A**, where the interpositional implant **12A** is optionally substantially similar to the implant **12** and is laterally remote from the resected surface of the glenoid **G** in the sense that, if the articular member **36** were omitted, the interpositional implant **12A** would be directly juxtaposed with the glenoid **G** (e.g., as is shown in the system **10** of FIG. 1).

(23) The humeral component **32** optionally supplements, or reinforces, a recess **22A** in the humerus **H**, where the recess **22A** defines articulation surface **24A** substantially similar to articulation surface **24**. The humeral component **32** optionally includes an articular member **40** with a generally concave surface **42** formed from a resected portion of the humerus **H** and installed in the recess **22A** according to similar methodology to that described in the ‘309 Publication, for example.

Where both the glenoid and humeral components **30**, **32** are present, the interpositional implant **12A** is positioned between the articular member **36** of the glenoid component **30** and the articular

member **40** of the humeral component **16A**—the radius of the interpositional implant **12A** being typically equal to or less than the radii of the concave articular surfaces **38, 42**.

(24) FIG. 5 illustrates a surgical kit **50**, or kit of parts, used in association with some surgical methods for implanting the interpositional implant **12**. The kit **50** includes a plurality of reamers **60**, a plurality of test implants **62**, and a plurality of compactors **64**. The kit **50** also optionally includes wrenches, pilot hole tips/bits, cleaning tips/bits, and other components as desired. In some embodiments, the kit **50** is prepackaged as a sterile unit and/or is adapted to be sterilized prior to use (e.g., via autoclave).

(25) In some embodiments, the plurality of reamers **60** are described as forming or shaping tools and are provided in graduating sizes. The plurality of reamers **60** are generally indicated for use in preparing the recess **22** in the resected end of the humerus **H**. Each of the plurality of reamers includes a shaft **70** and a cutting head **72**. In some embodiments, one of the plurality of reamers **60** is a starter reamer **74** having a smaller cutting head diameter than the other reamers **60**. The starter reamer **74** is optionally utilized early in the formation process of the recess **22** in order to form initial cuts into the resected head of the humerus **H**, for example. In some embodiments, the starter reamer **74** is cannulated and includes an optional pilot tip (not shown), such as a sharp thin projection inserted into the cannulated reamer and projecting from the reamer tip to guide the reaming process. The reamers **60** are optionally adapted to have reaming diameters graduating in size from about 34 mm to about 46 mm (e.g., in 2 mm increments), although a variety of dimensions are contemplated.

(26) Each shaft **70** is optionally color coded and/or otherwise marked with indicia (e.g., lettering) which, as described in greater detail, indicates whether a particular reamer **60** belongs to a corresponding operational tool set, where the tool sets are generally grouped by size (e.g., corresponding to an expected size for the implant **12** to be placed in the resected head of the humerus **H**). The cutting head **72** of one of the plurality of reamers **60** is shown in FIG. 6, according to some embodiments. Each of the reamers **60** is optionally substantially similar other than differing generally in reaming diameter, and as such the cutting heads of the plurality of reamers **60** are described collectively with reference to the head **72** shown in FIG. 6.

(27) As shown in FIG. 6, the head **72** is generally dome-shaped and includes a plurality of arcuate blades **76**, the profiles of which define a cutting or forming surface. In particular, the head **72** has a substantially convex outer profile such that the head **72** is adapted to cut, or carve a generally concave recess into bone, e.g., into the resected head of the humerus **H**. The convex outer profile of the cutting head **72** extends at least through a full hemispherical arc that defines a reaming diameter of the cutting head **72**. In some embodiments, the head **72** is adapted to cut at least a full hemisphere and optionally includes an extended cutting portion **78** sweeping upward beyond a hemispherical cutting portion **79** of the cutting head **72**. By extending the diameter of cut to a full hemisphere or more, the head **72** is adapted to form fully hemispherical recesses and recesses deeper than the diameter of cut of the cutting head **72**. In some embodiments, the extended cutting portion **78** includes one or more demarcation lines **RL** for indicating one or more selected reaming depths (two are shown in FIG. 6, though more or less are employed as appropriate). In some embodiments, a first one of the demarcation lines **RL** is located approximately at a height corresponding to the transition from the hemispherical cutting portion **79** to the extended cutting portion **78** and a second one of the demarcation lines **RL** is located a pre-determined height above the first demarcation line **RL**, although a variety of heights are contemplated. As shown, the demarcation lines **RL** are optionally grooves formed into the blades **76** that are adapted or otherwise configured to be viewed by a surgeon during reaming.

