US Patent & Trademark Office
Patent Public Search | Text View

United States Patent	12383246
Kind Code	B2
Date of Patent	August 12, 2025
Inventor(s)	Reynolds; Timothy C. et al.

Vessel closure device with improved safety and tract hemostasis

Abstract

A vessel closure device for delivering immediate hemostasis at a puncture site in a wall of a blood vessel includes an intravascular anchor having one or more suture attachment points, an extravascular cap having a lumen, a sealant, and a suture connected to at least one of the one or more suture attachment points of the intravascular anchor and threaded through the lumen of the extravascular cap, wherein each of the intravascular anchor, extravascular cap, sealant, and suture are formed of bioabsorbable materials.

Inventors: **Reynolds; Timothy C. (Sunnyvale, CA), Fortson; Aaron M. (Fremont, CA)**

Applicant: **Abbott Cardiovascular Systems, Inc.** (Santa Clara, CA)

Family ID: **1000008747687**

Assignee: **Abbott Cardiovascular Systems, Inc. (Santa Clara, CA)**

Appl. No.: **17/492418**

Filed: **October 01, 2021**

Prior Publication Data

Document Identifier	Publication Date
US 20220110617 A1	Apr. 14, 2022

Related U.S. Application Data

us-provisional-application US 63114202 20201116
us-provisional-application US 63090556 20201012

Publication Classification

Int. Cl.: **A61B17/00** (20060101); **A61L24/04** (20060101); **A61L31/06** (20060101); **A61L31/14** (20060101); A61L24/00 (20060101)

U.S. Cl.:

CPC **A61B17/0057** (20130101); **A61L24/046** (20130101); **A61L31/06** (20130101); **A61L31/148** (20130101); A61B2017/00592 (20130101); A61B2017/00597 (20130101); A61B2017/00615 (20130101); A61B2017/0065 (20130101); A61B2017/00663 (20130101); A61L24/0042 (20130101)

Field of Classification Search

CPC: A61B (17/0057); A61B (2017/00592); A61B (2017/00597); A61B (2017/00615); A61B (2017/0065); A61B (2017/00663); A61L (24/046); A61L (31/06); A61L (31/148); A61L (24/0042)

References Cited

U.S. PATENT DOCUMENTS

Patent No.	Issued Date	Patentee Name	U.S. Cl.	CPC
1147743	12/1914	Melvin	N/A	N/A
1413255	12/1921	Cason	N/A	N/A
2950722	12/1959	Mellon	N/A	N/A
3028648	12/1961	Renaud	N/A	N/A
3928128	12/1974	Kollmar et al.	N/A	N/A
4195013	12/1979	De Zarauz	N/A	N/A
4477634	12/1983	Linder et al.	N/A	N/A
4526938	12/1984	Churchill et al.	N/A	N/A
4712566	12/1986	Hoek	N/A	N/A
4745160	12/1987	Churchill et al.	N/A	N/A
4890612	12/1989	Kensey	606/213	A61B 17/0057
4936310	12/1989	Engstroem et al.	N/A	N/A
4941473	12/1989	Tenerz et al.	N/A	N/A
4942035	12/1989	Churchill et al.	N/A	N/A
4944308	12/1989	Aangstroem Kerfeldt	N/A	N/A
5018529	12/1990	Tenerz et al.	N/A	N/A
5085223	12/1991	Lars et al.	N/A	N/A
5092857	12/1991	Fleischhacker	N/A	N/A
5125058	12/1991	Tenerz et al.	N/A	N/A
5129889	12/1991	Hahn et al.	N/A	N/A
5143661	12/1991	Lawter et al.	N/A	N/A
5217495	12/1992	Kaplan et al.	N/A	N/A
5225521	12/1992	Spinu	N/A	N/A
5226423	12/1992	Tenerz et al.	N/A	N/A
5229528	12/1992	Brake et al.	N/A	N/A
5236431	12/1992	Gogolewski et al.	N/A	N/A
5264614	12/1992	Brake	N/A	N/A
5264617	12/1992	Brake	N/A	N/A

5264626	12/1992	Brake et al.	N/A	N/A
5268507	12/1992	Brake	N/A	N/A
5278256	12/1993	Bellis	N/A	N/A
5280427	12/1993	Magnusson et al.	N/A	N/A
5282827	12/1993	Kensey et al.	N/A	N/A
5307811	12/1993	Sigwart et al.	N/A	N/A
5342627	12/1993	Chopra et al.	N/A	N/A
5350399	12/1993	Erlebacher et al.	N/A	N/A
5364408	12/1993	Gordon	N/A	N/A
5371176	12/1993	Bezwada et al.	N/A	N/A
5378801	12/1994	Reichert et al.	N/A	N/A
5411520	12/1994	Nash	606/151	F16G 11/101
5462983	12/1994	Bloembergen et al.	N/A	N/A
5470829	12/1994	Prisell et al.	N/A	N/A
5529736	12/1995	Shalaby et al.	N/A	N/A
5531759	12/1995	Kensey	604/15	A61B 17/0401
5534150	12/1995	Bastioli et al.	N/A	N/A
5540715	12/1995	Katsaros et al.	N/A	N/A
5540929	12/1995	Narayan et al.	N/A	N/A
5542427	12/1995	Angstrom Kerfeldt	N/A	N/A
5630833	12/1996	Katsaros et al.	N/A	N/A
5641502	12/1996	Skalla et al.	N/A	N/A
5649959	12/1996	Hannam et al.	N/A	N/A
5662681	12/1996	Nash et al.	N/A	N/A
5674231	12/1996	Green et al.	N/A	N/A
5676689	12/1996	Kensey et al.	N/A	N/A
5694946	12/1996	Tenerz et al.	N/A	N/A
5697943	12/1996	Sauer et al.	N/A	N/A
5700901	12/1996	Hurst et al.	N/A	N/A
5702716	12/1996	Dunn et al.	N/A	N/A
5707393	12/1997	Kensey et al.	N/A	N/A
5739176	12/1997	Dunn et al.	N/A	N/A
5741283	12/1997	Fahy	N/A	N/A
5753234	12/1997	Lee et al.	N/A	N/A
5810746	12/1997	Goldstein et al.	N/A	N/A
5810826	12/1997	Angstrom et al.	N/A	N/A
5868684	12/1998	Aakerfeldt et al.	N/A	N/A
5908149	12/1998	Welch et al.	N/A	N/A
5916585	12/1998	Cook et al.	N/A	N/A
5938624	12/1998	Akerfeldt et al.	N/A	N/A
5972023	12/1998	Tanner et al.	N/A	N/A
5984853	12/1998	Smith	N/A	N/A
5997568	12/1998	Liu	N/A	N/A
6045570	12/1999	Epstein et al.	N/A	N/A
6056768	12/1999	Cates et al.	N/A	N/A
6074395	12/1999	Trott et al.	N/A	N/A
6089103	12/1999	Smith	N/A	N/A
6090052	12/1999	Akerfeldt et al.	N/A	N/A
6093201	12/1999	Cooper et al.	N/A	N/A
6106486	12/1999	Tenerz et al.	N/A	N/A

6112598	12/1999	Tenerz et al.	N/A	N/A
6162962	12/1999	Hinsch et al.	N/A	N/A
6179863	12/2000	Kensey et al.	N/A	N/A
6182513	12/2000	Stemme et al.	N/A	N/A
6184313	12/2000	Roovers et al.	N/A	N/A
6193951	12/2000	Ottoboni et al.	N/A	N/A
6194050	12/2000	Koerber et al.	N/A	N/A
6203802	12/2000	Handjani et al.	N/A	N/A
6241732	12/2000	Overaker et al.	N/A	N/A
6241740	12/2000	Davis et al.	N/A	N/A
6248083	12/2000	Smith et al.	N/A	N/A
6264673	12/2000	Egneloev et al.	N/A	N/A
6312380	12/2000	Hoek et al.	N/A	N/A
6332884	12/2000	Cooper	N/A	N/A
6335383	12/2001	Scopelianos et al.	N/A	N/A
6352667	12/2001	English	N/A	N/A
6368341	12/2001	Abrahamson	N/A	N/A
6391036	12/2001	Berg et al.	N/A	N/A
6409677	12/2001	Tulkki	N/A	N/A
6425911	12/2001	Akerfeldt et al.	N/A	N/A
6428336	12/2001	Akerfeldt	N/A	N/A
6461301	12/2001	Smith	N/A	N/A
6462169	12/2001	Shalaby	N/A	N/A
6477233	12/2001	Ribbing et al.	N/A	N/A
6485503	12/2001	Jacobs et al.	N/A	N/A
6494848	12/2001	Sommercorn et al.	N/A	N/A
6503266	12/2002	Sjoegren et al.	N/A	N/A
6508828	12/2002	Akerfeldt et al.	N/A	N/A
6511748	12/2002	Barrows	N/A	N/A
6517859	12/2002	Tice et al.	N/A	N/A
6561966	12/2002	Smith et al.	N/A	N/A
6565514	12/2002	Svanerudh et al.	N/A	N/A
6565875	12/2002	Tice et al.	N/A	N/A
6582971	12/2002	Singh et al.	N/A	N/A
6590061	12/2002	Rypacek et al.	N/A	N/A
6596012	12/2002	Akerfeldt et al.	N/A	N/A
6605090	12/2002	Trieu et al.	N/A	N/A
6605294	12/2002	Sawhney	N/A	N/A
6613089	12/2002	Estes et al.	N/A	N/A
6615067	12/2002	Hoek et al.	N/A	N/A
6615667	12/2002	Smith	N/A	N/A
6623418	12/2002	Smith	N/A	N/A
6623509	12/2002	Ginn	N/A	N/A
6626919	12/2002	Swanstrom	N/A	N/A
6645226	12/2002	Jacobs	N/A	N/A
6663653	12/2002	Akerfeldt	N/A	N/A
6685707	12/2003	Roman et al.	N/A	N/A
6685956	12/2003	Chu et al.	N/A	N/A
6689374	12/2003	Chu et al.	N/A	N/A
6692446	12/2003	Hoek	N/A	N/A

6696073	12/2003	Boyce et al.	N/A	N/A
6706854	12/2003	Buchholz et al.	N/A	N/A
6712837	12/2003	Aakerfeldt et al.	N/A	N/A
6754608	12/2003	Svanerudh et al.	N/A	N/A
6758863	12/2003	Estes et al.	N/A	N/A
6770717	12/2003	Kim et al.	N/A	N/A
6786915	12/2003	Akerfeldt et al.	N/A	N/A
6790455	12/2003	Chu et al.	N/A	N/A
6794484	12/2003	Newman et al.	N/A	N/A
6794485	12/2003	Shalaby et al.	N/A	N/A
6827727	12/2003	Staalemark et al.	N/A	N/A
6830747	12/2003	Lang et al.	N/A	N/A
6846313	12/2004	Rogers et al.	N/A	N/A
6858238	12/2004	Lee et al.	N/A	N/A
6881434	12/2004	Pokropinski et al.	N/A	N/A
6887974	12/2004	Pathak	N/A	N/A
6893431	12/2004	Naimark et al.	N/A	N/A
6893452	12/2004	Jacobs	N/A	N/A
6896692	12/2004	Ginn et al.	N/A	N/A
6916788	12/2004	Seo et al.	N/A	N/A
6926674	12/2004	Tenerz et al.	N/A	N/A
6926903	12/2004	Pirhonen et al.	N/A	N/A
6929655	12/2004	Egneloev et al.	N/A	N/A
6932824	12/2004	Roop et al.	N/A	N/A
6938474	12/2004	Melvaas	N/A	N/A
6939363	12/2004	Aakerfeldt	N/A	N/A
6942674	12/2004	Belef et al.	N/A	N/A
6949251	12/2004	Dalal et al.	N/A	N/A
6958158	12/2004	Tenhuisen et al.	N/A	N/A
6960352	12/2004	Noujaim et al.	N/A	N/A
6969391	12/2004	Gazzani	N/A	N/A
6993974	12/2005	Tenerz et al.	N/A	N/A
7011636	12/2005	Tenerz	N/A	N/A
7011678	12/2005	Tenerz et al.	N/A	N/A
7021152	12/2005	Tenerz	N/A	N/A
7025776	12/2005	Houser et al.	N/A	N/A
7026437	12/2005	Shalaby et al.	N/A	N/A
7030097	12/2005	Saltzman et al.	N/A	N/A
7044916	12/2005	Tenerz et al.	N/A	N/A
7060299	12/2005	Alavattam et al.	N/A	N/A
7070858	12/2005	Shalaby et al.	N/A	N/A
7073509	12/2005	Tenerz et al.	N/A	N/A
7074412	12/2005	Weber	N/A	N/A
7086172	12/2005	Aastroem	N/A	N/A
7094209	12/2005	Egneloev et al.	N/A	N/A
7122037	12/2005	Happonen et al.	N/A	N/A
7129319	12/2005	Shalaby	N/A	N/A
7135032	12/2005	Aakerfeldt	N/A	N/A
7156862	12/2006	Jacobs et al.	N/A	N/A
7160592	12/2006	Rypacek et al.	N/A	N/A

7162303	12/2006	Levin et al.	N/A	N/A
7172593	12/2006	Trieu et al.	N/A	N/A
7172765	12/2006	Chu et al.	N/A	N/A
7222539	12/2006	Tulkki	N/A	N/A
7250057	12/2006	Forsberg	N/A	N/A
7264641	12/2006	Prasad	N/A	N/A
7285097	12/2006	Tenerz et al.	N/A	N/A
7323190	12/2007	Chu et al.	N/A	N/A
7326088	12/2007	Tulkki	N/A	N/A
7329270	12/2007	Aakerfeldt et al.	N/A	N/A
7331236	12/2007	Smith et al.	N/A	N/A
7331979	12/2007	Khosravi et al.	N/A	N/A
7335220	12/2007	Khosravi et al.	N/A	N/A
7338514	12/2007	Wahr et al.	N/A	N/A
7343811	12/2007	Tenerz et al.	N/A	N/A
7350479	12/2007	Evans et al.	N/A	N/A
7357793	12/2007	Pacetti	N/A	N/A
7364768	12/2007	Rypacek et al.	N/A	N/A
7387994	12/2007	Stewart et al.	N/A	N/A
7416559	12/2007	Shalaby	N/A	N/A
7445625	12/2007	Aakerfeldt	N/A	N/A
7450989	12/2007	Svanerudh	N/A	N/A
7472601	12/2008	Tenerz et al.	N/A	N/A
7481839	12/2008	Zucherman et al.	N/A	N/A
7488761	12/2008	Ricci et al.	N/A	N/A
7494950	12/2008	Armitage et al.	N/A	N/A
7510566	12/2008	Jacobs et al.	N/A	N/A
7541049	12/2008	Toermaelae et al.	N/A	N/A
7553919	12/2008	Narayan et al.	N/A	N/A
7575780	12/2008	Alexander et al.	N/A	N/A
7582110	12/2008	Case et al.	N/A	N/A
7597705	12/2008	Forsberg et al.	N/A	N/A
7618436	12/2008	Forsberg	N/A	N/A
7618438	12/2008	White et al.	N/A	N/A
7621937	12/2008	Pipenhagen et al.	N/A	N/A
7635341	12/2008	Doorschodt	N/A	N/A
7637921	12/2008	Aakerfeldt et al.	N/A	N/A
7637924	12/2008	Gifford et al.	N/A	N/A
7645233	12/2009	Tulkki et al.	N/A	N/A
7648493	12/2009	Forsberg et al.	N/A	N/A
7654963	12/2009	Egneloev et al.	N/A	N/A
7674396	12/2009	Sterling et al.	N/A	N/A
7682603	12/2009	Hammer et al.	N/A	N/A
7713283	12/2009	Forsberg	N/A	N/A
7717929	12/2009	Faellman	N/A	N/A
7722914	12/2009	Shalaby	N/A	N/A
7724148	12/2009	Samuelsson et al.	N/A	N/A
7731726	12/2009	Belhe et al.	N/A	N/A
7744916	12/2009	Pauletti et al.	N/A	N/A
7749247	12/2009	Tegg	N/A	N/A

7749248	12/2009	White et al.	N/A	N/A
7776100	12/2009	Brekke et al.	N/A	N/A
7786220	12/2009	Lee et al.	N/A	N/A
7789887	12/2009	Roop et al.	N/A	N/A
7789893	12/2009	Drasler et al.	N/A	N/A
7790192	12/2009	Sawhney et al.	N/A	N/A
7806856	12/2009	Bagaoisan et al.	N/A	N/A
7824417	12/2009	Magnusson et al.	N/A	N/A
7828845	12/2009	Estes et al.	N/A	N/A
7837705	12/2009	White et al.	N/A	N/A
7842261	12/2009	Van et al.	N/A	N/A
7850614	12/2009	Haldeman	N/A	N/A
7850654	12/2009	Belhe et al.	N/A	N/A
7850710	12/2009	Huss	N/A	N/A
7863352	12/2010	Ricci et al.	N/A	N/A
7875052	12/2010	Kawaura et al.	N/A	N/A
7879355	12/2010	Sterling et al.	N/A	N/A
7897167	12/2010	Armstrong et al.	N/A	N/A
7926567	12/2010	Harris et al.	N/A	N/A
7931670	12/2010	Fiehler et al.	N/A	N/A
7931671	12/2010	Tenerz	N/A	N/A
7938846	12/2010	Kerfeldt et al.	N/A	N/A
7946997	12/2010	Huebinette	N/A	N/A
7951177	12/2010	Trieu et al.	N/A	N/A
7955616	12/2010	Kronenthal	N/A	N/A
7967761	12/2010	Smith	N/A	N/A
7972359	12/2010	Kreidler	N/A	N/A
7976564	12/2010	Blaeser et al.	N/A	N/A
7988706	12/2010	Forsberg	N/A	N/A
7988892	12/2010	Eisenhut et al.	N/A	N/A
7993367	12/2010	Bagaoisan et al.	N/A	N/A
7997054	12/2010	Bertsch et al.	N/A	N/A
7998089	12/2010	Smith	N/A	N/A
8002742	12/2010	Pai et al.	N/A	N/A
8007514	12/2010	Forsberg	N/A	N/A
8012167	12/2010	Zhu et al.	N/A	N/A
8016841	12/2010	Magnusson et al.	N/A	N/A
8021678	12/2010	Hossainy et al.	N/A	N/A
8021869	12/2010	Chu et al.	N/A	N/A
8029532	12/2010	Sirota	N/A	N/A
8029533	12/2010	Bagaoisan et al.	N/A	N/A
8038628	12/2010	Von et al.	N/A	N/A
8038687	12/2010	Pipenhagen et al.	N/A	N/A
8048086	12/2010	Lee-Sepsick et al.	N/A	N/A
8050067	12/2010	Fulcher et al.	N/A	N/A
8057817	12/2010	Shalaby	N/A	N/A
8075531	12/2010	Davey	N/A	N/A
8075589	12/2010	Pipenhagen et al.	N/A	N/A
8076388	12/2010	Shalaby et al.	N/A	N/A
8080034	12/2010	Bates et al.	N/A	N/A

8080035	12/2010	Lim et al.	N/A	N/A
8083755	12/2010	Mathisen et al.	N/A	N/A
8083768	12/2010	Ginn et al.	N/A	N/A
8088143	12/2011	Aakerfeldt	N/A	N/A
8088145	12/2011	Zhu et al.	N/A	N/A
8105352	12/2011	Egneloev	N/A	N/A
8109274	12/2011	Horne et al.	N/A	N/A
8109889	12/2011	Von et al.	N/A	N/A
8109945	12/2011	Boehlke	N/A	N/A
8114102	12/2011	Galdonik et al.	N/A	N/A
8114123	12/2011	Brenzel et al.	N/A	N/A
8118831	12/2011	Egneloev et al.	N/A	N/A
8128652	12/2011	Paprocki	N/A	N/A
8133225	12/2011	Pieske	N/A	N/A
8147860	12/2011	Rosenberg et al.	N/A	N/A
8156897	12/2011	Evans et al.	N/A	N/A
8187195	12/2011	Tulkki	N/A	N/A
8211351	12/2011	Gogolewski	N/A	N/A
8216359	12/2011	Lee et al.	N/A	N/A
8221781	12/2011	Rosenberg et al.	N/A	N/A
8226715	12/2011	Hwang et al.	N/A	N/A
8231686	12/2011	Mangiardi	N/A	N/A
8257394	12/2011	Saadat et al.	N/A	N/A
8267942	12/2011	Szabo et al.	N/A	N/A
8267959	12/2011	Faellman	N/A	N/A
8273094	12/2011	Belhe et al.	N/A	N/A
8277481	12/2011	Kawaura et al.	N/A	N/A
8277482	12/2011	Hruska et al.	N/A	N/A
8277831	12/2011	Young et al.	N/A	N/A
8298259	12/2011	Terwey	N/A	N/A
8299205	12/2011	Shalaby et al.	N/A	N/A
8302376	12/2011	Bertsch et al.	N/A	N/A
8308758	12/2011	Aakerfeldt	N/A	N/A
8308759	12/2011	Olsen et al.	N/A	N/A
8308762	12/2011	Mahlin et al.	N/A	N/A
8317679	12/2011	Surti	N/A	N/A
8317824	12/2011	Jenson et al.	N/A	N/A
8323351	12/2011	Kubena et al.	N/A	N/A
8347891	12/2012	Demarais et al.	N/A	N/A
8348917	12/2012	Beckman et al.	N/A	N/A
8348971	12/2012	Khanna et al.	N/A	N/A
8371142	12/2012	Nypeloe et al.	N/A	N/A
8382752	12/2012	Ootsubo	N/A	N/A
8382776	12/2012	Ducharme	N/A	N/A
8382793	12/2012	Egneloev et al.	N/A	N/A
8382797	12/2012	Khosravi et al.	N/A	N/A
8394488	12/2012	Dave et al.	N/A	N/A
8398675	12/2012	Egneloev	N/A	N/A
8398705	12/2012	Mangiardi	N/A	N/A
8399409	12/2012	Lynch et al.	N/A	N/A

