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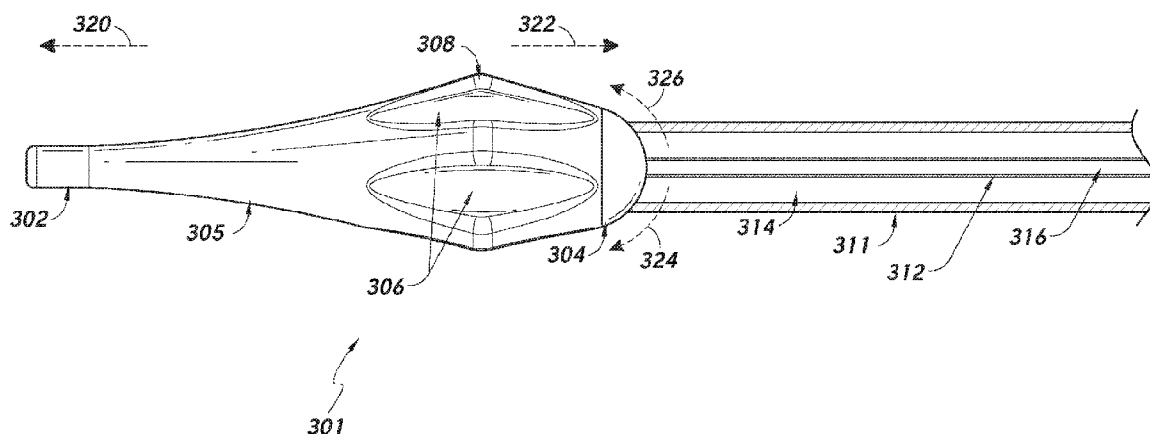


FIG. 3

(57) Abstract: A delivery system includes a tension line, a catheter, and a catheter tip comprising a distal end portion and a proximal end portion having an at least partially rounded surface. The proximal end portion is attached to the tension line. The catheter tip can further comprise an elongate body extending from the distal end portion to the proximal end portion, wherein the tension line is configured to apply force to the catheter tip and the catheter tip is configured to rotate independently of the catheter.



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MANEUVERABLE CATHETER DELIVERY SYSTEMS

RELATED APPLICATION

[0001] This application claims priority to U.S. Provisional Application No. 62/860,653, filed on June 12 2019, entitled MANEUVERABLE CATHETER DELIVERY SYSTEMS, the disclosure of which is hereby incorporated by reference in its entirety.

BACKGROUND

[0002] The present disclosure generally relates to the field of delivering medical implant devices and/or therapies.

[0003] Transcatheter delivery of implant devices and/or therapies to the heart can be performed to address various heart abnormalities. Delivery of implant devices and/or therapies to the heart can be performed for treatment of various conditions, such as elevated pressure in the left atrium.

SUMMARY

[0004] For purposes of summarizing the disclosure, certain aspects, advantages and novel features have been described herein. It is to be understood that not necessarily all such advantages may be achieved in accordance with any particular embodiment. Thus, the disclosed embodiments may be carried out in a manner that achieves or optimizes one advantage or group of advantages as taught herein without necessarily achieving other advantages as may be taught or suggested herein.

[0005] Some implementations of the present disclosure relate to a delivery system comprising a tension line, a catheter, and a catheter tip. The catheter tip comprises a distal end portion and a proximal end portion. The proximal end portion has an at least partially rounded surface and is configured to attach to the tension line. The catheter tip further comprises an elongate body extending from the distal end portion to the proximal end portion. The tension line is configured to apply force to the catheter tip and the catheter tip is configured to rotate independently of the catheter.

[0006] In some embodiments, the catheter tip further comprises an inner lumen extending through the elongate body, the distal end portion, and the proximal end portion. The inner lumen may be configured to receive a plurality of instruments.

[0007] The elongate body may have an at least partially uneven surface in which one or more first portions of the elongate body have a maximal radial distance from the inner lumen and all other portions of the elongate body have a lesser radial distance from the inner

lumen than the maximal radial distance. In some embodiments, each of the one or more first portions is in a first plane around the inner lumen. Approximately half of a surface area of the elongate body in the first plane may have the maximal radial distance from the inner lumen. In some embodiments, the elongate body has an at least partially tapered surface. Radius measurements of the elongate body may gradually decrease from the one or more first portions to the distal end portion. In some embodiments, radius measurements of the elongate body gradually decrease from the one or more first portions to the proximal end portion. The elongate body may have one or more indentations. In some embodiments, each of the one or more indentations is between two of the one or more first portions. Each of the one or more indentations may have an ellipse shape.