(28) FIG. 7 shows a first test implant **62A** of the plurality of test implants **62** along with an associated handle **80** for manipulating the test implants **62**. In some embodiments, each of the test implants **62** is substantially similar other than differing generally in size and color, and as such the test implants **62** are described collectively with reference to the first test implant **62A** shown in



FIG. 7. Though the test implants **62** are shown as being substantially similar, it should be understood that test implants of differing shape, material, or other characteristic(s) are also contemplated.

(29) As shown, the first test implant **62A** is substantially spherical, or spheroid, and has one or more test depth lines DL. In some embodiments, a first one of the test depth lines DL is located approximately at a height corresponding to an equator of the first test implant **62A** and a second one of the test depth lines DL is located a pre-determined height above the first test depth line DL, although a variety of heights are contemplated. Although two test depth lines DL are shown in FIG. 7, a greater or fewer number are contemplated as appropriate. As referenced above, the first test implant **62A** is optionally color coded and is made of a material that is suitable for being temporarily implanted to check whether the implant **12** will perform as desired. The first test implant **62A** also includes a receptacle **82** for securing the first test implant **62A** to the handle **80**. For example, the receptacle **82** optionally includes female threads for mating with the handle **80**. In some embodiments, the test implants **62** having diameters graduating in size similar to the size selections available for the implant **12**, for example from about 36 mm to about 46 mm (e.g., in 2 mm increments), although a variety of dimensions are contemplated.

(30) As shown, the handle **80** includes an elongate shaft **84** terminating with a tip **86** suitable for connecting to the test implants **62**. For example, the tip **86** is optionally provided with male threads for securing the tip **86** to receptacles in the test implants **62**, such as the receptacle **82** in the first test implant **62A**.

(31) In some embodiments, the plurality of compactors **64** are described as forming or shaping tools and are provided in graduating sizes. Though generally used to form a compacted, more structurally sound surface, the compactors **64** are also optionally used to break up and remove pieces of bone as appropriate. In some embodiments, the plurality of compactors **64** include a starter compactor **90** (FIG. 8) with an optional pilot tip, a plurality of initial compactors **92** (such as the one shown in FIG. 9), and a plurality of final compactors **94** (such as the one shown in FIG. 10). As described further, and according to some methods, the starter compactor **90** is optionally used to begin the compacting process, one or more of the initial compactor **92** are used to continue the compacting process, and one of the final compactors **94** is used to finalize the recess **22** into a suitable depth and form for receiving the implant **12**.

(32) The starter compactor **90** shown in FIG. 8 has a convex compacting surface **100**, also described as a forming surface, that extends through a hemispherical arc and is adapted to break up and compact bone (e.g., cancellous or spongy bone) as it forms a substantially concave cavity. As shown, the convex compacting surface **100** is generally equal to a full hemisphere in shape as designated by the broken line in FIG. 8, although the compacting surface **100** is optionally extended beyond a full hemispherical shape. For example, in some embodiments the compacting surface **100** is continued to sweep beyond a hemispherical shape. As shown, the starter compactor **90** optionally includes a pilot tip **102** to help ensure an accurate starting point for forming the recess **22**. In some embodiments, the starter compactor **90** is adapted to have a forming/compacting diameter of about 20 mm, although a variety of dimensions are contemplated.

(33) The initial compactors **92** graduate in size and, through an iterative process, can be used to progressively form a larger and larger compacted recess into the resected end of the humerus H. The initial compactors **92** are optionally substantially similar other than differing generally in size, and as such the initial compactors **92** are described collectively with reference to a first initial compactor **92A** shown in FIG. 9. In some embodiments, the initial compactors **92** are adapted to have forming/compacting diameters graduating in size from about 22 mm to about 34 mm (e.g., in 2 mm increments), although a variety of dimensions are contemplated.