8403868	12/2012	Von et al.	N/A	N/A
8404268	12/2012	Lee et al.	N/A	N/A
8409249	12/2012	Hnojewyj et al.	N/A	N/A
8420114	12/2012	Zanella et al.	N/A	N/A
8430906	12/2012	Forsberg et al.	N/A	N/A
8444673	12/2012	Thielen et al.	N/A	N/A
RE44297	12/2012	Aakerfeldt et al.	N/A	N/A
8454988	12/2012	Rosenberg et al.	N/A	N/A
8469944	12/2012	Mahlin	N/A	N/A
8469994	12/2012	Lafontaine	N/A	N/A
8470360	12/2012	McKay	N/A	N/A
8475829	12/2012	Sebree et al.	N/A	N/A
8475830	12/2012	Sebree et al.	N/A	N/A
8479585	12/2012	Shaw-Klein	N/A	N/A
8480651	12/2012	Abuzaina et al.	N/A	N/A
8480707	12/2012	Pavcnik et al.	N/A	N/A
8500776	12/2012	Ebner	N/A	N/A
8506592	12/2012	Killion et al.	N/A	N/A
8507614	12/2012	Shalaby et al.	N/A	N/A
8512372	12/2012	Egneloev et al.	N/A	N/A
8512393	12/2012	Ginn et al.	N/A	N/A
8524267	12/2012	Zanella et al.	N/A	N/A
8529598	12/2012	Jenson et al.	N/A	N/A
8529930	12/2012	Pacetti	N/A	N/A
8529931	12/2012	Pacetti	N/A	N/A
8529932	12/2012	Pacetti	N/A	N/A
8535301	12/2012	Cox et al.	N/A	N/A
8540750	12/2012	Tegels	N/A	N/A
8540760	12/2012	Paul et al.	N/A	N/A
8579825	12/2012	Tenerz et al.	N/A	N/A
8579882	12/2012	Abuzaina et al.	N/A	N/A
8580061	12/2012	Cik	N/A	N/A
8585774	12/2012	Henderson	N/A	N/A
8586087	12/2012	Lee et al.	N/A	N/A
8591542	12/2012	White et al.	N/A	N/A
8591875	12/2012	Belcheva et al.	N/A	N/A
8617184	12/2012	Oepen	N/A	N/A
8623396	12/2013	Gray et al.	N/A	N/A
8629172	12/2013	McKay et al.	N/A	N/A
8636767	12/2013	McClain	N/A	N/A
8636792	12/2013	Zheng et al.	N/A	N/A
8641633	12/2013	Smith	N/A	N/A
8647364	12/2013	Fiehler et al.	N/A	N/A
8647365	12/2013	Tegels	N/A	N/A
8647368	12/2013	Ducharme	N/A	N/A
8652166	12/2013	Aakerfeldt	N/A	N/A
8657852	12/2013	Roorda et al.	N/A	N/A
8690912	12/2013	Khanna et al.	N/A	N/A
8715200	12/2013	Pijls	N/A	N/A
8721679	12/2013	Drasler et al.	N/A	N/A

8721680	12/2013	Hundertmark et al.	N/A	N/A
8722079	12/2013	King	N/A	N/A
8726438	12/2013	Cik	N/A	N/A
8734366	12/2013	Egnelv et al.	N/A	N/A
8734483	12/2013	Tekulve et al.	N/A	N/A
8735504	12/2013	Clay	N/A	N/A
8740982	12/2013	Lee	N/A	N/A
8753115	12/2013	Schlottig et al.	N/A	N/A
8758429	12/2013	Taylor et al.	N/A	N/A
8764768	12/2013	Karpiel	N/A	N/A
8764791	12/2013	Armstrong	N/A	N/A
8778012	12/2013	Matheny	N/A	N/A
8778379	12/2013	Doshi et al.	N/A	N/A
8782101	12/2013	Moore	N/A	N/A
8790488	12/2013	Hadba et al.	N/A	N/A
8790684	12/2013	Dave et al.	N/A	N/A
8795709	12/2013	Sawhney et al.	N/A	N/A
8795762	12/2013	Fulton et al.	N/A	N/A
8802124	12/2013	Tenerz et al.	N/A	N/A
8814859	12/2013	Drasler et al.	N/A	N/A
8814930	12/2013	Zheng et al.	N/A	N/A
8821529	12/2013	Kariniemi et al.	N/A	N/A
8821532	12/2013	Schaeffer	N/A	N/A
8828419	12/2013	Dav et al.	N/A	N/A
8829072	12/2013	Friess et al.	N/A	N/A
8834562	12/2013	Chin-Chen et al.	N/A	N/A
8834935	12/2013	Armbruster et al.	N/A	N/A
8835492	12/2013	Lee et al.	N/A	N/A
8840678	12/2013	Sudhir et al.	N/A	N/A
8846068	12/2013	Wohabrebbi et al.	N/A	N/A
8852229	12/2013	Ginn	N/A	N/A
8852624	12/2013	Han et al.	N/A	N/A
8858591	12/2013	Preinitz et al.	N/A	N/A
8864843	12/2013	Lu et al.	N/A	N/A
8870945	12/2013	Dave et al.	N/A	N/A
8877226	12/2013	Zanella et al.	N/A	N/A
8906042	12/2013	Hodgkinson et al.	N/A	N/A
8906394	12/2013	Hossainy et al.	N/A	N/A
8911766	12/2013	Hossainy et al.	N/A	N/A
8914090	12/2013	Jain et al.	N/A	N/A
8920463	12/2013	Mcguckin et al.	N/A	N/A
8926545	12/2014	Brenneman et al.	N/A	N/A
8927004	12/2014	Dehnad et al.	N/A	N/A
8932615	12/2014	Pacetti	N/A	N/A
8936635	12/2014	Kaesemeyer	N/A	N/A
8936805	12/2014	Biris	N/A	N/A
8940011	12/2014	Teoh et al.	N/A	N/A
8940015	12/2014	Kariniemi	N/A	N/A
8945173	12/2014	Atthoff et al.	N/A	N/A
8956372	12/2014	Fenton et al.	N/A	N/A

8956641	12/2014	Zanella et al.	N/A	N/A
8968341	12/2014	Smith	N/A	N/A
8968767	12/2014	McKay	N/A	N/A
8974476	12/2014	Tegels	N/A	N/A
8974776	12/2014	Stopek et al.	N/A	N/A
8980317	12/2014	King	N/A	N/A
8992567	12/2014	Houser	N/A	N/A
9004920	12/2014	Schlottig et al.	N/A	N/A
9011831	12/2014	Ding	N/A	N/A
9017378	12/2014	Stocchero et al.	N/A	N/A
9017653	12/2014	Balkus et al.	N/A	N/A
9023074	12/2014	Theobald et al.	N/A	N/A
9023379	12/2014	Pathak et al.	N/A	N/A
9031792	12/2014	Wagner et al.	N/A	N/A
9034011	12/2014	Kirsch et al.	N/A	N/A
9034355	12/2014	Reynolds et al.	N/A	N/A
9039738	12/2014	Pipenhagen et al.	N/A	N/A
9044267	12/2014	Litvack et al.	N/A	N/A
9050251	12/2014	Boyden et al.	N/A	N/A
9060751	12/2014	Martin et al.	N/A	N/A
9060842	12/2014	Karp et al.	N/A	N/A
9066853	12/2014	Clay	N/A	N/A
9066992	12/2014	Stankus et al.	N/A	N/A
9072727	12/2014	McKay	N/A	N/A
9072814	12/2014	Pathak et al.	N/A	N/A
9078630	12/2014	Wahr et al.	N/A	N/A
9078631	12/2014	Tegels	N/A	N/A
9089262	12/2014	Hashiba	N/A	N/A
9089391	12/2014	Kassab et al.	N/A	N/A
9089412	12/2014	Kleiner	N/A	N/A
9089594	12/2014	Dyer et al.	N/A	N/A
9095342	12/2014	Becking et al.	N/A	N/A
9101340	12/2014	Preinitz	N/A	N/A
9101515	12/2014	Odermatt et al.	N/A	N/A
9101695	12/2014	Langer et al.	N/A	N/A
9103470	12/2014	Cik	N/A	N/A
9115156	12/2014	Belcheva et al.	N/A	N/A
9125902	12/2014	Haddock et al.	N/A	N/A
9125917	12/2014	McKay et al.	N/A	N/A
9131932	12/2014	Tegels	N/A	N/A
9132119	12/2014	Hobot et al.	N/A	N/A
9132194	12/2014	McKay	N/A	N/A
9132204	12/2014	McKay et al.	N/A	N/A
9133035	12/2014	Yun et al.	N/A	N/A
9144487	12/2014	Wang et al.	N/A	N/A
9149264	12/2014	Tegels	N/A	N/A
9149290	12/2014	Goode et al.	N/A	N/A
9155532	12/2014	Surti	N/A	N/A
9161756	12/2014	Sargeant et al.	N/A	N/A
9173645	12/2014	Overes et al.	N/A	N/A

9192362	12/2014	Paul et al.	N/A	N/A
9192364	12/2014	Terwey	N/A	N/A
9192386	12/2014	Tegels et al.	N/A	N/A
9192500	12/2014	Longo et al.	N/A	N/A
9211285	12/2014	McKay et al.	N/A	N/A
9220489	12/2014	Tegels	N/A	N/A
9220815	12/2014	Pacetti	N/A	N/A
9220816	12/2014	Pacetti	N/A	N/A
9226738	12/2015	Defonzo et al.	N/A	N/A
9233192	12/2015	Schwartz et al.	N/A	N/A
9241694	12/2015	Tegels et al.	N/A	N/A
9241708	12/2015	McCrea et al.	N/A	N/A
9254124	12/2015	Drasler et al.	N/A	N/A
9265733	12/2015	McKay	N/A	N/A
9265857	12/2015	Garigapati et al.	N/A	N/A
9271721	12/2015	Jimenez et al.	N/A	N/A
9271834	12/2015	Kim et al.	N/A	N/A
9272044	12/2015	Norton et al.	N/A	N/A
9277904	12/2015	Paul et al.	N/A	N/A
9282962	12/2015	Schmid et al.	N/A	N/A
9282994	12/2015	Pipenhagen et al.	N/A	N/A
9289197	12/2015	Forsberg	N/A	N/A
9289409	12/2015	Zanella et al.	N/A	N/A
9289534	12/2015	Lehtonen et al.	N/A	N/A
9295650	12/2015	Neumann et al.	N/A	N/A
9301740	12/2015	Thielen et al.	N/A	N/A
9301741	12/2015	Schaeffer	N/A	N/A
9301754	12/2015	Duncan	N/A	N/A
9301946	12/2015	Wilsey et al.	N/A	N/A
9307966	12/2015	Tegels	N/A	N/A
9307967	12/2015	Tegels et al.	N/A	N/A
9314545	12/2015	Tofighi et al.	N/A	N/A
9320632	12/2015	Longo et al.	N/A	N/A
9320833	12/2015	Pacetti	N/A	N/A
9332991	12/2015	Pereira et al.	N/A	N/A
9345460	12/2015	Houser et al.	N/A	N/A
9345814	12/2015	Ding	N/A	N/A
9351959	12/2015	McKay	N/A	N/A
9358223	12/2015	King	N/A	N/A
9364206	12/2015	Bagaoisan et al.	N/A	N/A
9364207	12/2015	Terwey	N/A	N/A
9364587	12/2015	Biris	N/A	N/A
9370345	12/2015	Tegels et al.	N/A	N/A
9375214	12/2015	Khanna et al.	N/A	N/A
9375420	12/2015	King	N/A	N/A
9381262	12/2015	Stephens et al.	N/A	N/A
9381277	12/2015	Lehtonen et al.	N/A	N/A
9381326	12/2015	Cully et al.	N/A	N/A
9386968	12/2015	Uchida et al.	N/A	N/A
9387197	12/2015	King	N/A	N/A

9398902	12/2015	Paul et al.	N/A	N/A
9402606	12/2015	Glazier et al.	N/A	N/A
9402757	12/2015	Kassab et al.	N/A	N/A
9408595	12/2015	Pipenhagen et al.	N/A	N/A
9408607	12/2015	Cartledge et al.	N/A	N/A
9414821	12/2015	Atanasoska et al.	N/A	N/A
9414824	12/2015	Fortson et al.	N/A	N/A
9414842	12/2015	Glimsdale et al.	N/A	N/A
9414930	12/2015	Lee	N/A	N/A
9427216	12/2015	Szabo et al.	N/A	N/A
9427217	12/2015	Drasler et al.	N/A	N/A
9427497	12/2015	Biris	N/A	N/A
9427554	12/2015	Davey	N/A	N/A
9451938	12/2015	Overes et al.	N/A	N/A
9452242	12/2015	Dehnad et al.	N/A	N/A
9456914	12/2015	Longo et al.	N/A	N/A
9457133	12/2015	Ruane et al.	N/A	N/A
9463004	12/2015	Campbell et al.	N/A	N/A
9464368	12/2015	Zussman et al.	N/A	N/A
9468429	12/2015	White	N/A	N/A
9468706	12/2015	Glauser et al.	N/A	N/A
9469919	12/2015	Kuhn et al.	N/A	N/A
9480468	12/2015	Tegels	N/A	N/A
9486191	12/2015	Gianotti et al.	N/A	N/A
9486192	12/2015	Pipenhagen	N/A	N/A
9486193	12/2015	Vidlund et al.	N/A	N/A
9486302	12/2015	Boey et al.	N/A	N/A
9487915	12/2015	Medoff	N/A	N/A
9492156	12/2015	Tegels	N/A	N/A
9498559	12/2015	Matheny	N/A	N/A
9504457	12/2015	Szabo et al.	N/A	N/A
9511018	12/2015	Clay et al.	N/A	N/A
9511077	12/2015	Biggs et al.	N/A	N/A
9526600	12/2015	Drapeau et al.	N/A	N/A
9526812	12/2015	Doshi et al.	N/A	N/A
9528044	12/2015	Van et al.	N/A	N/A
9533072	12/2016	Matheny	N/A	N/A
9549734	12/2016	Reydel	N/A	N/A
9549740	12/2016	Rees	N/A	N/A
9549920	12/2016	Wohabrebbi et al.	N/A	N/A
9550977	12/2016	Isogai et al.	N/A	N/A
9554783	12/2016	Pavcnik et al.	N/A	N/A
9554784	12/2016	Vidlund	N/A	N/A
9561611	12/2016	Kleiner	N/A	N/A
9566371	12/2016	Zheng et al.	N/A	N/A
9585643	12/2016	Terwey et al.	N/A	N/A
9585645	12/2016	Akerfeldt	N/A	N/A
9585782	12/2016	Longo et al.	N/A	N/A
9585872	12/2016	Zanella et al.	N/A	N/A
9592039	12/2016	Glazier et al.	N/A	N/A

9592243	12/2016	Wilsey	N/A	N/A
9602786	12/2016	Longo et al.	N/A	N/A
9603588	12/2016	Kramer et al.	N/A	N/A
9603601	12/2016	Tegels	N/A	N/A
9610070	12/2016	Martin	N/A	N/A
9610076	12/2016	Melsheimer et al.	N/A	N/A
9610150	12/2016	Flanagan et al.	N/A	N/A
9616104	12/2016	Binette	N/A	N/A
9617465	12/2016	Gullickson et al.	N/A	N/A
9629619	12/2016	Tenerz	N/A	N/A
9642615	12/2016	Halac et al.	N/A	N/A
9655602	12/2016	Ginn et al.	N/A	N/A
9662099	12/2016	Grant et al.	N/A	N/A
9675556	12/2016	Akala et al.	N/A	N/A
9681866	12/2016	Halac et al.	N/A	N/A
9687864	12/2016	Fulton et al.	N/A	N/A
9694096	12/2016	McKay et al.	N/A	N/A
9694104	12/2016	Matheny et al.	N/A	N/A
9700567	12/2016	Zanella et al.	N/A	N/A
9707000	12/2016	Hoke et al.	N/A	N/A
9713462	12/2016	Bagaoisan et al.	N/A	N/A
9713702	12/2016	Zare et al.	N/A	N/A
9717456	12/2016	Lim	N/A	N/A
9717487	12/2016	White et al.	N/A	N/A
9717610	12/2016	Huang et al.	N/A	N/A
9717779	12/2016	King	N/A	N/A
9724079	12/2016	Shanley	N/A	N/A
9724082	12/2016	Stanley et al.	N/A	N/A
9730699	12/2016	Hglund	N/A	N/A
9737286	12/2016	Grant et al.	N/A	N/A
9743220	12/2016	Shahar et al.	N/A	N/A
9744259	12/2016	Wang et al.	N/A	N/A
9750489	12/2016	Pipenhagen et al.	N/A	N/A
9757049	12/2016	Park et al.	N/A	N/A
9757105	12/2016	Hundertmark et al.	N/A	N/A
9757106	12/2016	Baxter et al.	N/A	N/A
9758558	12/2016	Henry et al.	N/A	N/A
9763652	12/2016	Terwey	N/A	N/A
9763788	12/2016	Biris	N/A	N/A
9770233	12/2016	Nelson	N/A	N/A
9782155	12/2016	Mcguckin et al.	N/A	N/A
9782168	12/2016	Shanley et al.	N/A	N/A
9782402	12/2016	Norton et al.	N/A	N/A
9814571	12/2016	Johnson et al.	N/A	N/A
9820727	12/2016	Zhou et al.	N/A	N/A
9820728	12/2016	Mylonakis et al.	N/A	N/A
9820735	12/2016	Tegels	N/A	N/A
9820839	12/2016	Jacinto et al.	N/A	N/A
9827117	12/2016	Taylor et al.	N/A	N/A
9833548	12/2016	McKay et al.	N/A	N/A