[0008] In some embodiments, the catheter tip is configured to move in a first direction through a vessel while the tension line applies force in a second direction to the catheter tip. The proximal end portion may be configured to fit at least partially into an inner lumen of the catheter. In some embodiments, the proximal end portion is configured to establish a complete ellipse of contact with a tubular end portion of the catheter. The catheter tip may be configured to rotate in at least three axes while maintaining the complete ellipse of contact with the tubular end portion of the catheter. In some embodiments, the tension line is configured to apply force to the catheter tip to press the catheter tip against the tubular end portion of the catheter.

[0009] Some implementations of the present disclosure relate to a delivery system comprising a tension line, a catheter, and a catheter tip. The catheter tip comprises a distal end portion and a proximal end portion. The proximal end portion has an at least partially rounded surface and is configured to fit at least partially into a lumen of the catheter and attach to the tension line. The tension line is configured to apply force to the catheter tip to press the catheter tip against a tubular end portion of the catheter. The catheter tip further comprises an elongate body extending from the distal end to the proximal end and an inner lumen extending through the elongate body, the distal end portion, and the proximal end portion. The inner lumen is configured to receive a plurality of instruments. The elongate body has an at least partially uneven surface in which one or more first portions of the elongate body have a maximal radial distance from the inner lumen and all other portions of the elongate body have a lesser radial distance from the inner lumen than the maximal radial distance.

[0010] In some embodiments, each of the one or more first portions is in a first plane around the inner lumen. Approximately half of a surface area of the elongate body in

the first plane may have the maximal radial distance from the inner lumen. In some embodiments, the elongate body has an at least partially tapered surface. Radius measurements of the elongate body may gradually decrease from the one or more first portions to the distal end portion. In some embodiments, radius measurements of the elongate body gradually decrease from the one or more first portions to the proximal end portion.

[0011] The elongate body may have one or more indentations. In some embodiments, each of the one or more indentations is between two of the one or more first portions. Each of the one or more indentations may have an ellipse shape. In some embodiments, the catheter tip is configured to move in a first direction through a vessel while the tension line applies force in a second direction to the catheter tip.

[0012] In some embodiments, the proximal end portion is further configured to establish a complete ellipse of contact with a tubular end portion of the catheter. The catheter tip may be configured to rotate independently of the catheter while maintaining the complete ellipse of contact with the tubular end portion of the catheter. In some embodiments, the catheter tip is configured to rotate in three axes while maintaining the complete ellipse of contact with the tubular end portion of the catheter.

[0013] Some implementations of the present disclosure relate to a method of accessing a heart location. The method comprises attaching a first end portion of a tension line to a rounded end portion of a catheter tip, attaching one or more implants to the tension line near the rounded end portion of the catheter tip, advancing a catheter over the tension line and into contact with the rounded end portion of the catheter tip. The catheter has an elliptical end portion. The method further comprises applying tension at the tension line to press the rounded end portion of the catheter tip against the elliptical end portion of the catheter to form a complete ellipse of contact between the rounded end portion of the catheter tip and the elliptical end portion of the catheter and creating a separation between the rounded end portion of the catheter tip and the elliptical end portion of the catheter to expose the one or more implants.

[0014] In some embodiments, an end portion of the tension line is attached to a tension spring. A second end portion of the catheter may be attached to a tension spring. In some embodiments, the tension line has an inner lumen configured to receive various instruments. In some embodiments, the method further comprises inserting at least the rounded end portion of the catheter tip, the first end portion of the tension line, and the elliptical end portion of the catheter into a blood vessel and advancing the rounded end portion of the catheter tip, the first end portion of the tension line, and the elliptical end

portion of the catheter through the blood vessel while maintaining the complete ellipse of contact between the rounded end portion of the catheter tip and the elliptical end portion of the catheter.