(34) The first initial compactor **92A** has a compacting surface **110** adapted to break up and compact bone (e.g., cancellous or spongy bone) as it forms a substantially concave cavity with the compacting surface **110**. Similarly to the starter compactor **90**, the convex compacting surface **110**

is equal to a full hemisphere in shape, although other configurations are contemplated. For example, in some embodiments the compacting surface **100** is continued and sweeps beyond the fully hemispherical shape.

(35) The final compactors **94** also graduate in size and are each optionally color coded to a corresponding one of the reamers **60** and test implants **62** forming one of the operational sets. For example, as shown in FIG. 5, each of the final compactors **94** includes indicia I, such as a colored dot, for indicating to which operational set the compactor **94** belongs. The final compactors **94** are optionally substantially similar other than differing generally in size, and as such the final compactors **94** are described collectively with reference to a first final compactor **94A** shown in FIG. 10. In some embodiments, the final compactors **92** are adapted to have forming/compacting diameters graduating in size from about 36 mm to about 46 mm (e.g., in 2 mm increments), although a variety of dimensions are contemplated.

(36) The first final compactor **94A** has a compacting surface **120** adapted to break up and compact bone (e.g., cancellous or spongy bone) as it forms a substantially concave cavity with the compacting surface **120**. As shown in FIG. 10, the compacting surface **120** defines a hemispherical portion **122** and an upswept portion **124**, where the compacting surface is extended, sweeping upward along a substantially straight line beyond the hemispherical portion **122** through the upswept portion **124**. In at least this manner, the compacting surface **120** is adapted to form/compact the recess **22** to a full hemisphere and to a depth greater than the forming/compacting diameter while helping ensure that substantially all, or at least a greater portion of, the articulation surface **24** is compacted and thereby reinforced for receiving the implant **12**.

(37) In some embodiments, the first final compactor **94A** defines one or more visible demarcation lines CL (e.g., a groove or line in the compacting surface **120**) at one or more predetermined heights from the bottom of the compacting surface **120** for delineating a desired forming/compacting depth at which to cease a compacting process. Although two demarcation lines CL are shown in FIG. 10, embodiments with greater or fewer demarcation lines are contemplated as appropriate. In some embodiments, the demarcation lines CL are provided in regular increments (e.g., 2 mm) for indicating a plurality of formation/compaction depths. In some embodiments, a first one of the demarcation lines CL is located approximately at a height corresponding to the transition from the hemispherical portion **122** to the upswept cutting portion **124** and a second one of the demarcation lines CL is located a pre-determined height above the first demarcation line CL, although a variety of heights are contemplated. Moreover, in some embodiments the demarcation lines RL, the test depth lines DL, and/or the demarcation lines CL are provided at corresponding heights to one another, such that a single operational set (described in further detail below) has a uniform set of depth markings on the tool used in a surgical joint repair/replacement procedure to form the recess **22** to a demarcated depth using the markings on the compactors **60** and reamers **64** and test the performance of the recess **22** to that depth using the markings on the test implant **62**.

(38) As referenced above, in some embodiments the reamers **60**, test implants **62**, and final compactors **94** graduate in size and are color coded and/or include indicia (e.g., writing) to group reamers **60**, test implants **62**, and compactors **64** into operational sets. For example, a single operational set is optionally designated by a single color, where the single operational set includes one of the reamers **60**, one of the test implants **62**, and one of the compactors **64**. Table 1 that follows is provided as an illustrative example and shows diametrical reaming/forming/test dimensions corresponding to a plurality of graduating, color coded operational sets, according to some embodiments, although other dimensions, color coding, and/or other indicia are contemplated.

(39) TABLE-US-00001

TABLE 1	Operational Sets	Compactor	Reamer	Test Implant	Operational Set
Diameter	Coding	Coding	Coding	1	36 mm Red Red Red
2	38 mm Yellow Yellow Yellow	3	40 mm Green Green Green	4	42 mm Blue Blue Blue
5	44 mm Grey Grey Grey	6	46 mm White White		

White

(40) In view of the foregoing, a surgeon or other user provided with the surgical kit **50** is able to quickly and reliably select an operational tool set for a particular implant size.

(41) Some methods for implanting the interpositional implant **12** to form the joint system **10** are described below with reference to FIGS. **1-10** (previously discussed) and FIGS. **11-14** which are illustrative of a method of selecting an appropriate depth of implantation.