9839415	12/2016	Tegels	N/A	N/A
9848859	12/2016	White	N/A	N/A
9850013	12/2016	Grant et al.	N/A	N/A
9855034	12/2017	Broom et al.	N/A	N/A
9861465	12/2017	Tan et al.	N/A	N/A
9872680	12/2017	Fenton et al.	N/A	N/A
9873790	12/2017	Andjelic et al.	N/A	N/A
9877711	12/2017	Schaeffer	N/A	N/A
9883936	12/2017	Sutton et al.	N/A	N/A
9888848	12/2017	Samuelsson et al.	N/A	N/A
9895144	12/2017	Tegels	N/A	N/A
9913634	12/2017	Hansen	N/A	N/A
9918924	12/2017	Dyer	N/A	N/A
9925033	12/2017	Cartledge et al.	N/A	N/A
9937337	12/2017	Powers et al.	N/A	N/A
9943298	12/2017	Stanley et al.	N/A	N/A
9943302	12/2017	Bennett	N/A	N/A
9943410	12/2017	Hollister et al.	N/A	N/A
9943426	12/2017	Sirhan et al.	N/A	N/A
9950093	12/2017	Zussman et al.	N/A	N/A
9955958	12/2017	Tegels	N/A	N/A
9956313	12/2017	Tofighi et al.	N/A	N/A
9968572	12/2017	Wilsey et al.	N/A	N/A
9968711	12/2017	Biris	N/A	N/A
9968712	12/2017	Han et al.	N/A	N/A
9980719	12/2017	Tegels	N/A	N/A
9987289	12/2017	Scher et al.	N/A	N/A
9999409	12/2017	Ditter	N/A	N/A
10010311	12/2017	Parsonage et al.	N/A	N/A
10016188	12/2017	Jacobs et al.	N/A	N/A
10016200	12/2017	Tegels	N/A	N/A
10023474	12/2017	Ben et al.	N/A	N/A
10035299	12/2017	Cik	N/A	N/A
10064726	12/2017	Wei	N/A	N/A
10076331	12/2017	Huang et al.	N/A	N/A
10076431	12/2017	Sirhan et al.	N/A	N/A
10098620	12/2017	Crabb et al.	N/A	N/A
10105293	12/2017	Liu et al.	N/A	N/A
10106402	12/2017	Han et al.	N/A	N/A
10111648	12/2017	Tegels et al.	N/A	N/A
10130365	12/2017	Hotter	N/A	N/A
10130509	12/2017	Korigodskiy et al.	N/A	N/A
10143700	12/2017	Koyakutty et al.	N/A	N/A
10149677	12/2017	Belson et al.	N/A	N/A
10149926	12/2017	Schewe et al.	N/A	N/A
10155063	12/2017	Herr et al.	N/A	N/A
10182800	12/2018	Uchida et al.	N/A	N/A
10183786	12/2018	Aagaard et al.	N/A	N/A
10201336	12/2018	Kariniemi et al.	N/A	N/A
10206668	12/2018	McGoldrick et al.	N/A	N/A

10227841	12/2018	Fripp et al.	N/A	N/A
10238388	12/2018	Shelton et al.	N/A	N/A
10238496	12/2018	Biris	N/A	N/A
10254274	12/2018	Miklas et al.	N/A	N/A
10266408	12/2018	Reynolds et al.	N/A	N/A
10271976	12/2018	Sirhan et al.	N/A	N/A
10272606	12/2018	McClain	N/A	N/A
10286102	12/2018	Garigapati et al.	N/A	N/A
10314567	12/2018	Uchida et al.	N/A	N/A
10327747	12/2018	Yassinzadeh et al.	N/A	N/A
10335419	12/2018	Scher et al.	N/A	N/A
10357248	12/2018	Dalessandro et al.	N/A	N/A
10363020	12/2018	Hill et al.	N/A	N/A
10376254	12/2018	Eichenschink et al.	N/A	N/A
10390707	12/2018	Kim et al.	N/A	N/A
10390809	12/2018	Akerfeldt	N/A	N/A
10390984	12/2018	Kassab et al.	N/A	N/A
10406102	12/2018	Libin et al.	N/A	N/A
10426449	12/2018	Fortson	N/A	N/A
10428264	12/2018	Chopade et al.	N/A	N/A
10433826	12/2018	Grant et al.	N/A	N/A
10441426	12/2018	Wei	N/A	N/A
10441757	12/2018	Kaufman et al.	N/A	N/A
10442175	12/2018	Schlachter	N/A	N/A
10449269	12/2018	Fahmy et al.	N/A	N/A
10456123	12/2018	Hundertmark et al.	N/A	N/A
10456124	12/2018	Mylonakis et al.	N/A	N/A
10499893	12/2018	Hundertmark et al.	N/A	N/A
10517984	12/2018	Diluccio et al.	N/A	N/A
10519434	12/2018	Morhet et al.	N/A	N/A
10524915	12/2019	Freeman et al.	N/A	N/A
10537313	12/2019	Gianotti et al.	N/A	N/A
10542996	12/2019	Willard et al.	N/A	N/A
10555727	12/2019	Walters et al.	N/A	N/A
10590388	12/2019	Ohta et al.	N/A	N/A
10595838	12/2019	Bagaoisan et al.	N/A	N/A
10596201	12/2019	Huang et al.	N/A	N/A
10603473	12/2019	Kaufman et al.	N/A	N/A
10611908	12/2019	Sheardown et al.	N/A	N/A
10624619	12/2019	Amplatz et al.	N/A	N/A
10639020	12/2019	Larzon et al.	N/A	N/A
10682128	12/2019	Walters et al.	N/A	N/A
10702275	12/2019	Adams et al.	N/A	N/A
10709433	12/2019	Flanagan et al.	N/A	N/A
10716549	12/2019	Keillor	N/A	N/A
10722224	12/2019	Stopek et al.	N/A	N/A
10722225	12/2019	Jacobs et al.	N/A	N/A
10722445	12/2019	Dyer	N/A	N/A
10729416	12/2019	Stanley et al.	N/A	N/A
10729702	12/2019	Scher et al.	N/A	N/A

10736985	12/2019	Odermatt et al.	N/A	N/A
10751035	12/2019	White	N/A	N/A
10751124	12/2019	Eisenfrats et al.	N/A	N/A
10758216	12/2019	Stanley	N/A	N/A
10758643	12/2019	Brosig et al.	N/A	N/A
10765414	12/2019	White	N/A	N/A
10765753	12/2019	Lee et al.	N/A	N/A
10786374	12/2019	Sirhan et al.	N/A	N/A
10799336	12/2019	Hutmacher et al.	N/A	N/A
10806438	12/2019	Bagaoisan et al.	N/A	N/A
10813763	12/2019	Schlachter	N/A	N/A
10835223	12/2019	Pipenhagen	N/A	N/A
10849607	12/2019	Stanley et al.	N/A	N/A
10849619	12/2019	Viola et al.	N/A	N/A
10864158	12/2019	Desai et al.	N/A	N/A
10869708	12/2019	Preiss-Bloom et al.	N/A	N/A
10869954	12/2019	Preiss-Bloom et al.	N/A	N/A
10874384	12/2019	Uchida et al.	N/A	N/A
10874402	12/2019	Cao et al.	N/A	N/A
10893926	12/2020	Vantassel et al.	N/A	N/A
10898353	12/2020	Taylor et al.	N/A	N/A
10898498	12/2020	Scher et al.	N/A	N/A
10918505	12/2020	Sirhan et al.	N/A	N/A
10925588	12/2020	Glimsdale	N/A	N/A
10926004	12/2020	Preiss-Bloom et al.	N/A	N/A
RE48485	12/2020	Piskun et al.	N/A	N/A
10939937	12/2020	Terefe et al.	N/A	N/A
10945716	12/2020	Chen et al.	N/A	N/A
10959720	12/2020	Juan et al.	N/A	N/A
10966698	12/2020	Grant et al.	N/A	N/A
10987445	12/2020	McKay et al.	N/A	N/A
10993719	12/2020	Jagelski et al.	N/A	N/A
11000633	12/2020	Gonalves et al.	N/A	N/A
11045178	12/2020	Onushko et al.	N/A	N/A
11051801	12/2020	Roorda et al.	N/A	N/A
11053361	12/2020	Legnetti et al.	N/A	N/A
11058406	12/2020	Mylonakis et al.	N/A	N/A
11065099	12/2020	Lu et al.	N/A	N/A
11096733	12/2020	Frei et al.	N/A	N/A
11103224	12/2020	Uchida et al.	N/A	N/A
11103588	12/2020	Cao et al.	N/A	N/A
11110208	12/2020	Koenig	N/A	N/A
11141142	12/2020	McGoldrick et al.	N/A	N/A
11154284	12/2020	Venkatraman et al.	N/A	N/A
11154395	12/2020	Matheny	N/A	N/A
11154510	12/2020	Albayrak	N/A	N/A
11167055	12/2020	McKay et al.	N/A	N/A
11179243	12/2020	Roeder et al.	N/A	N/A
11191788	12/2020	Huang et al.	N/A	N/A
11219436	12/2021	Mayberg	N/A	N/A

11220096	12/2021	Schlachter	N/A	N/A
11225551	12/2021	Zhang et al.	N/A	N/A
11259841	12/2021	Pilletere et al.	N/A	N/A
11272911	12/2021	Hundertmark et al.	N/A	N/A
11278269	12/2021	Grant et al.	N/A	N/A
11278641	12/2021	Herr et al.	N/A	N/A
11285244	12/2021	Hoerstrup et al.	N/A	N/A
11299822	12/2021	Zussman et al.	N/A	N/A
11311650	12/2021	Dashti et al.	N/A	N/A
11317957	12/2021	Preiss-Bloom et al.	N/A	N/A
11357837	12/2021	King	N/A	N/A
11382714	12/2021	O'Brien-Coon et al.	N/A	N/A
11406377	12/2021	Schmid et al.	N/A	N/A
11413242	12/2021	Peters	N/A	N/A
11439378	12/2021	Gianotti et al.	N/A	N/A
11504105	12/2021	Defonzo et al.	N/A	N/A
11529130	12/2021	Vidlund	N/A	N/A
11534150	12/2021	Uchida et al.	N/A	N/A
11576663	12/2022	Walters et al.	N/A	N/A
11589855	12/2022	Walters et al.	N/A	N/A
11707265	12/2022	Bagaoisan et al.	N/A	N/A
11707266	12/2022	Bagaoisan et al.	N/A	N/A
11717278	12/2022	Yassinzadeh et al.	N/A	N/A
11737740	12/2022	Joe et al.	N/A	N/A
11832804	12/2022	Hundertmark et al.	N/A	N/A
12029404	12/2023	Garrison	N/A	N/A
12035905	12/2023	Wiebe et al.	N/A	N/A
12048429	12/2023	Shattuck et al.	N/A	N/A
12156643	12/2023	Grant et al.	N/A	N/A
2002/0019648	12/2001	Akerfeldt	606/213	A61B 17/0057
2002/0054664	12/2001	Tiren	N/A	N/A
2002/0054665	12/2001	Tiren	N/A	N/A
2002/0161168	12/2001	Shalaby et al.	N/A	N/A
2002/0183787	12/2001	Wahr et al.	N/A	N/A
2002/0193808	12/2001	Belef et al.	N/A	N/A
2002/0198562	12/2001	Akerfeldt et al.	N/A	N/A
2003/0051735	12/2002	Pavcnik	128/831	A61B 17/12118
2003/0060846	12/2002	Egnelov et al.	N/A	N/A
2003/0093108	12/2002	Avellanet et al.	N/A	N/A
2004/0039413	12/2003	Akerfeldt et al.	N/A	N/A
2004/0093025	12/2003	Egnelov	606/214	A61B 17/0487
2004/0168519	12/2003	Kalvensten et al.	N/A	N/A
2004/0225232	12/2003	Malmborg et al.	N/A	N/A
2005/0085852	12/2004	Ditter	N/A	N/A
2005/0085855	12/2004	Forsberg	N/A	N/A
2005/0107827	12/2004	Paprocki	N/A	N/A
2005/0169974	12/2004	Tenerz	424/445	A61L 31/04
2005/0203552	12/2004	Laufer et al.	N/A	N/A
2005/0267521	12/2004	Forsberg	N/A	N/A

2005/0283193	12/2004	Tullberg et al.	N/A	N/A
2006/0009817	12/2005	Tulkki	N/A	N/A
2006/0034930	12/2005	Khosravi	424/484	A61K 9/0024
2006/0052700	12/2005	Svanerudh	N/A	N/A
2006/0058844	12/2005	White et al.	N/A	N/A
2006/0142786	12/2005	Mathisen et al.	N/A	N/A
2006/0142798	12/2005	Holman et al.	N/A	N/A
2006/0161224	12/2005	Samuelsson et al.	N/A	N/A
2006/0173492	12/2005	Akerfeldt et al.	N/A	N/A
2006/0178682	12/2005	Boehlke	N/A	N/A
2006/0205910	12/2005	Asplund et al.	N/A	N/A
2006/0211839	12/2005	Asplund et al.	N/A	N/A
2006/0229672	12/2005	Forsberg	N/A	N/A
2006/0247653	12/2005	Akerfeldt et al.	N/A	N/A
2006/0264978	12/2005	Belhe et al.	N/A	N/A
2007/0032824	12/2006	Terwey	N/A	N/A
2007/0093869	12/2006	Bloom et al.	N/A	N/A
2007/0149880	12/2006	Willis	N/A	N/A
2007/0150002	12/2006	Szabo et al.	N/A	N/A
2007/0156084	12/2006	Belhe et al.	N/A	N/A
2007/0185530	12/2006	Chin-Chen et al.	N/A	N/A
2007/0225755	12/2006	Preinitz et al.	N/A	N/A
2007/0225756	12/2006	Preinitz et al.	N/A	N/A
2007/0225757	12/2006	Preinitz et al.	N/A	N/A
2007/0225758	12/2006	Preinitz et al.	N/A	N/A
2007/0255145	12/2006	Smith et al.	N/A	N/A
2007/0276433	12/2006	Huss	N/A	N/A
2008/0009794	12/2007	Bagaoisan et al.	N/A	N/A
2008/0015636	12/2007	Olsen et al.	N/A	N/A
2008/0077050	12/2007	Von et al.	N/A	N/A
2008/0082123	12/2007	Forsberg et al.	N/A	N/A
2008/0091235	12/2007	Sirota	N/A	N/A
2008/0097479	12/2007	Boehlke et al.	N/A	N/A
2008/0097480	12/2007	Schorr et al.	N/A	N/A
2008/0097481	12/2007	Schorr et al.	N/A	N/A
2008/0097484	12/2007	Lim et al.	N/A	N/A
2008/0114395	12/2007	Mathisen et al.	N/A	N/A
2008/0154190	12/2007	St et al.	N/A	N/A
2008/0200798	12/2007	Eklund et al.	N/A	N/A
2008/0243182	12/2007	Bates et al.	N/A	N/A
2008/0262475	12/2007	Preinitz	N/A	N/A
2008/0302682	12/2007	Engstrom et al.	N/A	N/A
2008/0319458	12/2007	Reynolds	N/A	N/A
2009/0030450	12/2008	Preinitz et al.	N/A	N/A
2009/0036919	12/2008	Preinitz et al.	N/A	N/A
2009/0036920	12/2008	Preinitz et al.	N/A	N/A
2009/0054926	12/2008	Pipenhagen et al.	N/A	N/A
2009/0069844	12/2008	Green et al.	N/A	N/A
2009/0118643	12/2008	Smith et al.	N/A	N/A
2009/0171281	12/2008	Pipenhagen et al.	N/A	N/A

2009/0171282	12/2008	Pipenhagen et al.	N/A	N/A
2009/0171387	12/2008	Pipenhagen et al.	N/A	N/A
2009/0234377	12/2008	Mahlin	606/153	A61B 17/0057
2009/0312790	12/2008	Forsberg et al.	N/A	N/A
2010/0004671	12/2009	Gerberding et al.	N/A	N/A
2010/0023051	12/2009	White et al.	N/A	N/A
2010/0042118	12/2009	Garrison et al.	N/A	N/A
2010/0042144	12/2009	Bennett	N/A	N/A
2010/0061518	12/2009	Smith	N/A	N/A
2010/0069924	12/2009	Kochman et al.	N/A	N/A
2010/0109104	12/2009	Tiensuu et al.	N/A	N/A
2010/0145366	12/2009	Roop et al.	N/A	N/A
2010/0168789	12/2009	Bagaoisan et al.	N/A	N/A
2010/0179567	12/2009	Voss et al.	N/A	N/A
2010/0179588	12/2009	Sater et al.	N/A	N/A
2010/0179589	12/2009	Roorda et al.	N/A	N/A
2010/0185234	12/2009	Fortson et al.	N/A	N/A
2010/0191280	12/2009	Forsberg	N/A	N/A
2010/0217308	12/2009	Hansen	606/228	A61B 17/0057
2010/0234883	12/2009	White et al.	N/A	N/A
2010/0286727	12/2009	Terwey	N/A	N/A
2010/0312224	12/2009	Atthoff et al.	N/A	N/A
2011/0029012	12/2010	Tegels	N/A	N/A
2011/0046663	12/2010	Zhou et al.	N/A	N/A
2011/0077683	12/2010	Huss	N/A	N/A
2011/0172702	12/2010	Fiehler et al.	N/A	N/A
2011/0218568	12/2010	Voss	N/A	N/A
2011/0224725	12/2010	De et al.	N/A	N/A
2011/0270302	12/2010	Forsberg	N/A	N/A
2011/0301619	12/2010	Walters	N/A	N/A
2012/0000467	12/2011	Milne et al.	N/A	N/A
2012/0004669	12/2011	Overes et al.	N/A	N/A
2012/0022562	12/2011	Willard	N/A	N/A
2012/0035629	12/2011	Sherwinter	N/A	N/A
2012/0035653	12/2011	Shoemaker et al.	N/A	N/A
2012/0101519	12/2011	Hill et al.	N/A	N/A
2012/0116447	12/2011	Stanley et al.	N/A	N/A
2012/0143226	12/2011	Belson et al.	N/A	N/A
2012/0143243	12/2011	Hill et al.	N/A	N/A
2012/0143244	12/2011	Hill et al.	N/A	N/A
2012/0209323	12/2011	Uchida et al.	N/A	N/A
2012/0259346	12/2011	Hansen et al.	N/A	N/A
2013/0103077	12/2012	Ditter	N/A	N/A
2013/0123844	12/2012	White	N/A	N/A
2013/0190813	12/2012	Tegels et al.	N/A	N/A
2013/0253579	12/2012	Hundertmark et al.	N/A	N/A
2013/0310853	12/2012	Zaugg et al.	N/A	N/A
2013/0325060	12/2012	Jenson et al.	N/A	N/A
2014/0094846	12/2013	Lim	N/A	N/A
2014/0142618	12/2013	Leopold et al.	N/A	N/A

2014/0142620	12/2013	Marchi et al.	N/A	N/A
2014/0194918	12/2013	Tegels	N/A	N/A
2014/0194925	12/2013	Lim et al.	N/A	N/A
2014/0228868	12/2013	Hassan et al.	N/A	N/A
2014/0276973	12/2013	Tegels	N/A	N/A
2014/0277111	12/2013	Tegels	N/A	N/A
2014/0288640	12/2013	Ginn et al.	N/A	N/A
2014/0296907	12/2013	Khanna et al.	N/A	N/A
2014/0364899	12/2013	Ginn et al.	N/A	N/A
2015/0051641	12/2014	Baxter	N/A	N/A
2015/0157332	12/2014	Obermiller et al.	N/A	N/A
2015/0282789	12/2014	Huber	N/A	N/A
2015/0297202	12/2014	Khosravi et al.	N/A	N/A
2015/0327843	12/2014	Garrison	N/A	N/A
2016/0022035	12/2015	Hardy	N/A	N/A
2016/0081680	12/2015	Taylor	N/A	N/A
2016/0220235	12/2015	Almedhychy	N/A	N/A
2016/0262742	12/2015	Tegels	N/A	N/A
2017/0086804	12/2016	Larzon et al.	N/A	N/A
2017/0119400	12/2016	Amplatz et al.	N/A	N/A
2017/0209131	12/2016	Penner et al.	N/A	N/A
2017/0281142	12/2016	Martin et al.	N/A	N/A
2017/0319189	12/2016	Grant et al.	N/A	N/A
2017/0333014	12/2016	Grant et al.	N/A	N/A
2017/0367710	12/2016	Yang	N/A	N/A
2018/0028166	12/2017	Mylonakis et al.	N/A	N/A
2018/0199926	12/2017	Jacobs et al.	N/A	N/A
2018/0235636	12/2017	Culbert et al.	N/A	N/A
2018/0271445	12/2017	Braido et al.	N/A	N/A
2018/0368857	12/2017	Willard et al.	N/A	N/A
2019/0000432	12/2018	Stanley et al.	N/A	N/A
2019/0000504	12/2018	Terefe et al.	N/A	N/A
2019/0015087	12/2018	Tegels et al.	N/A	N/A
2019/0029659	12/2018	Uchida et al.	N/A	N/A
2019/0192127	12/2018	Hundertmark et al.	N/A	N/A
2019/0231326	12/2018	Joe et al.	N/A	N/A
2019/0231333	12/2018	Tegels et al.	N/A	N/A
2019/0274668	12/2018	Glimsdale et al.	N/A	N/A
2019/0336115	12/2018	Uchida et al.	N/A	N/A
2019/0336116	12/2018	Walters et al.	N/A	N/A
2019/0343497	12/2018	Walters et al.	N/A	N/A
2019/0388077	12/2018	Phillips	N/A	N/A
2020/0051313	12/2019	Uludag	N/A	N/A
2020/0054313	12/2019	Hundertmark et al.	N/A	N/A
2020/0054343	12/2019	Min et al.	N/A	N/A
2020/0078157	12/2019	McLawhorn et al.	N/A	N/A
2020/0107823	12/2019	Hundertmark et al.	N/A	N/A
2020/0129165	12/2019	Bagaoisan et al.	N/A	N/A
2020/0205828	12/2019	Kawaura et al.	N/A	N/A
2020/0315827	12/2019	Longo et al.	N/A	N/A