[0015] Some implementations of the present disclosure relate to a catheter tip comprising a distal end portion and a proximal end portion having an at least partially rounded surface. The proximal end portion is configured to connect to a tubular end of a catheter and rotate independently of the catheter while connected to the tubular end of the catheter. The catheter tip further comprises an elongate body extending from the distal end portion to the proximal end portion.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] Various embodiments are depicted in the accompanying drawings for illustrative purposes and should in no way be interpreted as limiting the scope of the inventions. In addition, various features of different disclosed embodiments can be combined to form additional embodiments, which are part of this disclosure. Throughout the drawings, reference numbers may be reused to indicate correspondence between reference elements. However, it should be understood that the use of similar reference numbers in connection with multiple drawings does not necessarily imply similarity between respective embodiments associated therewith. Furthermore, it should be understood that the features of the respective drawings are not necessarily drawn to scale, and the illustrated sizes thereof are presented for the purpose of illustration of inventive aspects thereof. Generally, certain of the illustrated features may be relatively smaller than as illustrated in some embodiments or configurations.

[0017] Figure 1 is a cross-sectional view of a human heart.

[0018] Figure 2A provides a side-view of a catheter tip in accordance with some embodiments.

[0019] Figure 2B provides another side-view of a catheter tip in accordance with some embodiments.

[0020] Figure 2C provides a front-view of a catheter tip in accordance with some embodiments.

[0021] Figure 2D provides a rear-view of a catheter tip in accordance with some embodiments.

[0022] Figure 2E provides a cross-sectional view illustrating an inner lumen of the catheter tip in accordance with some embodiments.

[0023] Figure 3 shows a delivery system including a catheter tip and a catheter in accordance with some embodiments.

[0024] Figure 4A illustrates a delivery state of the delivery systems, in which an implant may be situated within an outer shaft lumen of an outer shaft and/or may be attached to a tension line in accordance with some embodiments.

[0025] Figure 4B illustrates an open state of the delivery systems in accordance with some embodiments.

[0026] Figure 4C provides a detailed view of the tension spring and various other delivery system components.

[0027] Figure 5 illustrates another delivery system in accordance with one or more embodiments.

[0028] Figure 6 is a flow diagram of a delivery process in accordance with some embodiments.

DETAILED DESCRIPTION

[0029] The headings provided herein are for convenience only and do not necessarily affect the scope or meaning of the claimed invention.

[0030] Various features of a heart 1 are described with reference to Figure 1 to assist in understanding the present disclosure. The heart 1 includes four chambers, namely the left atrium 2, the left ventricle 3, the right ventricle 4, and the right atrium 5. A wall of muscle, referred to as the septum 17, separates the left atrium 2 and right atrium 5, and the left ventricle 3 and right ventricle 4. Blood flow through the heart 1 is at least partially controlled by four valves, the mitral valve 6, aortic valve 7, tricuspid valve 8, and pulmonary valve 9. The mitral valve 6 separates the left atrium 2 and the left ventricle 3 and controls blood flow therebetween. The aortic valve 7 separates and controls blood flow between the left ventricle 3 and the aorta 12. The tricuspid valve 8 separates the right atrium 5 and the right ventricle 4 and controls blood flow therebetween. The pulmonary valve 9 separates the right ventricle 4 and the pulmonary artery 11, controlling blood flow therebetween.

[0031] In a healthy heart, the heart valves can properly open and close in response to a pressure gradient present during various stages of the cardiac cycle (e.g., relaxation and contraction) to at least partially control the flow of blood to a respective region of the heart and/or to blood vessels. Deoxygenated blood arriving from the rest of the body generally flows into the right side of the heart for transport to the lungs, and oxygenated blood from the lungs generally flows into the left side of the heart for transport to the rest of the body.

During ventricular diastole, deoxygenated blood arrive in the right atrium 5 from the inferior vena cava 18 and superior vena cava 19 to flow into the right ventricle 4, and oxygenated blood arrive in the left atrium 2 from the pulmonary veins to flow into the left ventricle 3. During ventricular systole, deoxygenated blood from the right ventricle 4 can flow into the pulmonary artery 11 for transport to the lungs (e.g., via the left and right pulmonary arteries), and oxygenated blood can flow from the left ventricle 3 to the aorta 12 for transport to the rest of the body.