(42) In some embodiments, a preoperative assessment of the existing (e.g., degenerated) joint system in the patient is performed. The preoperative assessment optionally includes using frontal and axillary radiographs, as well as CT scanning to evaluate orientation of the glenoid G, quality of bone stock in the humerus H and glenoid G, and any muscle degeneration of the rotator cuff, for example. Based upon the preoperative assessment, the surgeon makes an initial determination of the optimal size and/or shape of the implant **12**. In some embodiments, the implant **12** is available in a variety of diameters, where the surgeon or other user initially selects from a plurality of sizes (e.g., such as 36 mm, 38 mm, 40 mm, 42 mm, 44 mm, and 46 mm diameter spheres, although a variety of dimensions are contemplated). From the foregoing, in some embodiments, each of the sizes has a corresponding operational set to be used during implantation, such as those shown in Table 1.

(43) Exposure of the humerus H and glenoid G is optionally accomplished via any of a variety of techniques. In some embodiments, the surgical incision is made using a deltopectoral approach to the humerus H and glenoid G. The incision is made from a tip of the coracoid process and follows the deltopectoral groove. The upper part of the pectoralis major is optionally released to improve external rotation, the clavipectoral fascia is incised at an outer edge of the coracobiceps, and the acromioclavicular ligament is partially severed to facilitate exposure of the sub-scapular and circumflex vessels. The circumflex vessels are then ligated to achieve hemostasis during the entire surgical procedure. The axillary nerve is identified and protected. After the superior arthrotomy, the subscapularis is incised with the capsule to about an inch and a half of the bicipital groove at the neck anatomy. By raising the arm in adduction and external rotation and retropulsion, the humeral head is then dislocated forward. The anterior capsule is released from front to back, allowing the exposure of osteophytes. Ultimately, the humeral head is freed and displaced from the glenoid G and exposed for processing.

(44) As indicated in FIG. **11**, once dislocated, the humeral head HH is resected (e.g., at the anatomical neck AN) to form a resected end defining a resection plane O (FIG. **12**). Transverse dimensions of the anatomical neck AN or the resected humeral head are then measured using calipers or other measuring tool in at least two planes to assess the size of implant use. In some embodiments, the two planes are generally perpendicular to one another, such as the antero-posterior and superoinferior planes. In some embodiments, where the measurements along the planes are different from one another, the smallest of the measurements is selected as the humeral head size. In some embodiments, the implant size is either initially selected or is confirmed to be about 2 mm to about 4 mm below the humeral head size.

(45) In order to determine a depth at which the implant **12** is to be installed (or alternatively, to what depth the recess **22** should be formed), the smallest of the resected end measurements is selected as the initial resected end diameter D.

(46) As shown in FIG. **12**, based upon empirical or other data, the resected end diameter D is correlated to a predicted projection height A, also described as a desired projection height A, of the implant **12** above the resection plane O that will help ensure proper tensioning of the glenohumeral joint once the implant is received by the glenoid G and the joint has healed. For example, empirical data may be obtained relating to natural projection heights (i.e., in healthy joints) of the humeral head relative to humeral head diameter at the anatomical neck. A thickness of the cortical bone at the resection plane O is either estimated via empirical data or is directly measured using any of a variety of techniques (e.g., using a micrometer, radiographs, and others). In some embodiments, the

implant diameter (and, therefore implant radius B) is selected by subtracting the thickness T of the cortical bone from the end diameter D ( $D - (2 \times T) = \text{implant diameter}$ ). As shown in FIGS. **12** and **13**, generally, the radius B of the implant **12** is greater than the predicted projection height A, such that B minus A equals the depth the midline M of the implant **12** is preferably pushed down with respect to the resection plane O in order to help ensure the surface of the implant **12** projecting from the recess **22** is well-positioned for proper tensioning of the joint as shown in FIG. **14**. In terms of implant height, the depth the midline M is depressed with respect to the resection plane O is one-half the implant height minus the predicted projection height A.

(47) In some embodiments, after a diameter of the implant **12** is selected and the depth of the recess **22** is determined, the recess **22** is formed according to a reaming and compacting process. With the implant diameter known, the surgeon selects the corresponding operational set (one of the reamers **60**, one of the test implants **62**, and one of the compactors **64**) for forming the recess **22**.