2020/0345306	12/2019	Samuelsson et al.	N/A	N/A
2020/0367905	12/2019	Drilling et al.	N/A	N/A
2020/0375582	12/2019	Bagaoisan et al.	N/A	N/A
2020/0397474	12/2019	Pilletere et al.	N/A	N/A
2021/0030405	12/2020	Mylonakis et al.	N/A	N/A
2021/0059650	12/2020	Eidenschink et al.	N/A	N/A
2021/0059684	12/2020	Meyer et al.	N/A	N/A
2021/0100604	12/2020	Maruyama	N/A	N/A
2021/0145421	12/2020	Hauck et al.	N/A	N/A
2021/0386414	12/2020	Grant et al.	N/A	N/A
2022/0031294	12/2021	Grant et al.	N/A	N/A
2022/0096069	12/2021	Genereux et al.	N/A	N/A
2022/0125419	12/2021	Mylonakis et al.	N/A	N/A
2022/0183674	12/2021	Wiebe et al.	N/A	N/A
2022/0192644	12/2021	Hundertmark et al.	N/A	N/A
2022/0225975	12/2021	Uchida et al.	N/A	N/A
2022/0265144	12/2021	Hbinette et al.	N/A	N/A
2022/0370054	12/2021	DeFonzo et al.	N/A	N/A
2022/0370057	12/2021	Gianotti et al.	N/A	N/A
2023/0050024	12/2022	Van Niekerk	N/A	N/A
2023/0070873	12/2022	Hundertmark et al.	N/A	N/A
2023/0149004	12/2022	Vidlund	N/A	N/A
2023/0172598	12/2022	Tawk	N/A	N/A
2024/0090883	12/2023	Joe et al.	N/A	N/A
2024/0138824	12/2023	Hauck et al.	N/A	N/A
2024/0215968	12/2023	Genereux et al.	N/A	N/A
2025/0032107	12/2024	Grant et al.	N/A	N/A

FOREIGN PATENT DOCUMENTS

Patent No.	**Application Date**	**Country**	**CPC**
2004202152	12/2004	AU	N/A
2004202234	12/2004	AU	N/A
2776597	12/2012	CA	N/A
0421966	12/1990	EP	N/A
0662802	12/1997	EP	N/A
0955902	12/1998	EP	N/A
0973438	12/1999	EP	N/A
1147743	12/2000	EP	N/A
1169968	12/2001	EP	N/A
0766947	12/2001	EP	N/A
1217642	12/2001	EP	N/A
0774237	12/2002	EP	N/A
1413255	12/2003	EP	N/A
1440661	12/2003	EP	N/A
1501421	12/2004	EP	N/A
1574168	12/2004	EP	N/A
1641399	12/2005	EP	N/A
1658811	12/2005	EP	N/A
1671592	12/2005	EP	N/A
1680029	12/2005	EP	N/A

1700872	12/2005	EP	N/A
2002800	12/2007	EP	N/A
1976438	12/2009	EP	N/A
2323566	12/2010	EP	N/A
2416711	12/2011	EP	N/A
2519161	12/2011	EP	N/A
2538848	12/2012	EP	N/A
2640277	12/2012	EP	N/A
2717781	12/2013	EP	N/A
2747667	12/2013	EP	N/A
2747668	12/2013	EP	N/A
2819586	12/2014	EP	N/A
1869301	12/2014	EP	N/A
2950722	12/2014	EP	N/A
2364112	12/2015	EP	N/A
3007631	12/2015	EP	N/A
2019631	12/2015	EP	N/A
2548518	12/2016	EP	N/A
3001954	12/2017	EP	N/A
2405824	12/2017	EP	N/A
3355803	12/2017	EP	N/A
3431023	12/2018	EP	N/A
3278740	12/2018	EP	N/A
3342448	12/2018	EP	N/A
3490461	12/2018	EP	N/A
3573538	12/2018	EP	N/A
3582695	12/2018	EP	N/A
2782506	12/2019	EP	N/A
3459467	12/2019	EP	N/A
3210542	12/2019	EP	N/A
3305207	12/2019	EP	N/A
2845613	12/2020	EP	N/A
3821817	12/2020	EP	N/A
3821820	12/2020	EP	N/A
3659523	12/2020	EP	N/A
3193738	12/2020	EP	N/A
3881771	12/2020	EP	N/A
3905963	12/2020	EP	N/A
3908177	12/2020	EP	N/A
3461420	12/2021	EP	N/A
3650075	12/2021	EP	N/A
4061244	12/2021	EP	N/A
3256051	12/2021	EP	N/A
3871612	12/2022	EP	N/A
4199832	12/2022	EP	N/A
4259008	12/2022	EP	N/A
4259009	12/2022	EP	N/A
3217888	12/2023	EP	N/A
3745962	12/2023	EP	N/A
4426204	12/2023	EP	N/A

05-212038	12/1992	JP	N/A
2006-167468	12/2005	JP	N/A
2014-509884	12/2013	JP	N/A
9003758	12/1990	SE	N/A
90/12537	12/1989	WO	N/A
91/01772	12/1990	WO	N/A
94/05221	12/1993	WO	N/A
94/28800	12/1993	WO	N/A
96/25110	12/1995	WO	N/A
98/31287	12/1997	WO	N/A
98/42253	12/1997	WO	N/A
99/22646	12/1998	WO	N/A
03/71956	12/2002	WO	N/A
2006/115904	12/2005	WO	N/A
2007/078812	12/2006	WO	N/A
2007/139755	12/2006	WO	N/A
2009/054800	12/2008	WO	N/A
2009/054801	12/2008	WO	N/A
2009/054802	12/2008	WO	N/A
2009/054803	12/2008	WO	N/A
2009/054805	12/2008	WO	N/A
2010/019719	12/2009	WO	N/A
2010/081102	12/2009	WO	N/A
2010/107698	12/2009	WO	N/A
2010/118312	12/2009	WO	N/A
2011/037866	12/2010	WO	N/A
2011/080588	12/2010	WO	N/A
2011/106713	12/2010	WO	N/A
2012/006161	12/2011	WO	N/A
2012/158738	12/2011	WO	N/A
2012/158740	12/2011	WO	N/A
2012/170597	12/2011	WO	N/A
2013/074488	12/2012	WO	N/A
2013/074490	12/2012	WO	N/A
2013/101366	12/2012	WO	N/A
2013/115993	12/2012	WO	N/A
2013/128292	12/2012	WO	N/A
2013/142515	12/2012	WO	N/A
2013/188575	12/2012	WO	N/A
2014/031259	12/2013	WO	N/A
2014/067021	12/2013	WO	N/A
2014/120315	12/2013	WO	N/A
2014/144741	12/2013	WO	N/A
2014/201105	12/2013	WO	N/A
2015/175537	12/2014	WO	N/A
2016/014496	12/2015	WO	N/A
2016/073870	12/2015	WO	N/A
2017/055919	12/2016	WO	N/A
2018/152457	12/2017	WO	N/A
2019/003051	12/2018	WO	N/A

2020/141122	12/2019	WO	N/A
2020/146688	12/2019	WO	N/A
2021/102044	12/2020	WO	N/A
2022/081357	12/2021	WO	N/A
2023/063780	12/2022	WO	N/A
2023/073137	12/2022	WO	N/A
2023/126843	12/2022	WO	N/A
2024/092233	12/2023	WO	N/A

OTHER PUBLICATIONS

US 9,642,619 B2, 05/2017, Prior et al. (withdrawn) cited by applicant
Advisory Action received for U.S. Appl. No. 12/106,928, mailed on Mar. 25, 2014, 3 pages. cited by applicant
Issue Notification received for U.S. Appl. No. 11/396,141, mailed on Mar. 19, 2014, 1 page. cited by applicant
Notice of Allowance received for U.S. Appl. No. 11/113,549, mailed on Mar. 14, 2014, 13 pages. cited by applicant
Notice of Allowance received for U.S. Appl. No. 11/411,925, mailed on Feb. 5, 2014, 9 pages. cited by applicant
Notice of Allowance received for U.S. Appl. No. 11/674,930, mailed on Apr. 3, 2014, 11 pages. cited by applicant
Notice of Allowance received for U.S. Appl. No. 11/852,190, mailed on Feb. 12, 2014, 9 pages. cited by applicant
Notice of Allowance received for U.S. Appl. No. 12/848,642, mailed on Feb. 3, 2014, 10 pages. cited by applicant
Notice of Allowance received for U.S. Appl. No. 12/941,809, mailed on Feb. 3, 2014, 7 pages. cited by applicant
Office Action received for U.S. Appl. No. 11/455,993, mailed on Jan. 29, 2014, 11 pages. cited by applicant
Office Action received for U.S. Appl. No. 12/106,937, mailed on Jan. 22, 2014, 7 pages. cited by applicant
Office Action received for U.S. Appl. No. 12/113,851, mailed on Mar. 17, 2014, 12 pages. cited by applicant
Office Action received for U.S. Appl. No. 12/114,031, mailed on Mar. 10, 2014, 9 pages. cited by applicant
Office Action received for U.S. Appl. No. 12/403,277, mailed on Jan. 27, 2014, 9 pages. cited by applicant

---

Primary Examiner: Ou; Jing Rui

Attorney, Agent or Firm: Workman Nydegger

Background/Summary

CROSS REFERENCE (1) This application claims the benefit of priority to U.S. Provisional Patent Application Ser. No. 63/090,556, filed Oct. 12, 2020, and to U.S. Provisional Patent Application Ser. No. 63/114,202, filed Nov. 16, 2020, the disclosures of which are incorporated herein in their entireties.

BACKGROUND

1. The Field of the Invention

(1) The present disclosure relates generally to systems, devices, and methods for blocking an opening in body lumens. More particularly, the present disclosure relates to techniques for percutaneous closure of arterial and venous puncture sites, which are usually accessed through a tissue tract.

2. The Relevant Technology

(2) A number of diagnostic and interventional vascular procedures are now performed translumenally. A catheter is introduced to the vascular system at a convenient access location and guided through the vascular system to a target location using established techniques. Such procedures require vascular access, which is usually established during the well-known Seldinger technique. Vascular access is generally provided through an introducer sheath, which is positioned to extend from outside the patient body into the vascular lumen. When vascular access is no longer required, the introducer sheath is removed and bleeding at the puncture site stopped.

(3) One common approach for providing hemostasis (the cessation of bleeding) is to apply external force near and upstream from the puncture site, typically by manual compression. This approach suffers from a number of disadvantages. For example, the manual compression procedure is time consuming, frequently requiring one-half hour or more of compression before hemostasis is achieved. Additionally, such compression techniques rely on clot formation, which can be delayed until anticoagulants used in vascular therapy procedures (such as for heart attacks, stent deployment, non-optical PTCA results, and the like) wear off. The anticoagulants may take two to four hours to wear off, thereby increasing the time required before completion of the manual compression procedure.

(4) The manual compression procedure is uncomfortable for the patient and frequently requires analgesics to be tolerable. Moreover, the application of excessive pressure can at times totally occlude the underlying blood vessel, resulting in ischemia and/or thrombosis. Following manual compression, the patient typically remains recumbent from four to as much as twelve hours or more under close observation to assure continued hemostasis. During this time, renewed bleeding may occur, resulting in blood loss through the tract, hematoma and/or pseudo-aneurysm formation, as well as arteriovenous fistula formation. These complications may require blood transfusion and/or surgical intervention.

(5) The incidence of complications from the manual compression procedure increases when the size of the introducer sheath grows larger, and/or when the patient is anticoagulated. The compression technique for arterial closure can be risky, and is expensive and onerous to the patient. Although the risk of complications can be reduced by using highly trained individuals, dedicating such personnel to this task is both expensive and inefficient. Nonetheless, as the number and efficacy of translumenally performed diagnostic and interventional vascular procedures increases, the number of patients requiring effective hemostasis for a vascular puncture continues to increase.

(6) Vascular closure devices were introduced to reduce the time to hemostasis, enable early ambulation and improve patient comfort. Initially, devices focused on technologies involving a suture or collagen plug. These technologies close the hole or puncture site, however, they often leave an intravascular component in the vessel which can cause complications and result in residual bleeding or tract ooze. Some amount of slow and steady tract bleeding is a common occurrence. This bleeding usually requires direct management by a trained health care professional until it is completely stopped. Anticoagulant medications typically given to catheterized patients can exacerbate bleeding and may require management with manual compression until the medication wears off.

BRIEF SUMMARY OF THE INVENTION

(7) This application is directed to a vessel closure device for delivering rapid hemostasis at a

puncture site in a wall of a blood vessel. The vessel closure device can include an intravascular anchor having one or more suture attachment points, an extravascular cap having a lumen, a sealant, and a suture connected to at least one of the one or more suture attachment points of the intravascular anchor and threaded through the lumen of the extravascular cap. Each of the intravascular anchor, extravascular cap, sealant, and suture can be formed of bioabsorbable materials.

(8) The present invention relates to a vessel closure device for delivering immediate hemostasis at a puncture site in a wall of a blood vessel, the closure device includes an intravascular anchor comprising one or more suture attachment points, an extravascular cap having a lumen, a sealant, and a suture connected to at least one of the one or more suture attachment points of the intravascular anchor and threaded through the lumen of the extravascular cap and through the sealant to connect the intravascular anchor to the extravascular cap and to the sealant. Each of the intravascular anchor, extravascular cap, sealant, and suture are formed of bioabsorbable materials.

(9) The present also relates to a vessel closure device having one or more of an elongate body having a flexible member and a keel (optionally with a plurality of ribs radiating from the keel to a raised edge of the elongate body), an extravascular cap being formed of an elastomeric material, the sealant being formed of polyethylene glycol (PEG), the suture having a distal suture portion and a proximal suture portion, the diameter of the lumen of the extravascular cap being smaller than the diameter of the distal suture portion, the intravascular anchor being formed or having a material selected from Polyglycolic acid (PGA), Poly-L-Latic acid (PLLA), Polycaprolactone (PCL), Poly-DL-lactic acid (PDLLA), Poly trimethylene carbonate (PTMC), and Poly para-dioxanone (PPDO), and the sealant can expand up to 4 times its original size when introduced to fluids.

(10) A vessel closure device for delivering immediate hemostasis at a puncture site in a wall of a blood vessel, the closure device including an intravascular anchor having one or more suture attachment points, an extravascular cap having a lumen, a sealant having a lumen, and a suture connected to at least one of the one or more suture attachment points of the intravascular anchor and threaded through the lumen of the extravascular cap and through the lumen of the sealant to connect the intravascular anchor to the extravascular cap and to the sealant. The suture can include a proximal suture portion and a distal suture portion, wherein the distal suture portion has a diameter greater than a diameter of the lumen of the extravascular cap. The distal suture portion can create an interference fit to lock the extravascular cap over the puncture site, and each of the intravascular anchor, extravascular cap, sealant, and suture are formed of bioabsorbable materials.

(11) The present also relates to a vessel closure device having one or more of the extravascular cap is formed of flexible material, the suture being a braided suture, the sealant is threaded onto the suture at a location proximal to the extravascular cap, the sealant when activated locks the extravascular cap in place and coagulates an access tract of the puncture site providing immediate hemostasis, the intravascular anchor having an elongate body, a raised keel located on a central axis of the elongate body and spanning the length of the elongate body (optionally including one or more suture attachment points), and the sealant being formed of polyethylene glycol (PEG).

(12) The present invention also relates to an intravascular anchor for a vessel closure device for delivering immediate hemostasis at a puncture site in a wall of a blood vessel, the intravascular anchor including an elongate body comprising a flexible membrane for conforming to the wall of the blood vessel, a keel having one or more suture attachment points, wherein the keel is an elongate member centrally located along a central axis of the elongate body, and wherein the intravascular anchor comprises a bioabsorbable material selected from Polyglycolic acid (PGA), Poly-L-Latic acid (PLLA), Polycaprolactone (PCL), Poly-DL-lactic acid (PDLLA), Poly trimethylene carbonate (PTMC), and Poly para-dioxanone (PPDO).

(13) These and other objects and features of the present invention will become more fully apparent from the following description and appended claims, or may be learned by the practice of the invention as set form hereinafter.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) A description of various aspects and features of the invention will be rendered by reference to various representative embodiments thereof illustrated in the appended drawings. It is appreciated that these drawings depict only typical embodiments of the invention and are therefore not to be considered limiting of its scope.

(2) FIGS. **1**A-**1**C illustrate a delivery system in which a closure device can be implemented according to one example.

(3) FIG. **1**D illustrates an alternate delivery system for deploying the closure device according to the present invention.

(4) FIG. **1**E illustrates a partial cross-sectional view of the alternate delivery system of FIG. **1**D.

(5) FIG. **1**F illustrates a schematic representation of another alternate delivery system according to the present invention.

(6) FIGS. **2**A and **2**B illustrate example embodiments of a closure device.

(7) FIG. **3**A illustrates an embodiment of a cap of a closure device.

(8) FIG. **3**B illustrates a cross-sectional view of the cap of FIG. **3**A.

(9) FIG. **3**C illustrates the cap of FIG. **3**A with an adhesive layer.

(10) FIG. **3**D illustrates a cross-sectional view of the cap of FIG. **3**C.

(11) FIG. **4** illustrates a cross-sectional view of a closure device as applied to a vessel.

(12) FIG. **5** illustrates a cross-sectional view of a closure device as applied to a vessel through an access tract.

(13) FIGS. **6**A and **6**B illustrate cross-sectional views of a closure device as applied to a vessel through an access tract.

(14) FIGS. **7**A-**7**D illustrate an embodiment of an intravascular anchor of a closure device.

(15) FIGS. **7**E and **7**F illustrate an alternate embodiment of an intravascular anchor of a closure device.

(16) FIGS. **7**G and **7**H illustrate an alternate embodiment of a closure device.

(17) FIG. **8**A illustrates a lumen facing side of an alternate embodiment of an intravascular anchor.

(18) FIG. **8**B illustrates an intima facing side of the embodiment of the intravascular anchor of FIG. **8**A.

(19) FIG. **9**A illustrates a lumen facing side of another embodiment of an intravascular anchor.

(20) FIG. **9**B illustrates an intima facing side of the embodiment of the intravascular anchor of FIG. **9**A.

(21) FIG. **10**A illustrates a lumen facing side of another embodiment of an intravascular anchor.

(22) FIG. **10**B illustrates an intima facing side of the embodiment of the intravascular anchor of FIG. **10**A.

(23) FIGS. **11**A-**11**D illustrate a method of delivering a closure device to an access site on a vessel.

(24) FIG. **12** illustrates an alternate embodiment of a delivery system in which a closure device can be implemented.

(25) FIGS. **13**A and **13**B illustrate side views of a handle assembly of the delivery system of FIG. **12**.

(26) FIG. **13**C illustrates a perspective view of the handle assembly of FIGS. **13**A and **13**B.

(27) FIG. **13**D illustrates a top plan view of the handle assembly of FIGS. **13**A-**13**C.

(28) FIG. **13**E illustrates a cross-sectional view of the handle assembly of FIGS. **13**A-**13**D.

(29) FIG. **13**F illustrates an enlarged view of **13**F of the handle assembly as shown in FIG. **13**E.

(30) FIG. **14**A illustrates an exploded view of the handle assembly of the delivery system.

(31) FIG. **14**B illustrates an enlarged view of a chamber of the handle assembly of FIGS. **12**-**14**A.