[0032] A number of conditions can contribute to a higher than normal pressure in the left atrium 2. Dysfunction of the mitral valve 6 can contribute to elevated left atrial pressure. Conditions such as mitral valve regurgitation and/or stenosis may result in difficulty in pumping blood from the left atrium 2 to the left ventricle 3, contributing to elevated pressure in the left atrium 2. Valve stenosis can cause a valve to become narrowed or obstructed. Mitral valve stenosis can restrict blood flow from the left atrium 2 to the left ventricle 3. Valve regurgitation occurs when a valve does not close properly. For example, regurgitation can occur due to improper coaptation of the valve leaflets. Mitral valve regurgitation can result in blood flow leakage back into the left atrium 2 from the left ventricle 3 when the left ventricle 3 contracts. Restricted flow of blood from the left atrium 2 into the left ventricle 3, and blood flow leakage from the left ventricle 3 back into the left atrium 2 can both contribute to elevated atrial pressure. Dysfunction in the left ventricle 3 can also contribute to elevated left atrial pressure. Elevated left atrial pressure may lead to left atrial enlargement, producing symptoms such as shortness of breath during exertion, fatigue, chest pain, fainting, abnormal heartbeat, and swelling of the legs and feet.

[0033] Various medical procedures for treatment and/or prevention of various heart conditions involve use of steerable catheter/sheath systems. A steerable catheter can be used to facilitate introduction of various medical devices into the human body. For example, steerable catheters can be used in cardiopulmonary bypass procedures, such as minimal incision aortic valve replacement procedures, mitral valve repair or replacement procedures, tricuspid valve procedures, re-operations, intracardiac myxoma resection, patent foramen ovale repairs, atrial septal defect repairs, and ablative maze procedures for atrial fibrillation. Steerable catheters may utilize one or more steerable catheter tips allowing for improved insertion and/or navigation through the coronary sinus. In some cases, catheter tips may have tapered shapes that may be configured to provide for tracking and/or pre-dilation of vessels.

[0034] Some embodiments described herein provide improved catheter tips and/or other delivery devices and/or improved methods for steering and/or otherwise delivering

catheters and/or other shafts into and/or through vessels of the human body. The term “catheter tip” is used herein according to its broad and ordinary meaning and may refer to any device and/or set of devices configured to dilate and/or pre-dilate a blood vessel and/or facilitate insertion and/or navigation of a catheter into and/or through a human body. Similarly, the terms “catheter,” “tube,” “shaft” (e.g., inner/outer shaft), “sheath,” “delivery sheath,” “steerable sheath,” and/or “steerable catheter” are used herein according to their plain and ordinary meanings and can refer or apply generally to any type of elongate and/or tubular delivery devices. A catheter may comprise an inner lumen configured to slidably receive instrumentation, such as for positioning within an atrium or coronary sinus, including for example delivery catheters and/or cannulas.

[0035] A catheter tip as described herein may have one or more features for improving maneuverability of the catheter tip and/or a catheter through blood vessels. In some embodiments, a catheter tip may have features for reducing friction as the catheter tip moves through and/or dilates blood vessels. Such features may include grooves and/or other indentations at an outer surface of the catheter tip. In this way, contact between the catheter tip and a blood vessel may be minimized for improved delivery of the catheter tip.

[0036] In some embodiments, a catheter tip may have an at least partially elastic and/or bendable structure to improve maneuverability through a blood vessel. For example, the catheter tip may have minimal material density due at least in part to indentations in the catheter tip. Accordingly, the catheter tip may have a relatively elastic structure such that the catheter tip may be configured to bend and/or be bent at least partially to further improve the maneuverability of the catheter tip into and/or through various blood vessels. For example, when traveling through a curved blood vessel, the catheter tip may be configured to bend and/or otherwise conform to the shape of the blood vessel. While maximizing maneuverability of the catheter tip and/or catheter, the catheter tip may also have sufficient structure to pre-dilate and/or otherwise facilitate delivery of a catheter. In some embodiments, the catheter tip may have, at least at a first lateral plane of the catheter tip having a maximal diameter, a sufficient diameter to contact and/or dilate a blood vessel. To reduce friction, the material of the catheter tip at the plane of maximal diameter may be configured to not cover the full circumference of the catheter tip. For example, approximately 50% of the material of the catheter tip in a lateral plane may extend to a maximal radius from a center point of the catheter tip. In this way, the catheter tip may be configured to provide a serviceable amount of pre-dilation while minimizing surface contact between the catheter tip and the blood vessel.

[0037] A catheter tip may be configured to attach to and/or otherwise contact a catheter and/or other delivery device. For example, an end of the catheter tip may be configured to attach to and/or otherwise contact a tension line, which may include a wire, catheter, sheath, and/or tube, such as a guidewire tube. In some embodiments, the tension line may be at least partially hollow such that various devices (e.g., implants) may be delivered through and/or via the tension line.