(48) The reaming and compacting processes are generally used iteratively to form the recess **22** with an adequate depth. As previously referenced, the reamers **60** are well suited to forming a fully hemispherical and/or deeper shape for the recess **22** (in comparison to traditional reamers that terminate the cutting surface prior to a full hemisphere).

(49) Similarly, the compactors **64** are also well suited to forming fully hemispherical recesses and/or deeper recesses. In some embodiments, the visible demarcation on each of the final compactors **94** (e.g., visible demarcation CL) corresponds to the desired depth to which the recess is to be formed and compacted relative to the resection plane O, which, in some embodiments is greater than the radius B of the implant **12** by an amount corresponding to the implant radius B minus the predicted projection height A. Using the visible demarcations, such as demarcation CL, a surgeon performing the compacting process is readily able to visualize when the desired recess depth has been achieved.

(50) The compacting process is particularly useful to reinforce the articulation surface **24**. For example, compacting helps artificially densify the spongy metaphyseal bone, building a stronger lining or floor to receive the implant **12**. It has been surprisingly found that by using a relatively low Young's modulus for the implant **12** (e.g., low relative to titanium, for example), further bone densification of the articulation surface **24** is encouraged over time during operational loading, but without overly stressing the articulation surface **24**. Eventually, the bone density at the surface **24** may approach that of the cortical bone of the humerus, as generally indicated in FIG. **14** by the continuous, white region on the exterior surface and recess **22** of the humerus H.

(51) In some embodiments, compaction begins with the starter compactor **90** (e.g., being of 20 mm diameter). The starter compactor **90** helps initially center the recess **22** in the middle of the resection plane O and ensures that the recess **22** remains centered during ensuing compacting/reaming with larger diameter tools.

(52) Compaction of the metaphyseal bone continues by gradually increasing the diameter of compaction with the initial compactors **92** until one of the final compactors **94** corresponding to the operational set that has been selected is used to form the recess **22** to its final, predetermined size. The starter compactor **90** and initial compactors **92** are generally only inserted to the depth of their respective compacting surfaces (e.g., only up to a single radial depth of cut) to help ensure that the recess **22** is not initially formed too deep. Thus, in some embodiments, each of the starter and initial compactors **90**, **92** is inserted to the end of the cutting surface, which marks the height corresponding to a hemisphere. In some embodiments, this also helps avoid risk of humeral fracture during the initial compacting phases.

(53) Once the recess **22** is sufficiently formed, the final compactor **94** of the selected operational set is used to form the recess **22** to the predetermined depth by compacting the articulation surface **24** with the final compactor **94** until the demarcation line is generally parallel with the resection plane O. If, during the process, it appears that the final compactor **94** will contact the external cortical bone, or if the final compactor **94** actually begins to contact the cortical bone, the surgeon

optionally switches to a smaller diameter for the implant **12**.

(54) Additionally, where the quality of the metaphyseal bone is poor, the surgeon optionally strengthens the articulation surface **24** during compaction by packing pieces of bone grafts taken from the humeral head into the recess **22**. Depending on the quality of the bone in the humerus **H**, the compacting and reaming process can lead to an opening on the medullary canal at the bottom of the newly-created articulation surface **24**. In some embodiments, the surgeon blocks or plugs such an opening with a plug material (e.g., a cement or bone slurry) or using a plug built using the resected head (e.g., similar to the articular member **36** of the joint system **10A** shown in FIG. **4**).

(55) Alternatively, if the cancellous bone is dense and inhibits satisfactory preparation of the recess **22**, the reamers **60** are used to mill/ream the recess **22**, where reaming stops once the reamer **60** has been inserted to the full hemispherical depth of the cutting surface of the reamer **60**. Where reaming is needed, the recess **22** is prepared by starting with a smaller reamer diameter (e.g., 34 mm) and gradually increasing the reamer diameter up to the selected diameter of the implant **12**. As previously mentioned, reaming and compaction are optionally used interchangeably by the surgeon until a satisfactory depth for the recess **22** is achieved and the articulation surface **24** is in an acceptable state.