(32) FIG. **14**C illustrates a cross-sectional view of the handle assembly of FIGS. **13**A-**13**E with an

implant assembly removed from the handle assembly.
(33) FIG. **14**D illustrates a cross-sectional view of a slider of the implant assembly of FIG. **14**C.
(34) FIGS. **14**E and **14**F illustrates a perspective views of the slider of FIG. **14**D as positioned within a handle body.
(35) FIG. **15** illustrates the implant assembly of FIGS. **14**A and **14**C.
(36) FIG. **16** illustrates an exploded view of the implant assembly of FIG. **15**.
(37) FIGS. **17**A and **17**B illustrate a dilator tube for implantation of a closure device.
(38) FIGS. **18**A and **18**B illustrate a delivery sheath of a delivery system.
(39) FIGS. **19**A and **19**B illustrate the insertion and attachment of a handle assembly to a delivery sheath.
(40) FIG. **19**C illustrates the delivery system of FIG. **19**A in a partially-deployed state.
(41) FIG. **19**D illustrates a close up view of the implant assembly partially deployed from the delivery sheath as shown in FIG. **19**B.
(42) FIGS. **20**A-**20**B illustrate a dilator tube being inserted into a deliver sheath according to a method of delivering a closure device to an access site on a vessel.
(43) FIG. **21**A illustrates the combination dilator tube and delivery sheath being inserted through a tissue tract according to according to a method of delivering a closure device to an access site on a vessel.
(44) FIG. **21**B illustrates the delivery sheath in the tissue tract according to a method of delivering a closure device to an access site on a vessel.
(45) FIGS. **21**C-**21**D illustrates the handle assembly being connected to the delivery sheath according to a method of delivering a closure device to an access site on a vessel.
(46) FIG. **22** illustrates partial deployment of the closure device according to a method of delivering a closure device to an access site on a vessel.
(47) FIGS. **23**A-**23**C illustrate deployment of the closure device and removal of the handle assembly and delivery sheath according to a method of delivering a closure device to an access site on a vessel.

DETAILED DESCRIPTION

(48) One or more specific embodiments of the present disclosure will be described below. In an effort to provide a concise description of these embodiments, some features of an actual embodiment may be described in the specification. It should be appreciated that in the development of any such actual embodiment, as in any engineering or design project, numerous embodiment-specific decisions will be made to achieve the developers' specific goals, such as compliance with system-related and business-related constraints, which may vary from one embodiment to another. It should further be appreciated that such a development effort might be complex and time consuming, but would nevertheless be a routine undertaking of design, fabrication, and manufacture for those of ordinary skill having the benefit of this disclosure.
(49) One or more embodiments of the present disclosure may generally relate to apparatuses, systems, and methods to provide a closure device or closure implant configured to close an opening formed in tissue. The closure devices or closure implants can be configured to provide immediate or substantially immediate hemostasis at the vessel puncture and delivery of a hemostatic agent in the access tract to eliminate track ooze. The configuration of the disclosed closure devices or closure implants can prevent extravascular components from passing through the puncture site, as well as improved resistance to fracture and possible embolization.
(50) One or more embodiments of the present disclosure may also generally related to apparatuses, systems, and methods used to close an opening, with a portion of the closure device or closure implants temporary remaining within the patient to close the opening and being subsequently degraded, absorbed, or resorbed over a period of time.
(51) While the present disclosure will describe a particular implementation of apparatuses and systems, with associated methods, for removing closing an opening in tissue, it should be

understood that any of systems, apparatuses, and methods described herein may be applicable to other uses, including and not limited to closing existing or formed openings in tissue or body lumens in other locations with a patient's anatomy. Additionally, elements described in relation to any embodiment depicted and/or described herein may be combinable with elements described in relation to any other embodiment depicted and/or described herein.

Vessel Closure Delivery System

(52) The present disclosure relates to devices, systems, and methods for closing an opening in a blood vessel. For example, the present disclosure includes an anchor, such as an intravascular anchor formed from, in one configuration, a bioabsorbable, bioresorbable, and/or biodegradable material. The anchor may be passed through an opening defined in a wall of a blood vessel and deployed. The anchor can then be drawn proximally to draw the anchor into contact with a distal side of the blood vessel lumen wall. A closure element, such as an extravascular cap, can then be deployed to close the puncture.

(53) In at least one example, once deployed within a blood vessel, the anchor (and optionally the cap) may degrade, absorb, or resorb in a predetermined amount of time, such as between about 36-72 hours, in less than 48 hours, less than about 36 hours, in a day, less than an hour, or some other amount of time as desired. The rapid degradation, absorption, or resorption of one or more components of the device can allow the anchor, for example, to be left in place after the closure device or closure implant has been deployed by obviating the need for removal of the anchor. By leaving the anchor in place until it degrades, absorbs, or resorbs, damage that may occur by drawing the anchor through the closed puncture and/or the deployed closure element can be reduced or eliminated.

(54) In addition, the degradation, absorption, or resorption time of the anchor may fall within the time frame of the action of an anti-thrombotic medication being used in conjunction with the treatment of a patient. Accordingly, the closure device or closure implant of the present disclosure may reduce the risk of formation of intra-arterial clots associated with the closure of the blood vessel puncture site.

(55) While reference has been made to the anchor remaining in the blood vessel and degraded, absorbed, or resorbed by the patient's body, it will be understood that in other configurations the anchor may be deployed and subsequently removed once sufficient closure of the puncture has occurred.

(56) Reference is now made to FIGS. **1**A-**1**B, which illustrates a closure device delivery system or closure implant delivery system **30** according to one example. As shown in FIGS. **1**A-**1**B, the delivery system **30** may include a delivery sheath **40** with a nested set of actuators **50**, **60**, and **70** that are configured to cooperate to deploy a closure device or closure implant **100** including an anchor **108**, such as an intravascular “foot” or anchor, a closure element, such as a cap **102** (see FIGS. **2**-**4**), a fluid-blocking component **104**, such as a sealant (see FIGS. **2**-**4**) (the term fluid-blocking component and sealant will be used interchangeably herein), and a suture element **106**. For instance, the actuator **50** can be used to deploy the anchor **108**, the actuator **60** can be used to deploy the cap **102**, and the actuator **70** can be used to deploy the fluid-blocking component **104**. In at least one example, the delivery sheath **40** is configured to house the anchor **108**, the cap **102**, and the fluid-blocking component **104** while the actuators **50**, **60**, and **70** are configured to deploy the anchor **108**, the cap **102**, and the fluid-blocking component **104**, respectively from the delivery sheath **40**. The exemplary delivery sheath **40**, actuators **50**, **60**, and **70**, anchor **108**, and closure device **100** of FIG. **1**A will be discussed in more detail with reference to FIG. **1**B.

(57) While the set of actuators **50**, **60**, and **70** are illustrated as being coaxially disposed within the delivery sheath **40**, the actuators **50**, **60**, and **70** can be non-coaxially disposed in the delivery sheath **40**, such as illustrated in FIGS. **1**D and **1**E where the actuator **50** is disposed to a side of the actuator **60**. Additionally, returning to FIGS. **1**A-**1**B, while the following discussion provides one manner by which specific actuators can be used to deploy the anchor **108**, the cap **102**, and the

fluid-blocking component **104**, it will be understood by those skilled in the art that one of the actuators **50**, **60**, and **70** can deploy any combination of the anchor **108**, the cap **102**, and the fluid-blocking component **104** in any order or sequence. For instance, while the actuator **60** can deploy the cap **102** and the actuator **70** can deploy the fluid-blocking component **104**, in other configurations one of the actuators can be eliminated, such as for example the actuator **70**, and the actuator **60** can deploy the cap **102**, advance the fluid-blocking component **104** toward the cap **102**, and deploy the fluid-blocking component **104** through a combination of distal and/or proximal movement in relation to the anchor **108**. In other configurations, the delivery system **30** can include two or more actuators, such as two or more of the actuators **50**, **60**, or **70**, to delivery/deploy the anchor **108**, the cap **102**, and the fluid-blocking component **104**. It is also possible for other combinations of deployment functions to be performed by other individual or combination of actuators. The one or more lumens of the one or more actuators **50**, **60**, or **70** can include one or more valves or seals **58**, **68**, and **78**, and the delivery sheath **40** can also include one or more valves or seals **45**, to prevent blood flowing from the ends of the delivery sheath **40** and the actuators **50**, **60**, and **70**.

(58) FIG. **1**B illustrates an exploded view of the delivery system **30**. As shown in FIG. **1**B, the delivery sheath **40** includes an outer housing **42** and a handle or grip portion **44**. Each of the actuators **50**, **60**, and **70** include, respectively, a shaft or housing portion **52**, **62**, **72**, a handle or grip portion **54**, **64**, and **74**, and distal ends that can cooperate with, respectively, the anchor **108**, the cap **102**, and the fluid-blocking component **104**. For instance, the actuator **50** can include a notch **58** (FIG. **1**A) to receive the suture **106** and optionally a portion of the anchor **108**. An interior lumen **46** is defined in the outer housing **42** that is configured to receive the actuators **50**, **60**, and **70** in such a manner as to allow the actuators **50**, **60** and **70** to be extended from and retracted within a distal end **48** of the outer housing **42**. Each actuator **50**, **60** and **70** also includes, respectively interior lumens **56**, **66**, and **76** to allow for translation of the actuators **50**, **60**, and **70**, either independently or in combinations of 2 or more of the actuators, and the delivery sheath **40**. Translation distance of the actuators **50**, **60**, and **70** can be controlled through contact between adjacent handle or grip portions **44**, **54**, **64**, and **74**. For instance, the grip portion **44** can limit distal movement of each of the grip portions **54**, **64**, and **74** associated with the actuators **50**, **60**, and **70**, while grip portion **74** can limit distal movement of each of the grip portions **54**, and **64** and the grip portion **64** can limit movement of the grip portion **54**. In this way, over translation of individual actuators is limited and the anchor **108**, cap **102**, and fluid-blocking component **104** can be effectively deployed to access and close a tissue opening.

(59) While reference is made to the handle or grip portions limiting actuator translation, it is understood that other approaches can be used for controlling translation. For instance, complementary structures can be formed in the housings and the interior lumens to limit translation. In another configuration, the handle or grip portions are combined into a single handle assembly having different actuation controls, such as switches, knobs, sliders, etc. to allow independent or combined movement of one or more of the actuators **50**, **60**, and **70**.

(60) In another configuration, as illustrated in FIG. **1**C, an interior lumen **46**′ can include a first portion **46**A′ configured to receive the shaft portion **54**′ of the actuator **50**′ while a second portion **46**B′ of the interior lumen **46**′ can be configured to receive a distal end **54**A′ of the shaft portion **54**′ having the interior lumen **56**′. More specifically, the second portion **46**B′ of the interior lumen **46**′ may have a larger width aspect than the width aspect of the first portion **46**A′. The width aspects of the first portion **46**A′ and the second portion **46**B′ can be the diameters thereof or other cross-sectional profiles that are generally transverse to a center axis C of the delivery sheath **40**′. For ease of reference, the center axis C of the delivery sheath **40**′ will be referenced in describing the position and movement of the other components described herein. In the illustrated example, the interior lumen **46**′ may transition from the smaller diameter of the first portion **46**A′ to a second larger diameter of the second portion **46**B′ at a shoulder **46**C′.

(61) Such a configuration can allow the actuator **50′** to translate axially relative to the delivery sheath **40′** within a desired range of motion. In particular, the handle portion **52′** can translate within the second portion **46**B′ of the interior lumen **46′** to advance the shaft portion **54′** within the outer housing **42′** and in relation to the handle or grip port **44′** to thereby move the distal end **54**A of the shaft portion **54′** relative to the distal end **42**A of the outer housing **42′**. Interaction between the handle portion **52′** and the shoulder **46**C′ can help ensure the distal end **54**A′ does not extend beyond a desired position within the outer housing **42**.
(62) In the illustrated example, the first portion **46**A′ may also be configured to receive the anchor **108** and the cap **102** proximally of the distal end **54**A′ of the shaft portion **54′**. Accordingly, as the distal end **54**A′ of the shaft portion **54′** is advanced toward the distal end **42**A′ of the outer housing **42′**, the distal end **54**A′ of the shaft portion **54′** can engage the anchor **108** and/or the cap **102** to move the anchor **108** and/or the cap **102** distally from the outer housing **42**.
(63) Returning to FIG. **1**A, the anchor **108** can be configured to move from a pre-deployed state having a pre-deployed width aspect to a deployed state having a deployed width aspect. The deployed width aspect may be greater than the pre-deployed width aspect. The anchor **108** can have any configuration that allows for this. In the illustrated example, anchor **108** is configured to rotate or be rotated between the pre-deployed state and the deployed state. In other examples, portions or all of the anchor **108** may be configured to unfold from a configuration have a pre-deployed width aspect to a deployed state having a greater width aspect. For example, one or more arms or wings may be configured to unfold and fold about a plurality of pivot points, hinges, living hinges, bending locations, preferential bending location, combinations or modifications thereof.
(64) As shown in FIG. **1**A, the anchor **108** includes wing members **132**, **134** that define a major axis **136** of the anchor **108**. The anchor **108** can further include one or more holes or eyelets **138** disposed along a length of the anchor **108**. The holes or eyelets **138** can be located at a position that causes the anchor **108** to rotate when a force acting initially parallel to the major axis **136** is exerted on the eyelets **138**. Such a configuration can allow the anchor **108** to move from a state in which the major axis **136** is aligned with the central axis C to a state in which the major axis **136** is oriented more obliquely to the central axis C, such as generally perpendicular to the central axis C.
(65) This rotation can be accomplished by applying a distally acting force on the anchor **108** to move the anchor **108** out of the outer housing **42** and then a proximally directed force to the anchor **108** by way of the interaction between the suture **106** and the eyelets **138**. In at least one example, the distally acting force applied to the anchor **108** can be provided from the actuator **50** while the proximally directed force can be applied by way of the suture element **106**. The anchor **108** can thus be used to position the delivery system **30** for deployment of the closure element **102**.
(66) In one embodiment, the closure element **102** may be configured to close an opening in a lumen of a blood vessel as well as at least partially obstruct a tissue tract leading from an external surface of the tissue to the lumen. The shape of the closure element **102** may be configured to be housed within the interior lumen **46** (or one of the other lumens of the actuators **50**, **60**, **70**). For example, the closure element **102** may conform to the shape of the interior lumen **46**. In one embodiment, the closure element **102** may be generally cylindrical in shape prior to being deployed from the delivery sheath **40** in which portions of the closure element **102** are at least partially wrapped around or curved towards a central portion of the closure element **102**, whether or not those peripheral portions curve proximally, distally, or transverse to a direction of deployment of the closure element **102** toward the previously deployed anchor **108**. Once deployed from the delivery sheath **40**, at least a portion of the closure element **102** may be at least partially deformable to conform to any desired shape of the vessel wall to close an opening in a blood vessel and/or the tissue tract leading to the lumen opening.
(67) As shown, the suture element **106** can loop through the anchor **108** such that the suture element **106** passes through or near the closure element **102**, and extends proximally into or beyond the handle portion **52** of the actuator **50′**. In at least one example, the free end of the suture element

106 passes through separate portions or channels of the closure element **102**. The suture element **106** can be extended from the closure element **102** and into the actuator **50** by way of the interior lumen **56**.

(68) Generally, the structures and components of the delivery system **30** can be formed of polymers, metals, alloys, combinations or modifications thereof. For instance, by way illustration only, the delivery sheath and the actuators can be formed from metal hypotubes, polymer tubes, composite tubes have a multilayer configuration, or other tubular structures optionally including reinforcing members or braids. The delivery sheath and the actuators can range in outside diameter from about 6 F to about 10 F, from about 2 mm to about 4 mm, from about 2 mm to about 3.33 mm, or other sizes as known to those skilled in the art.

(69) Vessel Closure Device

(70) FIGS. **2**A-**2**B illustrates an example of the closure device **100**. In this particular configuration, the closure device **100** can be a fully bioabsorbable vessel closure implant including intravascular and extravascular components. The extravascular components can include an extravascular cover or cap **102** (hereinafter “extravascular cap” or “cap”) and a second extravascular component or fluid-blocking component **104**, such as a bioabsorbable sealant (see FIGS. **4**-**6**B), which can also be collectively referred to as a closure element. The intravascular components can include an intravascular foot or anchor **108** and a suture **106**, both of which can be bioabsorbable. As mentioned above, in other configurations, the intravascular foot or anchor **108** can be temporarily deployed, with the extravascular components being fully bioabsorbable (such as through degradation, absorption, and/or resorption).

(71) The extravascular cap **102** can be made from bioabsorbable materials and be of sufficient size and geometry to prevent it from passing through the punctured access site **18** at the surface of the blood vessel **10**. The size and geometry of the extravascular cap **102** can significantly increase patient safety by preventing extravascular components from passing through the access site **18** during or after deployment. The cap **102** can have a diameter from about 1 mm to about 10 mm, from about 3 mm to about 8 mm, from about 4 mm to about 5 mm, or other size based upon the specific dimensions of the access site **18** so that the cap **102** does not pass through the access site **18**.

(72) The cap **102** can be of low profile and made from a biodegradable material having desired flexibility to conform to the patient's access site anatomy (especially in vessels with significant calcification present) and provide more effective sealing than would rigid materials. The cap can be deployed through a small catheter access tissue tract **22** and placed on top of the vessel **10** as the primary extravascular seal.

(73) Turning to FIGS. **2**A-**3**B, illustrated is one configuration of the cap **102**. As illustrated, the cap **102** can have a generally circular disk shape, though in other embodiments, the shape of the cap **102** can be interrupted (e.g. star-shape) which can impart the cap **102** with increased flexibility to allow it to conform to the access tract **22** which is typically narrow. The cap **102** can include a medial portion **113** which may be raised relative to the surrounding surface **111** of the cap **102**. The medial portion **113** can have a thickness of about 0.050 mm to about 5 mm, from about 0.10 mm to about 2 mm, from about 0.10 mm to about 0.5 mm, or various other thicknesses. The cap surface **111** can include relief cuts **115** which may provide for increased cap flexibility and conformance to the access tract **22** above the vessel **10**. The relief cuts **115** can extend to a longitudinal axis of the cap **102**, inclined, curved, non-linear, combinations or modifications thereof. Alternatively, or in addition to the relief cuts **115**, a relief cut **115***a* can have a generally circular form disposed around the medial portion **113**, such as to circumscribe, surround, or encircle all or a portion of the medial portion **113**. The relief cut **115***a* can modify the flexibility of surface **111** to improve conformance to the tract and resist entry to the vessel. The cap **102** can have a mass ranging from about 4.0 mg to about 10.0 mg (for 4 mm to about 6 mm diameter cap). With a lower overall mass, less force is used to hold the cap **102** in place between the frictional engagement between the cap **102** and the

suture **106**. This results in smaller overall system, thereby making positioning within the patient simpler with reduced overall impact on the patient's recovery.

(74) The access tract **22** (see FIGS. **4**-**6**B) is typically size restricted, circular, and formed at an angle in relation to the vessel wall. The cap **102** can be configured to slide down a delivery system **30** through the access tract **22** and be deposited on top of the artery or vessel **10**. The suture **106** can then be pulled to tension the cap **102** and intravascular anchor **108** towards each other to seal the access site **18**. The cap **102** can include a lumen **110** in the medial portion **113** through which the suture **106** can be threaded to attach the suture **106** to the intravascular anchor **108**. The lumen **110** can have a diameter ranging from about 0.010″ (0.254 mm) to about 0.020″ (0.508 mm), from about 0.012″ (0.3048 mm) to about 0.017″ (0.4318 mm), or from about 0.014″ (0.3556 mm) to about 0.015″ (0.381 mm).

(75) The lumen **110** can be sized to accommodate the suture **106** of a certain diameter. For instance, as illustrated FIGS. **2**A-**2**B, with the suture **106** looped around the anchor **108**, two rails or portions of the suture **106** can pass through the lumen **110** and proximally along the delivery device **30**. Optionally, portions of the two sutures **106** can be braided together with two suture tails extending proximally from the cap **102**. Alternatively, as illustrated in FIG. **4**, the suture **106** is looped back on itself and braided into itself to increase a portion of the suture that interference fits or otherwise engages with the lumen wall of the lumen **110**, with a single rail extending proximally along the delivery device **30**. In still another case, the two sutures **106** can pass through or cooperate with an elongate member **107** (such as another suture portion or braided tubular member), shown in phantom in FIG. **2**A-**2**B, and be braided to and with the elongate member **107**, to increase a size of the portion(s) of the suture **106** disposed within the cap **102**. One or more elongated member **107** can optionally be inserted into the one or more sutures **106** to increase their dimensions. In each case, i.e., the two adjacent non-braided sutures rails, two adjacent braided suture rails, braided suture and tubular member, or a suture end braided into another portion of the suture after being interwoven through 2 or more holes of the anchor **108**, a thick suture portion **112** is formed which can interference fit with the lumen **110**, which is narrow relative to the thick suture portion **112**, to secure the cap **102** in the desired position. The thick suture portion **112** can have a diameter ranging from about 0.020″ (0.508 mm) to about 0.040″ (1.016 mm), from about 0.024″ (0.6096 mm) to about 0.034″ (0.8636 mm), from about 0.028″ (0.7112 mm) to about 0.030″ (0.762 mm).