[0038] In some embodiments, a catheter tip may be configured to form a rotatable joint connection with a catheter to improve maneuverability of the catheter tip and/or catheter. For example, an end portion of the catheter tip may be at least partially rounded (e.g., convex, non-linear, bent, etc.) such that a connection point between the catheter tip and a catheter may operate similarly to a ball joint/socket connection. For example, a portion of the rounded catheter tip end may be configured to fit into an inner lumen (i.e., hollow interior) and/or an elliptical (e.g., tubular, circular) end of the catheter and/or establish a full ellipse of contact with the elliptical end of the catheter. As the catheter tip turns (e.g., in response to moving around a curve of a blood vessel), the end of the tension line attached to the catheter tip may move with the rounded end of the catheter tip. Moreover, the rounded end of the catheter tip may move along the elliptical end of the catheter while maintaining a full ellipse of contact between the catheter tip and the catheter. For example, there may be no gap between an elliptical end of the catheter and the rounded end of the catheter tip as the catheter tip and catheter move through a blood vessel. In this way, the catheter tip and/or catheter may be prevented from snagging or otherwise damaging vessel tissue as the catheter tip and/or catheter move through the vessel.

[0039] In some embodiments, one or more tension devices may be configured to press/pull the catheter tip and catheter together to establish and/or maintain a connection between the catheter tip and the catheter. An end of the catheter (e.g., a rounded end) may be coupled to a tension line and tension may be applied to the tension line to at least partially control movement of the catheter tip. For example, as the catheter tip and/or tension line progress forward through a vessel, the tension line may be configured to pull backward on the catheter tip to press the catheter tip against the catheter and maintain contact between the catheter tip and the catheter. In some embodiments, a tension spring and/or other tension device may be configured to apply tension to the tension line.

[0040] Figures 2A-2E provide views of a catheter tip 200 in accordance with some embodiments; Figures 2A and 2B provide side-views, Figure 2C provides a front-view, and Figure 2D provides a rear-view. Figure 2E provides a cross-sectional view illustrating an

inner lumen 203 of the catheter tip 200 in accordance with some embodiments. The catheter tip 200 may include a distal (e.g., leading) end 202 and/or end portion, a proximal (e.g., tail) end 204 and/or end portion, and/or an elongate body 205. The distal end 202 and/or proximal end 204 may comprise lateral end points of the catheter tip 200 and/or may comprise end portions of the catheter tip 200. For example, the proximal end 204 may comprise a portion of the catheter tip 200 extending to and/or including an end point of the catheter tip 200.

[0041] The elongate body 205 may be situated between the distal end 202 and the proximal end 204. The catheter tip 200 may be configured to move through a vessel in a first direction led by the distal end 202 and/or in a second direction led by the proximal end 204. In some embodiments, the catheter tip 200 may have an inner lumen 203 which may pass through the distal end 202, the proximal end 204, and/or the elongate body 205. The inner lumen 203 may be accessible via one or more openings at the distal end 202 and/or the proximal end 204 and/or may be configured to allow guidewires and/or other devices to pass through the catheter tip 200. In some embodiments, the inner lumen 203 may be positioned at a center point of the catheter tip 200. For example, any lateral (i.e., into the page of Figure 2B) cross-section of the catheter tip 200 may include the inner lumen 203 at and/or around a center point of the catheter tip 200. However, the inner lumen 203 may be situated at any position of the catheter tip 200.

[0042] The catheter tip 200 may be configured to dilate and/or pre-dilate a blood vessel. In some embodiments, a maximal diameter 207 (see Figure 2B) of the catheter tip 200 may be larger than a diameter of a blood vessel. As the catheter tip 200 moves through the blood vessel, the catheter tip 200 (particularly, at least one or more peak portions 208 of the catheter tip 200) may be configured to stretch and/or otherwise dilate the blood vessel to create a greater diameter at the blood vessel. Accordingly, as the catheter tip 200 moves through the blood vessel, the catheter tip 200 (particularly, at least the one or more peak portions 208 of the catheter tip 200) may contact and/or rub against inner walls of the blood vessel. To reduce friction during delivery of the catheter tip 200 and/or other devices, the catheter tip 200 may have an at least partially uneven outer surface (e.g., a grooved and/or indented surface) including one or more indentations 206, particularly at and/or around a lateral plane of the catheter tip 200 having the maximal diameter 207. In this way, the catheter tip 200 may be configured to dilate a blood vessel while also advantageously having reduced friction due at least in part to reduce surface contact with the inner walls of the blood vessel. The reduced friction may simplify delivery processes and/or reduce risk of damage to the blood vessel.