(56) Once the recess **22** has been formed as desired, the test implant **62** of the selected operational set is selected. For example, using the color coding previously mentioned, the test implant **62** of the same color as the final reamer **60** and final compactor **64** is used. The test implant **62** is assembled onto the handle **80**. The test implant **62** is then introduced in the recess **22**. The test depth lines **DL** of the test implant **62** help the surgeon visualize whether the test implant **62** has been sufficiently inserted into the recess **22** and, in turn, whether the recess **22** is formed to a sufficient depth. The test implant **62** is then placed into contact with the glenoid **G** to allow articulation about the test implant **62**. Stability and mobility testing is performed by physically manipulating the humerus. During testing the handle **80** is optionally removed to facilitate freedom of movement and later resecured to the test implant **62** for removal thereof from the recess **22**. During the stability and mobility testing, the surgeon verifies there is no gleno-humeral impingement or impingement between the humerus and the acromion.

(57) The test implant **62** is removed after testing with the aid of the handle **80**. If the surgeon perceives too much tension in the muscles or articulation of the joint appears particularly tight, a smaller test implant **62** is and/or a smaller size of the implant **12** is selected or the surgeon optionally attempts to depress the test implant **62** further into the recess **22** and/or depress the implant **12** further into the recess upon implantation thereof. If the surgeon perceives insufficient tension in the muscles and/or in the case of gleno-humeral impingement, a larger size for the test implant **62** and/or implant **12** can be selected instead, with additional compacting/reaming steps as appropriate.

(58) Once the testing is completed to the surgeon's satisfaction, the implant **12** of the selected size (typically of the same diameter as the test implant **62**) is then selected and introduced into the recess **22**. In some embodiments, where the implant **12** is formed of pyrocarbon, for example, it is important that the surface of the implant **12** not be maned or otherwise damaged. For example, the implant **12** should not be impacted into place in the recess **22**. The implant **12** is not cemented or otherwise fixed in the recess **22** according to some embodiments. The joint is reformed with the implant **12** in place, for example, according to the general methodology that follows.

(59) The scapula **S** is repaired tendon-by-tendon as necessary and the aid of bone sutures secured to the humerus are used as needed. Where fixed to the humerus, the tendon is optionally displaced medially to promote recoupration and external rotation. Wound closure proceeds step-by-step in a traditional manner and the arm can be immobilized with a sling, for example. Generally, the same post operatives are recommended to that of a total prosthesis joint replacement (e.g., non-strenuous exercise and work resumed the first day after surgery with a sufficient waiting period before increased stretching/movement of the joint).

(60) Various modifications, permutations, and additions can be made to the exemplary embodiments and aspects of the embodiments discussed without departing from the scope of the present invention. For example, while the embodiments describe concave articular surface above refer to particular features, the scope of this invention also includes embodiments having different combinations of features and embodiments that do not include all of the features. Accordingly, the scope of the present invention is intended to embrace all such alternatives, modifications, permutations, and variations as fall within the scope of the claims, together with all equivalents thereof.

## Claims

1. A method of repairing a joint, the method comprising: exposing a first bone of the joint; resecting an end portion of the first bone to form a resected end defining a resection plane; forming a concavity in the resected end portion of the first bone using a shaping tool, the concavity extending at least through a full hemispherical arc; selecting a diameter of the prosthesis to be implanted; and implanting a prosthesis having the selected diameter in the concavity.
  2. The method of claim 1, wherein forming the concavity comprises compacting the resected end portion of the first bone with a plurality of compactors having gradually increasing diameters.
  3. The method of claim 1, wherein forming the cavity comprises shaping the resected end portion of the first bone until a demarcation line on the shaping tool is parallel with the resection plane.
  4. The method of claim 3, wherein the demarcation line is at a position on the shaping tool that corresponds to a diameter of the prosthesis minus a predicted projection height of the prosthesis above the resected end that promotes adequate tensioning of the joint.
  5. The method of claim 1, wherein forming the concavity comprises reaming the resected end portion of the first bone with a plurality of reamers having gradually increasing diameters.
  6. The method of claim 1, wherein forming the concavity comprises iteratively compacting and reaming the resected end portion of the first bone.
  7. The method of claim 1, further comprising selecting a test prosthesis based on a final shaping tool used to form the concavity.
  8. The method of claim 7, further comprising selecting the test prosthesis having a same color as the final shaping tool.
  9. The method of claim 7, further comprising introducing the test prosthesis into the concavity.
  10. The method of claim 9, further comprising confirming the concavity is formed to a sufficient depth using depth lines on the test prosthesis.
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