(76) The suture **106** can be made of a bioabsorbable material. For example, the suture **106** can be a multifilament or braided absorbable suture, such as those available from VITREX®. In one configuration, the suture is a braided 3-0 suture. It may be advantageous for the suture to have a high tensile strength which can maintain its integrity under the application of from about 3 lbf. to about 6 lbf., although other sutures can accommodate application of forces ranging from about 1 lbf. to about 16 lbf., from about 1 lbf. to about 8 lbf., from about 2 lbf. to about 6 lbf., from about 2.5 lbf. to about 5 lbf., or about 2 lbf.

(77) The cap **102** can be initially positioned on the proximal suture end **116**, or the end of the suture **106** which does not have a diameter larger than the diameter of the lumen **110** of the cap **102**. When the cap **102** is advanced along the suture **106** to the external vessel surface **20** at the arteriotomy location, the thick suture portion **112** causes an interference that can lock the cap **102** in place, resulting in an immediate dry close.

(78) The interference fit can eliminate the need for the use of a knot to maintain the dry close. Use of a knot can pose serious risk to a patient if the set tension on the suture becomes overtightened. The suture can become stressed by a patient walking or coughing causing the suture to over tension and break. The interference fit may be advantageous because it is knotless and the flexibility of the cap can adapt to force applied to the suture.

(79) In addition to, or instead of the interference fit between the cap **102** and the thick suture portion **112**, the cap can optionally include an adhesive applied to a side of the cap contacting the extravascular tissue, as illustrated in the embodiment of FIGS. **3**C-**3**D. For instance, the cap **102**

can include an adhesive layer **128** that bonds to the extravascular tissue when the cap **102** is advanced towards the anchor **108**. The adhesive for the adhesive layer **128** can be a non-migrating adhesive in that it will not flow through the puncture as the extravascular tissue is sandwiched between the cap **102** and the anchor **108**. Such adhesive can include a non-expanding glue, such as a non-expanding polyethylene glycol (PEG), a glue protein, such as a barnacle glue, cross-linked gelatins (non-biologic) cyanoacrylates, polyurethane adhesives, or glues or adhesives, combinations and modifications thereof. More generally, the adhesives can use cross-linking mechanisms that rely on chemical conjugation between reactive groups, free radical polymerization, oxidation reduction reaction, biological or biochemical coupling.

(80) FIGS. **4**-**6**B illustrate an example of a second extravascular component or fluid-blocking component **104**, which can be a sealant. The fluid-blocking component **104** can be an active biologic material, such as polyethylene glycol (PEG), fibrin sealants, copolymer of glucosamine and N-acetyl glucosamine, dextran (complex branched glucan(a polysaccharide. polypeptide adhesive structures, adhesive protein containing L-3,4-dihydroxyphenylalanine (L-DOPA), adhesive protein containing DOPA and phosphoserine, collagen, polyacrylic acid, cross-linked with allyl sucrose or allyl pentaerythritol, polyacrylic acid, cross-linked with divinyl glycol, Acrylic resinous polymer composed of methyl-2-cynoacrylate units, or another fully bioabsorbable sealant-type material that could be optionally incorporated into a shaped, flexible substrate. The sealant material could be activated by fluids present in the patient's tissue tract, such as blood or other fluids, and can be protectively stored inside the sheath/actuators or a chamber of the delivery device until positioned directly on top of the cap **102**.

(81) Once advanced into the desired location, the sealant **104** can be exposed to the blood or fluid, such as through unsheathing the fluid-blocking component **104** and positioning the fluid-blocking component **104** into direct contact with the tissue where it can react by coming into contact with blood and other fluids. This reaction can cause the fluid-blocking component **104** to expand and absorb blood and other fluids and bond to surrounding tissue and the cap **102**. The sealant can act as a glue and aid with “locking” the cap **102** in place on the blood vessel **10**, and actively coagulates the entire access tract **22**. The chemical formulation, quantity, carrier matrix, and dimensions of the fluid-blocking component **104** can be selected specifically to provide one or more of the functions of locking in place of the sealing component (e.g. cap **102**), to provide a fast acting and leak-free dry close, and reduce tissue tract oozing.

(82) For instance, the sealant can form a plug having a length of about 1 mm to about 10 mm and can optionally be trimmed to length in the patient along with the suture after deployment, or the adhesive component can extend the full length of the tissue tract and trimmed to fit the patient. When the fluid-blocking component **104** is formed of a matrix, the matrix can have an area of about 0.012 square inches to about 0.12 square inches, about 0.12 square inches to 0.6 square inches, about 0.6 to 1.0 square inches. The matrix material can be thin and flexible such that it can be wrapped around the suture in the delivery system to fit inside a tube for delivery to the implant location. This results in a volume of fluid-blocking component, optionally including a matrix containing a sealant such as PEG or other biocompatible material, of between about 0.004 to about 0.040 cubic inches in volume, about 0.0.040 to about 0.100 cubic inches, about 0.100 to about 0.400 cubic inches.

(83) The fluid-blocking component **104** can be deployed so that is disposed on the suture **106**. The fluid-blocking component **104**, therefore, can be deployed in a flowable composition without a carrier matrix or can be formed as part or with a carrier matrix. For instance, the fluid-blocking component **104** can be disposed around the suture in a generally cylindrical component, can be bonded to the suture itself, can be bonded to the cap, and combinations or modifications thereof. Because the sealant **104** is positioned proximal relative to the cap **102**, the sealant **104** can actively coagulate the access tract **22** and optionally actively coagulate all of access tract **22** to the surface of the skin **16**.

(84) Sealant **104**, as shown in FIGS. **4**-**6**B, can have a conical configuration when deployed, though in other embodiments the sealant **104** can have a continuous or uniform thickness along its length. The extravascular cap **102** can displace tissue at the access site **18** because the cap **102** can be larger than the arteriotomy. The sealant **104** can also fill the space created by the displaced tissue. The sealant **104** can be formed of material with properties which can cause it to swell from its original size when it comes into contact with bodily fluids, causing it to effectively cover and reinforce the seal formed by the cap **102**. The sealant **104** can swell from its original size about 1 time to about 6 times, from about 2 times to about 4 times, or from about 2.5 times to about 3.5 times. It can be advantageous to optionally have the sealant expand up the access tract **22** as close as possible to the skin **16** to mitigate any bleeding.
(85) When the sealant has a predetermined conical or tapered shape, the sealant **104** can be formed as a separate sealant component with a hole through the center, or other locations, to allow the sealant **104** to be threaded on to the suture **106**. More generally, the suture may be threaded through one or more points through or around the sealant. The sealant component could be foam matrix or other formed substrate that a biocompatible material can be infused into and then formed into the desired shape, such as PEG. The sealant **104** can be a combination of two or more components which can be loaded into one of the actuators **50**, **60**, or **70**, and then simultaneously activated by pressing down the handle or grip portions to expose the sealant **104** to bodily fluid. The two or more components can include one or more flowable component, with or without a matrix having a preformed shape or being biased to a particular shape.
(86) In other embodiments, the sealant **104** and cap **102** can be deployed together as if they are one component. The cap **102** can cover the access site **18** and the sealant **104** can be activated on top of and above the cap **102** to seal the access tract **22**.
(87) In other embodiments, as illustrated schematically in FIG. **1**F (in which the actuator **50**, the anchor **108**, and the cap **102** are omitted for ease of explanation), the fluid-blocking component or sealant **104** can be stored in a chamber **103** at a proximal end of the delivery system. The fluid-blocking component or sealant **104** can be stored in a generally planar or flat-sheet form, optionally biased to that generally planar or flat-sheet form, and advanced to the cap **102** through a funnel **105** or other proximal deployment port that curls, folds, or otherwise changes the planar or flat-sheet form to a formed capable of being advanced toward the cap **102**. In one configuration, the actuator **70** can be used to advance the fluid-blocking component or sealant **104** from the chamber (arrow A) along the actuator **60** to deploy the sealant **104** from within the actuator **60**, such as when the actuator **70** is distally advanced (arrow B), when the actuator **60** is partially withdrawn proximally from engagement with the cap **102** following sandwiching the tissue between the cap **102** and the anchor, through movement of another actuator or structure, or combinations or modifications thereof. The movement exposes the fluid-blocking component or sealant **104** to the blood or other fluids causing the fluid-blocking component or sealant **104** to expand.
(88) When introducing a coagulant or sealant, there is a risk of introducing embolizing material into the vessel **10** which can cause a clot and threaten a limb. Emergency surgery may be required to remove the foreign body. This risk can be mitigated by the configuration of closure device **100** due to the use of the cap **102** to first cover the access site **18** so that the extravascular fluid-blocking component or sealant **104 104** cannot pass into the vessel **10**.
(89) The combination of a low profile cap component, including degradable, absorbable, or resorbable material that is stable (material does not expand or aggressively bond to tissue), plus the active sealant material on top, combined as an extravascular implant is unique and distinguishes this design from other closure devices.
(90) Turning now to FIGS. **7**A-**7**H, the closure device **100** can include an intravascular anchor **108**, for example, a graft-type anchor. The intravascular anchor **108** can include one or more of the following elements: 1) a large surface area in an elongate shape otherwise referred to as elongate member **117**, 2) a central keel **120** which can provide suture attachment and overall rigidity, 3) a

flexible portion or membrane **122** which can conform to a vessel wall, 5) holes, eyelets, or other structure **118** which can provide for suture attachment to an extravascular component (e.g., cap **102**) of a closure device **100**, and 6) flexible edges **126** of the flexible portion or membrane which can allow for storage in a cylindrical state to permit delivery of the closure device **100** to the vessel **10**. The anchor **108** can be formed of multiple sub-components that are joined together or be formed as a monolithic component where the identified one or more elements are formed as a single component, such as through casting or through machining of a starting workpiece.

(91) The intravascular anchor **108** (also referred to as "anchor") can be formed of a bioabsorbable material, while having flexibility properties that allow the anchor **108** to be curled up into a smaller profile inside of a delivery sheath, such as the delivery sheath **40**. This allows a larger sealing surface that can unfurl once free of the delivery tube. The intravascular anchor **108** is attached to the suture **106** using a pattern that can distribute the tensile load more widely across the breadth of the anchor **108** to prevent fracture from a high concentration of force during device deployment.

(92) The intravascular anchor **108** can have a curved profile in order to better conform to the curvature of the vessel wall. The anchor **108** can also have an enlarged central portion or a keel **120**. The keel **120** can help to reinforce the seal formed over the access site **18** by the closure device **100** and provide a suture attachment point. The rigidity of the keel **120** can provide mechanical leverage and a robust location to advance and eject the anchor **108** out from the delivery sheath **40**. The keel **120** can have a thickness of about 0.5 mm to about 0.8 mm, of about 0.6 mm to about 0.9 mm, of about 0.7 mm to about 1.0 mm, or other thickness to provide the desired suture attachment location.

(93) Surrounding the keel **120** is the elongate member **117**. The materials forming the elongate member **117** can be the same as the keel **120**, such a bioabsorbable material, with the material a have a durometer ranging from about 50 Shore A to about 100 Shore A, from about 80 Shore A to about 90 Shore A, or durometers as chosen based upon the closure location. The elongate member **117** can have thinner, flexible sections relative to the keel **120**, which can conform to the curved vessel wall **14**. The flexibility can also allow the anchor **108** to conform to the unique calcification buildup in the vessel **10**. The elongate member **117** can have an ellipse or oval shape having a minor axis dimension from about 2.0 mm to about 10.0 mm, from about 3.0 mm to about 5.0 mm, or about 4 mm, while a major axis can range from about 4.0 mm to about 12.0 mm, from about 6.0 mm to about 8.0 mm, or about 6.0 mm. It is understood that the configuration of the anchor, and more generally, the closure device or implant can be varied based upon the particular opening to close so that the dimensions can be adjusted to accommodate, generally, 5-8 F openings or openings larger than 8 F and smaller than 5 F.

(94) The ridge or keel **120** can run the length of the central axis of the elongate member **117** and can impart rigidity where suture **106** can be attached. The suture **106** can be attached through suture attachment points or holes **118** in the keel **120**. One or more holes **118** can provide points through which the suture **106** can be threaded to attach the anchor **108** to the cap **102** and sealant **104**. The holes **118** can be evenly or non-evenly spaced along the length of the keel **120**. The spacing of the holes **118** can help to spread the tensile load across a desired length of the anchor **108**, such as all or some portion of the length of the anchor **108**, and can prevent fracture of the anchor **108** under load. In the embodiment shown in FIGS. **7**A-**7**H, free distal ends of the suture **106** can each be threaded through each of the outermost holes **118***a* and then both can be threaded through the middle holes **118***b* and up through the access site **18** and braided back onto the suture **106** to form the thick suture portion **112**.

(95) The anchor **108** can be injection molded, cast, stamped, machined, combinations or modifications thereof, and include one or more bioabsorbable materials, bioabsorbable polymers, or bioabsorbable elastomers depending on the degree of strength, stiffness and absorption rate desired. The anchor **108** structure can be formed of a homogenous material mixture where flexibility is adjusted through a combination of geometry and material formulation. A secondary

adhesive material may be attached or bonded to the bottom surface of anchor **108** to increase attachment strength and improve sealing performance against the blood vessel. The anchor provides a safe manner for the sealant to interact directly with the blood vessel tissue without risk of embolizing into the blood vessel lumen because it is attached to anchor **108**. The bioabsorbable materials can include, for example, and not by way of limitation, Polyglycolic acid (PGA), Polylactide (PLA), Poly-L-Latic acid (PLLA), Polycaprolactone (PCL), Poly-DL-lactic acid (PDLLA), Poly trimethylene carbonate (PTMC), Poly para-dioxanone (PPDO), combinations and/or modifications thereof. More generally, the materials forming the anchor **108** can have a durometer ranging from about 80 Shore A to about 90 Shore A. Alternatively, when the anchor **108** is temporarily deployed, the anchor can be formed of a non-bioabsorbable material, such as polyvinyl chloride (PVC), Polyether ether ketone (PEEK), Polytetrafluorethylene (PTFE), nylon, silicone, urethane, thermoplastic elastomers like Polyether block amide (PEBAX), polyethylene terephthalate (PET), Fluoropolymers, or biocompatible materials, combinations and/or modifications thereof.

(96) The anchor **108** can have a mass ranging from about 4 mg to 8 mg (for 4 mm×6 mm ellipse), from about 8 mg to about 16 mg (for 5 mm×7 mm ellipse), or from about 15 mg to 30 mg (for 8×10 mm ellipse). With a lower overall mass, less force is used to hold the anchor **108** in place between the frictional engagement between the cap **102** and the suture **106**. This results in smaller overall system, thereby making positioning within the patient simpler with reduced overall impact on the patient's recovery.

(97) FIGS. **8**A and **8**B illustrate another example embodiment of the intravascular anchor **108**. In FIGS. **8**A-**8**B, the anchor **108** includes a lumen facing side **127** (FIG. **8**A) and an intima facing side **129** (FIG. **8**B). The anchor **108** can include an elongate body **117** having a flexible member or membrane **122**, a keel **120** positioned at the central axis of the elongate body **117** and spanning the length of the elongate body **117** which can provide adequate stiffness for attachment of the intravascular anchor **108** to the extravascular element of the closure device **100** by suture **106** (e.g., cap **102**).

(98) The keel **120** can be raised relative to the lumen facing side surface of the anchor **108**, which can help to maintain the position of the anchor **108** on the vessel wall **114**. The intima side of the anchor **108** can include a plurality of ribs **124** radiating outward from the keel **120** to the raised edge **126** forming the perimeter of the elongate body **117**. The raised elements of the ribs **124** and raised edge **126** provide for encapsulation of localized plaque on the vessel wall **114**. The stiffness of the raised edge **126** of the anchor **108** may be correlated to the stiffness and/or pattern, number, and/or thickness of the ribs **124** ribs radiating from the keel **120**. The width and taper of the ribs **124** may be varied to influence the compliance or the stiffness of the edge **126** of the anchor **108**.

(99) FIGS. **9**A-**9**B illustrate another embodiment of an anchor **208**. The anchor **208** can include an elongate body **217** having a flexible member or membrane **222** and a centrally-located raised keel **220** spanning the length of the elongate body **217**. The elongate shape of the anchor **208** is modified to maximize the surface area of the anchor **208**. In this depiction the number of ribs **224** is reduced which may increase compliance to the vessel lumen wall **14**. The anchor **208** can also have a raised edge **226** running the perimeter of the elongate body **117**. One or more holes **218** in the keel **220** provide points through which a suture **106** can be threaded to attach the anchor **208** to extravascular components of the closure device **100**.

(100) FIGS. **10**A-**10**B, illustrate another embodiment of an anchor **308**. The anchor **308** can include an elongate body **317** having a flexible membrane and a raised keel **320** located on and spanning the length of the central axis of the elongate body **317**. The keel **320** can include one or more holes **318** through which suture **106** can be threaded. In this embodiment the ribs (**124**, **224**) are omitted to permit maximum flexibility of the anchor **308**. The raised edge **326** running the perimeter of the intima side of the anchor **308** can impart the anchor **308** with requisite structural integrity to maintain the shape of the anchor **308** when positioned on the lumen wall **14**.

(101) Method of Closure Device Insertion
(102) Reference is now made to FIG. **11**A, which illustrates a step in the process of deploying the anchor **108**. As shown in FIG. **11**A, the delivery sheath **40** can be positioned to move the distal end of the outer housing **42** through an access tract **22** defined in tissue **72** and into proximity with a lumen **12** and a puncture or access site **18** defined in a lumen wall **14** in particular. The distal end of the delivery sheath **40** is advanced into the lumen **12** until pulsating blood is visually observed from a proximally positioned blood outlet port **49** (FIG. **1**A) of a bleed back or blood marker lumen formed in a wall of the delivery sheath **40** or formed by a separated bleed back tube formed either interior or externally of the delivery sheath **40**. The blood inlet port **47** (FIG. **1**A) in fluid communication with the blood outlet port **49** is disposed toward the distal end of the delivery sheath.
(103) Once blood flow is observed, the actuator **50** can be manipulated as described above (and as shown in FIG. **11**B) to cause the anchor **108** to be pushed out of the distal end **42**A of the outer housing **42**. Alternatively, the actuator **60** may push the closure element or cap **102** which may, in turn, push the anchor **108** distally relative to the outer housing **42**, thereby deploying the anchor **108** from the distal end **42**A of the outer housing **42**. In such a case the actuator **50** can optionally be omitted.
(104) In one embodiment, once deployed, the anchor **108** may rotate or be rotated from a first orientation, in which the major axis **136** of the anchor **108** is at a small angle or generally parallel with the outer housing **42** and generally perpendicular to the lumen wall **14** as shown in FIG. **11**A, to a second orientation in which the major axis **136** of the anchor **108** is generally parallel with the lumen **12** and at a greater angle or generally perpendicular to the delivery sheath **40** as shown in FIG. **11**B.
(105) In particular, as shown in FIG. **11**B, once the anchor **108** is pushed from the distal end **42**A of the outer housing **42**, the anchor **108** may rotate or be rotated to the second orientation, such as by tension applied to by the suture element **106** to the anchor **108** by way of the central or middle hole **118***b*. The anchor **108** can then be drawn in the proximal direction to secure the anchor **108** against a distal surface **14**A of the lumen wall **14**, as illustrated in phantom in FIG. **11**B. While the suture **106** is illustrated extending proximally within the lumen of the actuator **50** in FIG. **11**A and FIG. **11**B, when the actuators are non-coaxial, such as illustrated in FIGS. **15** and **16**, the suture **106** need not extend within a lumen of the actuator **50** and actuator **50** need not include a lumen. The suture **106** can extend within any lumen of the delivery system **30**, such as illustrated in solid and dashed schematic representations of the suture **106** in FIG. **16**
(106) With the anchor **108** deployed and positioned against the lumen wall **14** and the delivery sheath **40** partially retracted into the access tract **22** so that the distal, the actuator **60** may then deploy the cap **102** proximal the puncture **18** between the lumen wall **14** and the tissue **72** through which the tract **22** is formed. In particular, as shown in FIG. **11**C the actuator **60** can be advanced distally, the delivery sheath **40** can be drawn proximally, and/or some combination of such movements can be used to move the cap **102** distally out of the outer housing **42** and into contact with the proximal side or extravascular side **14**B of the lumen wall **14** adjacent the puncture **18**. The lumen wall **14** is positioned between the anchor **108** and the cap **102** with the cap **102** positioned on the extravascular side of the access site **18** and “locked” in place as a result of an interference fit created by the thick suture portion **112**. Thus, the cap **102** can be positioned to reduce or stop the flow of fluid out of the tract **22** by covering the puncture **18** and/or obstructing the tract **22**.
(107) To verify that flow is reduced or stopped, the practitioner can view blood flow from the blood outlet port **49** (FIG. **1**A) and determine a degree of hemostasis. A continued degree of blood flow from the blood outlet port **49** (FIG. **1**A) may indicate that hemostasis has not been adequately achieved and indicate to the practitioner to continue positioning the cap **102** against the tissue to provide improved hemostasis. Alternatively, blood flow can be observed by maintaining one or

more of the valves or seals **58**, **68**, **78** of the actuators **50**, **60**, or **70** or the one or more valves or seals **45** of the delivery sheath **40** open to allow blood to flow from an end of one or more of the actuators **50**, **60**, or **70** or the delivery sheath **40**. For instance, by way of example of one particular configuration, the actuator **60** can include an enlarged portion that maintains the valve or seal **45** of the delivery sheath **40** open so that blood exits from the end of the lumen when hemostasis has not been achieved. As with the blood flow from the blood outlet port **49** (FIG. **1**A), a continued degree of blood flow from the end of one or more of the actuators **50**, **60**, or **70** or delivery sheath **40** may indicate that hemostasis has not been adequately achieved and indicate to the practitioner to continue positioning the cap **102** against the tissue to provide improved hemostasis. Retracting the enlarged portion away from or advancing the enlarged portion through the one or more valves or seals allows the valves or seals to close following advancing the cap **102** towards the anchor **108** to improve hemostasis and reduce blood flow.

(108) Returning to FIG. **11**C, advancing the cap **102** towards the anchor **108** aids with stabilizing the tissue around the puncture **18** in order to facilitate closure of the puncture **18**. In particular, once the anchor **108** and the cap **102** are deployed, tension can be applied to the suture **106** to secure the anchor **108** against a distal side **14**A of the lumen wall **14** while the actuator **60** advances the cap **102** distally. In one example, a suture lock (not shown) can be utilized to help maintain the tension in the suture element **106**. The combination of the forces exerted by the anchor **108** and the cap **102** on the lumen wall **14** provides a compressive force on the tissue near the puncture **18**, i.e., sandwiching the tissue between the anchor **108** and the cap **102**. The tension applied to the suture can range 1 lbf. to about 16 lbf., from about 1 lbf. to about 8 lbf., from about 2 lbf. to about 6 lbf., or about 2.5 lbf. Because the anchor **108** is formed of a resilient compliably material and the cap **102** can be formed of elastomeric materials (such as bioabsorbable polymers, bioabsorbable elastomers, etc.), the properties allow the anchor **108** and the cap **102** to accommodate the applied forces without fracturing. The suture **106** can also include a visual indicator to show the user when the cap **102** has reached the proper depth, i.e. the cap **102** has reached the artery. If too much force is applied, this may cause the suture to break, however, due to the lack of a knot or other static element maintaining the cap **102** in a fixed position, the cap **102** and the anchor **108** will not over-tension. Because of this feature, the user does not have to worry about the degree of force applied.

(109) Placement of the cap **102** also pushes the tissue **72** in a transverse direction in relation to an axis of the tract **22**. This increases a space for subsequent delivery of the sealant **104** and so increases a surface area of the lumen wall **14** and the cap **102** that can receive the sealant **104**. By so doing, the efficacy of access site closure is enhanced.

(110) Optionally, in a configuration when the actuator **60** can deploy both the anchor **108** and the cap **102**, the actuator **60** can remain in continuous contact with the cap **102** throughout the deployment process. Such a configuration can allow the anchor **108** and/or cap **102** to be deployed by advancing the actuator **60** in a single direction. By facilitating deployment of the anchor **108** and cap **102** using one-way movement of the actuator **60**, and by utilizing a single actuator, the delivery system can be used quickly and easily deploy the anchor **108** and/or cap **102** and sealant **104**.

(111) Optionally, in one configuration when the actuator **60** can both deploy the cap **102** and advance the sealant **104** towards the cap **102**, the distal movement of the actuator **60** advances the sealant **104** towards the cap **102**, with subsequent proximal movement releasing the sealant **104** from within the actuator **60**. In this configuration, the actuator **70** is optionally omitted.

(112) Returning to the illustrated configuration, once the cap **102** is placed, the sealant **104** can be deployed from the delivery sheath **40** by proximally withdrawing the delivery sheath **40**, and optionally the actuator **60**, and distally advancing the actuator **70**, or some combination of one or more of such movements, to advance or release the sealant **104** from the outer housing **42** and into contact with the proximal side **14**B of the lumen wall **14** and the cap **102**. As the delivery sheath **40** is proximally moved or removed, and/or the actuator **60** is proximally moved or withdrawn, the sealant **104** is exposed to bodily fluids to activate the sealant **104**, as illustrated in FIG. **11**D. The

activated sealant **104** can act as an adhesive to secure the cap **102** in place as well as reinforce the hemostatic effect of the cap **102** by preventing leakage and coagulating the access tract **22**. It can be advantageous to have the sealant as close to the surface of the skin as possible to mitigate any potential bleeding.

(113) While the sealant is activated, such as can occur in from about 0.25 minutes to about 5 minutes, from about 0.5 minutes to about 4 minutes, from about 1 minute to about 3 minutes, from about 0.25 minutes to about 1 minute, from about 0.25 minutes to about 0.75 minutes, the practitioner can view blood flow, if any, from the blood outlet port **49** (FIG. **1**A) and determine a degree of hemo stasis. Based upon the force applied to the cap **102** to seal the access site **18**, the cap **102** can seal or substantially seal the access site **18** resulting in the sealant **104** being used to limit tissue oozing around the cap **102** and from the tissue tract **22** and provide secondary securing of the cap **102** in relation to the suture **106** and the access site **18**. Stated another way, primary closure of the access site **18** can be achieved through the sealing provided by the anchor and cap, while the sealant **104** provides secondary sealing and/or stopping of tract ooze. If there is, however, a continued degree of blood flow from the blood outlet port **49** (FIG. **1**A), the physician can manipulate the actuators and anchor to tighten the cap **102** on the suture **106** or optionally wait for the sealant **104** to sufficiently activate to reduce or eliminate blood flow to the physician's preferences. More generally, with the cap **102** and sealant **108** combination, dry close may be achieved within seconds of activating the sealant. Users can also compress the area with a gauze to express out any blood and then check for hemostasis. While illustrative times to hemostasis are provided, time to hemostasis can be impacted by anticoagulant medications given to patient. With the combination of cap and proximal sealant, hemostasis may be achieved faster than sealant alone.

(114) Whether complete or substantial complete hemostasis occurs from the cap **102**, or a combination of the cap **102** and the sealant **104**, after hemostasis is achieved, the suture **106** can be trimmed by pushing down on the skin **16** while tensioning the suture **106** and using a suture trimming device (not shown), such as scalpel or other suture trimming device, to trim the suture as close to the skin as possible. Once the skin is released, the suture will sit well below the surface of the skin as shown in FIG. **11**D.

(115) While reference has been made to the anchor **108** (**208**, **308**) remaining in the blood vessel and degraded, absorbed, or resorbed by the patient's body, it will be understood that in other configurations, the anchor **108** may be deployed and subsequently removed once sufficient closure of the puncture has occurred. In such a case, the anchor **108** is “temporarily” deployed and the other portions of the closure element, such as the cap **102** with the adhesive layer **128** (see FIGS. **3**C and **3**D) and the fluid-blocking component **104** described herein can be used to close the access site following removal of the anchor **108**. The cap **102** with the adhesive layer **128** may or may not cooperate with a suture **106** and lock onto a suture **106** that is optionally attached to the anchor **108**. The cap **102** is maintained in place against the vessel wall **14** by the adhesive layer **128** and optionally the fluid-blocking component **104**, with the fluid-blocking component **104** reducing or eliminating any tissue tract oozing. Delivery of the temporary anchor, the cap, and the sealant in this alternate configuration can be performed using the delivery systems and devices described herein, while accommodating removal of the anchor **108** by proximally drawing on the suture **106**, or another anchor actuator, to remove the anchor **108**. The anchor **108** may optionally pass through the lumen **110** of the cap **102**, with the body of the cap being sufficiently resilient to return to a closed state to close the access site. Alternatively, the anchor **108** can be withdrawn past a side of the cap **102**, with the cap **102** having sufficient resiliency to temporary deformation to return to a state to seal against the extravascular side of the vessel wall.

(116) Handle Assembly Vessel Closure Delivery System

(117) FIGS. **12**-**23**B illustrate a delivery system and method of inserting a closure device of the type disclosed above. Delivery system **430** can comprise a handle assembly **400** and a delivery sheath **440**. The handle assembly **400** can be configured to be selectively attached to a delivery

sheath **440** (similar to delivery sheath **40**). Once attached to the delivery sheath **440**, the handle assembly **400** can be used to insert a closure device, such as, for example, closure device **100**.
(118) As shown in FIGS. **12**-**13**E, the handle assembly **400** can include a handle body **402** having a proximal end **404** and a distal end **406**, an actuator, such as slider **450**, and an elongate opening **408** configured to provide a track for the slider **450**. The slider **450** can be configured to slide along the elongate opening **408** when engaged by a user and be selectively locked in place by the locking assembly **425**. This engagement can deploy the closure device **100**. The handle assembly **400** can also include a second slider **460** (see FIG. **13**A) configured in a second elongate opening **412** on the handle body **402**. Engagement of the slider **450** can deploy the anchor **108**, and then engagement of the second slider **460** can deploy the cap **102**.
(119) In other embodiments, the handle assembly **400** may only have one actuator element, such as slider **450**, which when engaged can subsequently deploy the anchor **108** and cap **102** without the need for a second slider.
(120) In some embodiments, such as the embodiment shown in the drawing, the handle body **402** can include one or more textured portions **414** to improve a user's grip on the handle assembly **400**. The handle assembly **400** can further include a connecting member **416** located at the distal end **406** of the handle body **402** and configured to be selectively attached to and removeable from a delivery sheath **440**. The connecting member **416** can be configured to attach to a sheath hub **418** of a delivery sheath **440**. The connecting member **416**, as shown in FIGS. **13**A-**13**F, comprises a set of locking members **420** having hooked ends **422**. The locking members **420** can be configured to selectively attach to the sheath hub **418** of a delivery sheath **440**, which attaches the handle assembly **400** to the delivery sheath **440** to form the delivery system **430**.
(121) The handle assembly **400** can also include a release button **424** which can release the suture **106** once the closure device **100** is placed at a desired location. Engagement of the release button **424** can release the delivery system **430** from the implanted closure device **100**. The release button **424** can include an engagement element such as release button fin **419**. The release button fin **419** can fit within release groove **407** and can be configured to slide within the length of groove **407** to release the suture **106** of the closure device **100** from the handle assembly **400**. In other embodiments, the functions of the release button **424** may be incorporated into one or more actuator elements such as slider **450** and/or secondary slider **460**.
(122) FIG. **13**E illustrates a cross-sectional view of the handle assembly **400**. As shown in the Figures, slider **450** can include a first slider portion **450***a* and a second slider portion **450***b*. Slider portions **450***a*,**450***b* can be selectively connected together by interlocking ends **466***a*,**466***b*. A proximal locking assembly **421** can engage slider **450** to "lock" slider **450** at the proximal end **404** of the handle assembly **400**. For instance, complementary structures **421***a* and **451***a* on the proximal locking assembly **421** and the slide portion **450***a* of the slider **450** can engage to limit movement of the slider **450**, while depressing the proximal locking assembly **421** detaches or separates the complementary structure **421***a* from the complementary structure **451***a* to allow the slider **450** to move distally. The slider portions **450***a*,**450***b*, interlocking ends **466***s*,**466***b* and proximal locking assembly **421** can be made of a resilient material, such as flexible plastic, to allow the components to flex when depressed by a user. For example, a user can depress proximal locking assembly **421** to release slider **450** and allow the slider **450** to slide along elongate groove **408**. The proximal locking assembly **421** can be formed with the handle body **402**, such as having a living hinge connection with the handle body **402** or can be a separated mechanism connected or mounted to the handle body **402**.
(123) FIGS. **14**A and **14**C illustrate an exploded view of the handle assembly **400**. The handle body **402** can comprise a first side **403** and a second side **405**, which when assembled together form the lumen **428** of the handle body **402**. The first side **403** and second side **405** can be assembled together to form the handle body **402** by using fasteners, such as screws **409** inserted into corresponding bores **411**.

(124) The handle body **402** can also house a chamber assembly **427** having a chamber body **427***a* and a chamber cap **427***b* as shown in FIGS. **13**F and **14**B, which can be disposed at the distal end **406** of the handle body **402**. While the chamber assembly **427** is illustrated as two pieces, it will be understood that the chamber assembly **427** can utilize less or more pieces to form an assembly that can provide the functions described herein. The chamber assembly **427** can also be formed separately from the handle body **402**, as shown, though in other embodiments, the chamber assembly **427** may be integrally formed within the handle body **402**. The chamber assembly **427**, and in particular the chamber body **427** can align with the lumen **428** and the distal opening **436** to form a channel **437** through which the implant assembly **426** can deploy the closure device **100**.
(125) The chamber assembly **427** can include a chamber body **427***a* with a nozzle **429** and a nozzle ring **439**. The nozzle **429** and ring **439** can be shaped to interface with the delivery sheath **440** and form a fluid-tight seal. The implant assembly **426** can be deployed from the lumen **428** through the channel **437** and then out of the nozzle **429** of the chamber assembly **427**, such as from the chamber body **427***a*, into the delivery sheath **440**. In some embodiments, the chamber assembly **427** can include a valve **431**. The valve **431** can be a one-way valve, preventing fluids from entering the lumen **428** of the handle body **402**. The valve **431** can be seated within a valve notch **472** at the proximal end of the chamber body **427***a*. The chamber body **427***a* can also include a plateau **433**. The chamber assembly **427** as shown includes a chamber cap **427***b*. The chamber cap **427***b* can be situated on top of the chamber **427** in the distal end **406** of the handle body **402**. The chamber cap **427***b* can help form the channel **437** and can include one or more positioning elements **435** which can retain the chamber cap **427***b* in the correct orientation and location in the handle body **402**. The chamber body **427***a* and the chamber cap **427***b*, when connected or coupled together, form a cavity **449** to receive the closure device, as illustrated in FIG. **13**F. The cavity **449** communicates with, and forms part of the lumen **428**.
(126) An implant assembly **426** is contained within the handle body **402**. The implant assembly **426** houses the closure device **100** and other elements required to place the closure device **100**. The implant assembly **426** can be configured to be positioned within the lumen **428** of the handle body **402**. The lumen **428** can extend from a proximal opening **434** of the proximal end **404** along a longitudinal axis **432** and terminate at a distal opening **436** on the distal end **406** of the handle body **402**. The implant assembly **426** can be situated within the lumen **428** so that it can be in mechanical communication with elements of the handle body (i.e., slider **450** and secondary slider **460**).
(127) The implant assembly **426**, shown in detail in FIGS. **14**A, **14**C-**14**F, **15** and **16**, includes a closure device such as closure device **100**, a support tube **442**, a slider **438**, and a stopper **444**. The slider **438** can comprise a slider body **446** having a protrusion **448** providing for mechanical interface between slider **450** on the external side of the handle body **402** and slider body **446** situated on the implant assembly **426** within the lumen **428** of the handle body **402**. The slider **438** can also include a groove **447***a* configured to receive the nested elements (support tube **442**, closure device **100**, tamper tube **454**, and push wire **452**) of the implant assembly **426**. Slider **438** can also include suture groove **447***b*, which can allow mechanical communication between the implant assembly and the handle body **402** to facilitate release of suture **106** from the implant assembly **426**.
(128) The stopper **444** can include a stopper elbow **466** configured to engage with interior locking mechanism **423**. When the stopper **444** is moved in a distal direction towards the distal end **406** of the handle body **402** the stopper **444** will pass the interior locking assembly **423**. Once past the interior locking assembly **423**, the stopper elbow **466** can engage the interior locking assembly **423**, preventing the stopper **444** from moving in a proximal direction. The stopper **444** can prevent closure device elements, such as the fluid blocking component **104**, from flowing back into the handle assembly **400**. The interior locking mechanism **423** can be formed with the handle body **402**, such as having a living hinge connection with the handle body **402** or can be a separated mechanism connected or mounted to the handle body **402**.

(129) FIGS. **14**D and **14**E illustrate detailed views of slider **438** of the implant assembly **426**. As discussed above, the slider **438** can include one or more structures configured to engage with exterior elements of the handle body **402** to control insertion and placement of the closure device **100** and disengagement of the closure device **100** from the delivery system **430**. The suture groove **447***b* of slider **438** can house a pin **417** positioned within a bore **415**.
(130) As shown in FIG. **14**F, the suture **106** can be looped around the pin **417** during assembly and a friction fit of the suture **106** between the pin and the suture groove **447***b* can retain the suture **106** within the slider **438** during insertion of the closure device **100**. After the closure device **100** is deployed to the blood vessel, the delivery system **430** is decoupled from the closure device **100** by releasing the suture **106** from the slider **438**. The release button **424** is slid in a proximal direction towards the pin **417**, causing the release button fin **419** to push the pin **417** into bore **415**. When the pin **417** is pushed into the bore **415**, the suture **106** is released from the pin **417**, effectively releasing the suture **106** and closure device **100** from the delivery system **430**.
(131) The support tube **442** can contain the suture **106** which can be threaded therethrough. The support tube **442** can also contain a push wire **452** and a tamper tube **454**. The distal tip **456** of the push wire **452** can have a forked or pronged shape to help push the closure device **100** out of the delivery system **430**, while a proximal end includes a push wire bend **477** that mounts to the slider portion **450***a* so that the push wire **452** can be moved through movement of the slider portion **450***a*. The tamper tube **454** can be used to tamp the cap **102** of the closure device **100** after the anchor **108** is positioned. The stopper **444** can prevent the implant assembly **426** from sliding out of the distal opening **436** of the handle body **402**. The closure device **100**, as discussed above, can comprise an anchor **108**, a cap **102**, and a fluid-blocking component **104** all configured on a suture **106**. The fluid-blocking component **104** can be an active biologic material, such as polyethylene glycol (PEG), fibrin sealants, copolymer of glucosamine and N-acetyl glucosamine, dextran (complex branched glucan(a polysaccharide. polypeptide adhesive structures, adhesive protein containing L-3,4-dihydroxyphenylalanine (L-DOPA), adhesive protein containing DOPA and phosphoserine, collagen, polyacrylic acid, cross-linked with allyl sucrose or allyl pentaerythritol, polyacrylic acid, cross-linked with divinyl glycol, Acrylic resinous polymer composed of methyl-2-cynoacrylate units, or another fully bioabsorbable sealant-type material that could be optionally incorporated into a shaped, flexible substrate. The sealant material could be activated by fluids present in the patient's tissue tract, such as blood or other fluids, and can be protectively stored inside the sheath/actuators or a chamber of the delivery device until positioned directly on top of the cap **102**.
(132) Once advanced into the desired location, the sealant **104** can be exposed to the blood or fluid, such as through unsheathing the fluid-blocking component **104** and positioning the fluid-blocking component **104** into direct contact with the tissue where it can react by coming into contact with blood and other fluids. This reaction can cause the fluid-blocking component **104** to expand and absorb blood and other fluids and bond to surrounding tissue and the cap **102**. The sealant can act as a glue and aid with “locking” the cap **102** in place on the blood vessel **10**, and actively coagulates the entire access tract **22**. The chemical formulation, quantity, carrier matrix, and dimensions of the fluid-blocking component **104** can be selected specifically to provide one or more of the functions of locking in place of the sealing component (e.g. cap **102**), to provide a fast acting and leak-free dry close, and reduce tissue tract oozing.
(133) For instance, the sealant can form a plug having a length of about 1 mm to about 10 mm and can optionally be trimmed to length in the patient along with the suture after deployment, or the adhesive component can extend the full length of the tissue tract and trimmed to fit the patient. When the fluid-blocking component **104** is formed of a matrix, the matrix can have an area of about 0.012 square inches to about 0.12 square inches, about 0.12 square inches to 0.6 square inches, about 0.6 to 1.0 square inches. The matrix material can be thin and flexible such that it can be wrapped around the suture in the delivery system to fit inside a tube for delivery to the implant location. This results in a volume of fluid-blocking component, optionally including a matrix

containing a sealant such as PEG or other biocompatible material, of between about 0.004 to about 0.040 cubic inches in volume, about 0.0.040 to about 0.100 cubic inches, about 0.100 to about 0.400 cubic inches.

(134) The fluid-blocking component **104** can be deployed so that is disposed on the suture **106**. The fluid-blocking component **104**, therefore, can be deployed in a flowable composition without a carrier matrix or can be formed as part or with a carrier matrix. For instance, the fluid-blocking component **104** can be disposed around the suture **106** in a generally cylindrical component, can be bonded to the suture **106** itself, can be bonded to the cap **102**, and combinations or modifications thereof. Because the sealant **104** is positioned proximal relative to the cap **102**, the sealant **104** can actively coagulate the access tract **22** and optionally actively coagulate all of access tract **22** to the surface of the skin **16**.

(135) FIGS. **17**A and **17**B illustrate a dilator assembly **470** having a dilator tube **456** with a dilator hub **458** which can be assembled on the dilator tube **456**. The dilator tube **456** can be inserted into the delivery sheath **440** in order to stretch the opening in the skin **16** and access tract **22** to allow for insertion of the delivery sheath **440**. The dilator hub **458** can be configured to be selectively attached to and removed from the delivery sheath **440** via the sheath hub **418**. The dilator hub **458** can include locking arms **459** which can selectively engage the receiving members **468** of the sheath hub **418**, such as through an interference or friction fit. The dilator tube **456** and/or the dilator hub **458** can be formed of biocompatible materials, such as but not limited to nylon, Polyethylene, High Density Polyethylene (HDPE), or other polymeric materials.

(136) The dilator tube **456** includes distal openings **455***a*,**455***b* toward a distal end and a proximal opening **461** towards a proximal end. The distal openings **455***a*,**455***b* communicate with a passageway **475** to form a fluid marker (e.g., blood marker) to aid with positioning the dilator tube **456** within a body lumen. For instance, a fluid from inside a body lumen, such as blood, is permitted to flow through one or both of the distal openings **455***a*, **455***b* and through the passage **475** and out of the proximal opening **461** to indicate a particular depth. While the distal openings **455***a*, **455***b* are illustrated as being positioned on opposite sides of the dilator tube **456**, it will be understood that the location and number of openings can vary.

(137) Disposed between the locking arms **459** is a mounting member **463** that aids with mounting the dilator hub **458** to the delivery sheath **440**. The mounting member **463** can be bifurcated with a first leg **465***a* and a second leg **465***b* each having a protruding portion **467**. The bifurcated structure allows for flexing of the mounting member **463** as it engages with the delivery sheath **440**, while the protruding portion **467** friction or interference fits within the sheath hub **418**.

(138) The delivery sheath **440** shown in FIGS. **18**A and **18**B comprises a sheath **441** for delivering the dilator tube **456** and the implant assembly **426** through the access tract **22**. A sheath hub **418** can be assembled on the sheath **441** in order to allow for the selective attachment of other surgical instruments to the delivery sheath **440** such as dilator tube **456**. The sheath hub **418** can include receiving members **468** configured to receive surgical instruments and selectively retain the surgical instruments on the delivery sheath **440**, such as but not limited to the locking member **420** and the locking arms **459** of the dilator hub **458**. The receiving member **468** can be channels or passages formed by a wall **471**. The proximal end **443** of the sheath **441** can cooperate with a valve **462** to prevent the backflow of fluid into a surgical instrument attached to the delivery sheath **440**. The valve **462** is retained within the sheath hub **418** by a valve cap **464**, with a strain relief member **469** extending distally from the sheath hub **418**. One or more of the sheath hub **418**, the sheath **441**, the valve **462**, the valve cap **464**, the strain relief member **469** can be bonded together through an overmold bond technique or otherwise mounted together using a combination of friction or interference fit and adhesives, thermal, chemical, or other bonding techniques.

(139) When the dilator assembly **470** is mounted to the delivery sheath **440**, the mounting member **463** passes through the valve cap **464** and the valve **462**. With one or more ports **473** aligned with the distal openings **455** a fluid pathway is formed to allow for depth determination and location of

the delivery sheath **440**. Additionally, indicia **474** are provided on the sheath **441** to provide a depth indication for the delivery sheath **440**. For instance, letters, numbers, or other symbols can be used to identify insertion depth. In one configuration, first indica **474***a*, can be separated by about 1 cm, with a second indica **474***b* being about 0.5 cm from the adjacent first indicia **474***a*. It will be understood that one or more second indica **474***b* can be disposed between adjacent first indica **474***a*, thereby changing the depth granularity. Additionally, the separation of the first indica **474***a* can range from about 0.1 cm to about 5 cm, from about 0.25 cm to about 2.5 cm, about 0.5 cm to about 1 cm, less than about 5 cm, less than about 4 cm, less than about 3 cm, less than about 2 cm, less than about 1 cm, less than about 0.5 cm.

(140) As shown in FIGS. **19**A and **19**B, the handle assembly **400** can be selectively attached to the delivery sheath **440** by inserting locking members **420** of the handle assembly **400** into the receiving members **418** of the delivery sheath to form the delivery system **430**. The locking members **420** can be made of a resilient material, such as flexible plastic, to allow the locking members **420** to flex when inserted into the receiving member **418**. The locking members **420** can be flexed to disengage the hooked ends **422** to decouple the handle assembly **400** from the delivery sheath **440**. As the locking members **420** cooperate with the receiving members **468**, the chamber nozzle **429** penetrates the valve **462** to provide access to the sheath **441** for delivery and deployment of the closure device **100**. When the delivery system **430** is engaged to deploy the closure device **100**, as in FIG. **19**C, the slider **450** can be moved in a distal direction towards the delivery sheath **440**, which can cause the anchor **108** of the closure device **100** to be deployed.

(141) FIG. **19**D illustrates a close-up view of the partially-deployed closure device of FIG. **19**C. The forked end **457** of the push wire **454** deploys the anchor **108** of the closure device **100** out from the delivery sheath **441**.

(142) Method of Closure Device Insertion with Handle Assembly

(143) FIGS. **20**A through **23**C illustrate an example of a method of inserting a closure device using deployment system **430**. First the dilator tube **456** can be inserted into the delivery sheath **440**. The dilator tube **456** can be selectively attached to the sheath **441** by connecting the dilator hub **458** to the sheath hub **418** in order to maintain the position of the dilator tube **456** in the delivery sheath **440** (FIGS. **20**A-**20**B). The dilator tube **456** can be used to stretch the opening of the skin **16** and access tract **22** to allow for placement of a closure device **100**.

(144) Next, the dilator hub **458** can be disengaged from the sheath hub **418** and the dilator tube **456** can be removed, as shown in FIG. **21**B. The delivery sheath **440** can remain in the access tract **22**. FIGS. **21**C and **21**D illustrate a method of connecting the handle assembly **400** to the delivery sheath **440**. The handle assembly **400** can be selectively connected to the delivery sheath **440** by engaging the connecting members of the handle assembly **400** with the receiving member or sheath hub **418** of the delivery sheath **440**.

(145) Once the handle assembly **400** is connected to the delivery sheath **440**, the user can depress the proximal locking assembly **421** to unlock the slider **450** and push the slider in a distal direction towards the distal end **406** of the handle body **400**, as illustrated in FIG. **22**. This causes the delivery system **430** to eject the anchor **108** into the blood vessel lumen **12** so that the anchor **108** can contact the lumen wall **14** and be positioned on the puncture or access site **18**. Once the slider **450** reaches the distal end **406**, the anchor **108** should be ejected from the delivery system **430**, with the cap **102** and fluid-blocking component **104** remaining in the support tube **442** of the implant assembly **426** within the delivery sheath **440**.

(146) Turning to FIG. **23**A, the slider **450** can be configured to slide along the elongate opening **408** until slider portion **450***b* slides past locking assembly **425**, at which point locking assembly **425** can lock slider portion **450***b* at the distal end of elongate opening **408** (the locking assembly **425** can be formed with the handle body **402**, such as having a living hinge connection with the handle body **402** or can be a separated mechanism connected or mounted to the handle body **402**). Once slider portion **450***b* is locked by the locking assembly **425**, the user can depress slider portion

450*a* to release interlocking end **466***a* from interlocking end **466***b*, effectively releasing slider portion **450***a* from slider portion **450***b*. Slider portion **450***a*, to which the push wire bend **477** of the push wire **452** is mounted, can be moved proximally to retract the push wire **452** in a proximal direction from the tissue and into the handle assembly **400**.

(147) After the anchor **108** is deployed, a user can engage the secondary slider **460** by depressing plunger **476** and pushing the slider **460** in a distal direction toward the distal end **406** of the handle assembly **400**. FIG. **23**B illustrates the secondary slider **460** engaging the tamper tube **454** (or a portion of the slider **438**) and tamping the cap **102** to eject the cap **102** from the delivery system **430**. The delivery system **430** can then be pulled in a proximal direction to tension the suture **106** and secure the position of the anchor **108** and cap **102**. After the anchor **108** and cap **102** are placed, the release button **424** can be engaged to release the suture **106** and closure device **100** from the delivery system **430** with the fluid-blocking component **104** remaining in the access tract **22**, as illustrated in FIG. **23**C. Thereafter the suture can be trimmed at or below the level of the skin or tissue.

(148) The articles “a,” “an,” and “the” are intended to mean that there are one or more of the elements in the preceding descriptions. The terms “comprising,” “including,” and “having” are intended to be inclusive and mean that there may be additional elements other than the listed elements. Additionally, it should be understood that references to “one embodiment” or “an embodiment” of the present disclosure are not intended to be interpreted as excluding the existence of additional embodiments that also incorporate the recited features. Numbers, percentages, ratios, or other values stated herein are intended to include that value, and also other values that are “about” or “approximately” the stated value, as would be appreciated by one of ordinary skill in the art encompassed by embodiments of the present disclosure. A stated value should therefore be interpreted broadly enough to encompass values that are at least close enough to the stated value to perform a desired function or achieve a desired result. The stated values include at least the variation to be expected in a suitable manufacturing or production process, and may include values that are within 5%, within 1%, within 0.1%, or within 0.01% of a stated value.

(149) A person having ordinary skill in the art should realize in view of the present disclosure that equivalent constructions do not depart from the spirit and scope of the present disclosure, and that various changes, substitutions, and alterations may be made to embodiments disclosed herein without departing from the spirit and scope of the present disclosure. Equivalent constructions, including functional “means-plus-function” clauses are intended to cover the structures described herein as performing the recited function, including both structural equivalents that operate in the same manner, and equivalent structures that provide the same function. It is the express intention of the applicant not to invoke means-plus-function or other functional claiming for any claim except for those in which the words ‘means for’ appear together with an associated function. Each addition, deletion, and modification to the embodiments that falls within the meaning and scope of the claims is to be embraced by the claims.

(150) The terms “approximately,” “about,” and “substantially” as used herein represent an amount close to the stated amount that still performs a desired function or achieves a desired result. For example, the terms “approximately,” “about,” and “substantially” may refer to an amount that is within less than 5% of, within less than 1% of, within less than 0.1% of, and within less than 0.01% of a stated amount. Further, it should be understood that any directions or reference frames in the preceding description are merely relative directions or movements. For example, any references to “up” and “down” or “above” or “below” are merely descriptive of the relative position or movement of the related elements.

(151) Following are some further example embodiments of the invention. These are presented only by way of example and are not intended to limit the scope of the invention in any way. Further, any example embodiment can be combined with one or more of the example embodiments.

(152) Embodiment 1. A vessel closure device including a bioabsorbable vessel closure device for

delivering immediate hemostasis at a puncture site in a wall of a blood vessel, the closure device including an intravascular anchor comprising one or more suture attachment points, an extravascular cap comprising a lumen, a sealant, and a suture connected to at least one of the one or more suture attachment points of the intravascular anchor and threaded through the lumen of the extravascular cap and through the sealant to connect the intravascular anchor to the extravascular cap and to the sealant, wherein each of the intravascular anchor, extravascular cap, sealant, and suture are formed of bioabsorbable materials.

(153) Embodiment 2. The vessel closure device of embodiment 1, wherein the intravascular anchor includes an elongate body comprising a flexible member and a keel.

(154) Embodiment 3. The vessel closure device of any of embodiment 1-2, wherein the extravascular cap is formed of a flexible material.

(155) Embodiment 4. The vessel closure device of any of embodiment 1-3, wherein the sealant comprises polyethylene glycol (PEG).

(156) Embodiment 5. The vessel closure device of any of embodiment 1-4, wherein the suture comprises a distal suture portion and a proximal suture portion.

(157) Embodiment 6. The vessel closure device of any of embodiment 1-5, wherein the diameter of the lumen of the extravascular cap is smaller than the diameter of the distal suture portion.

(158) Embodiment 7. The vessel closure device of any of embodiment 1-6, wherein the intravascular anchor comprises a material selected from Polyglycolic acid (PGA), Poly-L-Latic acid (PLLA), Polycaprolactone (PCL), Poly-DL-lactic acid (PDLLA), Poly trimethylene carbonate (PTMC), and Poly para-dioxanone (PPDO).

(159) Embodiment 8. The vessel closure device of any of embodiment 1-7, wherein the intervascular anchor comprises a plurality of ribs radiating from the keel to a raised edge of the elongate body.

(160) Embodiment 9. The vessel closure device of any of embodiment 1-8, wherein the sealant can expand up to 4 times its original size when introduced to fluids.

(161) Embodiment 10. A vessel closure device for delivering immediate hemostasis at a puncture site in a wall of a blood vessel, the closure device including an intravascular anchor comprising one or more suture attachment points, an extravascular cap comprising a lumen, a sealant comprising a lumen, and a suture connected to at least one of the one or more suture attachment points of the intravascular anchor and threaded through the lumen of the extravascular cap and through the lumen of the sealant to connect the intravascular anchor to the extravascular cap and to the sealant, wherein the suture comprises a proximal suture portion and a distal suture portion, wherein the distal suture portion has a diameter greater than a diameter of the lumen of the extravascular cap, wherein the distal suture portion creates an interference fit to lock the extravascular cap over the puncture site, wherein each of the intravascular anchor, extravascular cap, sealant, and suture are formed of bioabsorbable materials.

(162) Embodiment 11. The vessel closure device of any of embodiment 10, wherein the extravascular cap is formed of a flexible material.

(163) Embodiment 12. The vessel closure device of any of embodiment 10-11, wherein the suture is a braided suture.

(164) Embodiment 13. The vessel closure device of any of embodiment 10-12, wherein the sealant is threaded onto the suture at a location proximal to the extravascular cap.

(165) Embodiment 14. The vessel closure device of any of embodiment 10-13, wherein the sealant when activated locks the extravascular cap in place and coagulates an access tract of the puncture site providing immediate hemostasis.

(166) Embodiment 15. The vessel closure device of any of embodiment 10-14, wherein the intravascular anchor comprises an elongate body comprising a flexible member.

(167) Embodiment 16. The vessel closure device of any of embodiment 10-15, wherein the intravascular anchor comprises a raised keel located on a central axis of the elongate body and

spanning the length of the elongate body.
(168) Embodiment 17. The vessel closure device of any of embodiment 10-16, wherein the raised keel comprises one or more suture attachment points.
(169) Embodiment 18. The vessel closure device of any of embodiment 10-17, wherein the sealant comprises polyethylene glycol (PEG).
(170) Embodiment 19. An intravascular anchor for a vessel closure device for delivering immediate hemostasis at a puncture site in a wall of a blood vessel, the intravascular anchor includes an elongate body including a flexible member for conforming to the wall of the blood vessel, a keel having one or more suture attachment points, wherein the keel is an elongate member centrally located along a central axis of the elongate body, wherein the intravascular anchor comprises a bioabsorbable material selected from Polyglycolic acid (PGA), Poly-L-Latic acid (PLLA), Polycaprolactone (PCL), Poly-DL-lactic acid (PDLLA), Poly trimethylene carbonate (PTMC), and Poly para-dioxanone (PPDO).
(171) Embodiment 20. The intravascular anchor of claim 19, wherein the elongate body includes a plurality of ribs radiating from the keel to a raised edge forming the perimeter of the elongate body.
(172) The present invention may be embodied in other specific forms without departing from its spirit or essential characteristics. The described embodiments are to be considered in all respects only as illustrative and not restrictive. The scope of the invention is, therefore, indicated by the appended claims rather than by the foregoing description. All changes which come within the meaning and range of equivalency of the claims are to be embraced within their scope. It shall be further understood that although the present invention has been described in relation to vessel closure, it is contemplated that the closure component of the present invention may be utilized to close other openings in the body such as PFO openings, or openings formed in organs such as the stomach for certain surgical procedures.

Claims

1. A vessel closure device for delivering hemostasis at a puncture site in a wall of a blood vessel, the vessel closure device is configured to be disposed within a handle that is configured to attach to a delivery sheath before delivery of the vessel closure device to the wall of the blood vessel through the delivery sheath, the vessel closure device comprising: an intravascular anchor comprising one or more suture attachment points; an extravascular cap comprising a lumen; a sealant comprising polyethylene glycol (PEG), the sealant being configured to expand from about 2 times to about 4 times its original size when introduced to fluids, the sealant being configured to lock the extravascular cap in a spaced relationship with the intravascular anchor when the sealant is disposed on the extravascular cap; and a suture connected to at least one of the one or more suture attachment points of the intravascular anchor and threaded through the lumen of the extravascular cap and through the sealant to connect the intravascular anchor to the extravascular cap and to the sealant, a first portion of the suture configured to extend between the intravascular anchor and the extravascular cap and a second portion of the suture configured to extend between the intravascular anchor and the extravascular cap, the first portion of the suture and the second portion of the suture being braided together to form an engagement portion configured to extend between the intravascular anchor and the extravascular cap and having a diameter greater than a remainder of the suture, the engagement portion being configured to cooperate with the extravascular cap, wherein each of the intravascular anchor, extravascular cap, sealant, and suture are formed of bioabsorbable materials.
2. The vessel closure device of claim 1, wherein the intravascular anchor comprises an elongate body comprising a flexible member and a keel.
3. The vessel closure device of claim 1, wherein the extravascular cap is formed of an elastomeric material.

4. The vessel closure device of claim 1, wherein the suture comprises a distal suture portion and a proximal suture portion.
5. The vessel closure device of claim 4, wherein the diameter of the lumen of the extravascular cap is smaller than the diameter of the distal suture portion.
6. A vessel closure device for delivering hemostasis at a puncture site in a wall of a blood vessel, the vessel closure device is configured to be disposed within a handle that is configured to attach to a delivery sheath before delivery of the vessel closure device to the wall of the blood vessel through the delivery sheath, the closure device comprising: an intravascular anchor comprising one or more suture attachment points; an extravascular cap comprising a lumen; a sealant comprising a preformed lumen comprising polyethylene glycol (PEG), the sealant being configured to expand about 2 times to about 4 times its original size, including expanding longitudinally, when introduced to fluids to provide secondary sealing of the puncture site and stop oozing of a tissue tract extending to the puncture site; and a suture connected to at least one of the one or more suture attachment points of the intravascular anchor and threaded through the lumen of the extravascular cap and through the lumen of the sealant to connect the intravascular anchor to the extravascular cap and to the sealant, wherein the suture comprises a proximal suture portion and a distal suture portion, wherein the distal suture portion has a diameter greater than a diameter of the lumen of the extravascular cap, the distal suture portion being formed of a first portion of the suture configured to extend between the intravascular anchor and the extravascular cap and a second portion of the suture configured to extend between the intravascular anchor and the extravascular cap, the first portion of the suture and the second portion of the suture being braided together to form an engagement portion configured to extend between the intravascular anchor and the extravascular cap and having a diameter greater than a remainder of the suture, the engagement portion having the diameter greater than the diameter of the lumen of the extravascular cap and being configured to cooperate with the extravascular cap; wherein the distal suture portion creates an interference fit to lock the extravascular cap over the puncture site; wherein each of the intravascular anchor, extravascular cap, sealant, and suture are formed of bioabsorbable materials.
7. The vessel closure device of claim 6, wherein the extravascular cap is formed of flexible material.
8. The vessel closure device of claim 7, wherein the sealant when activated locks the extravascular cap in place and coagulates an access tract of the puncture site providing hemostasis.
9. The vessel closure device of claim 6, wherein the suture is a braided suture.
10. The vessel closure device of claim 6, wherein the sealant is threaded onto the suture at a location proximal to the extravascular cap.
11. The vessel closure device of claim 6, wherein the intravascular anchor comprises an elongate body comprising a flexible member.
12. The vessel closure device of claim 11, wherein the intravascular anchor comprises a raised keel located on a central axis of the elongate body and spanning a length of the elongate body.
13. The vessel closure device of claim 12, wherein the raised keel comprises one or more suture attachment points.