[0043] The indentations 206 may be configured to reduce surface contact between the catheter tip 200 and a blood vessel as the catheter tip 200 moves through the blood vessel. In some embodiments, the outer surface of the catheter tip 200 may have an at least partially tapered structure. For example, a distance from the outer surface of the catheter tip to a center point of the catheter tip 200 (e.g., the lumen 203) may gradually increase from the distal end 202 and/or the proximal end 204 to one or more peak portions 208 of the elongate body 205. At the one or more peak portions 208, the radius of the of the catheter tip 200 (i.e., a first distance 211 from the outer surface of the peak portion 208 to a central point and/or the inner lumen 203 of the catheter tip 200) may be half of a maximal diameter 207 for the catheter tip 200. For example, a lateral cross-section of the catheter tip 200 at a peak portion 208 may provide a first distance 211 (see Figures 2C and 2D) from the inner lumen 203 (or a central point) of the catheter tip 200 to the outer surface of the catheter tip 200 at a peak portions 208 that is greater than a second distance 213 from the inner lumen 203 to an indentation 206 and/or any other portions other than a peak portion 208.

[0044] In some embodiments, the one or more peak portions 208 may each be in a common plane. For example, a lateral cross-section of the catheter tip 200 at a first peak portion 208 may include all peak portions 208 of the elongate body 205. A peak portion 208 may be a pointed and/or rounded tip or may be an approximately flat surface and/or may have any shape and/or size. Each of the indentations 206 may be situated between and/or around one or more peak portions 208. Accordingly, a lateral cross-section of the catheter tip 200 may have a shape similar to that shown in the front view and rear views of Figures 2C and 2D, respectively. For example, each of the peak portions 208 may extend a maximal distance from the inner lumen 203 to form a first ellipse 215 of maximal extension of the catheter tip 200. Due to the indentations 206, the peak portions 208 may form only a partial ellipse. In other words, the indentations 206 may represent gaps in the first ellipse 215. In some embodiments, the peak portions 208 may cover approximately half of the circumference of the first ellipse 215 and/or approximately half of the surface area of the catheter tip 200 in a cross-sectional plane of the catheter tip 200. In this way, an amount of material of the catheter tip 200 having the maximal radius 211 may be approximately half and/or may advantageously be minimized to reduce surface friction as the catheter tip 200 moves through a vessel.

[0045] The indentations 206 may provide a decrease in radius and/or diameter of the catheter tip 200. In some embodiments, the indentations 206 may form part of a base

ellipse 217 and/or may gradually slope from the maximal radius 211 (at the peak portions 208) to a base radius 213. The base radius 213 may be smaller than the maximal radius 211.

[0046] As shown in Figures 2A and 2B, one or more of the indentations 206 may have a shape of an ellipse (e.g., an oval). Each indentation 206 may be situated between two peak portions 208. In other words, the indentations 206 may represent removed material at and/or around a cross-sectional plane including one or more peak portions 208. In this way, an amount of surface area of the catheter tip 200 having a maximal radius 211 may be reduced due to the indentations 206. In some embodiments, the indentations 206 may reduce a surface area of the catheter tip 200 having the maximal radius 211 by approximately fifty percent in comparison to a catheter tip 200 having a fully rounded lateral cross-section at the one or more peak portions 208.

[0047] While the catheter tip 200 is shown in Figures 2C and 2D having five indentations 206, the catheter tip 200 may have any number of indentations 206. Moreover, the indentations 206 may have any shape and/or size. In some embodiments, the indentations 206 may have a depth approximately equivalent to a cross-sectional distance between the first ellipse 215 and a base 210 of the proximal end 204. A width and/or length of an indentation 206 may be approximately equal to, smaller than, or greater than a depth of the indentation 206.

[0048] While the indentations 206 are shown having an oval/ellipse shape, the indentations 206 may have any shape. For example, an indentation 206 may have a circular, rectangular, or triangular shape. In some embodiments, the one or more indentations 206 may comprise one or more thin, shallow grooves which may have a straight, curved, wavy, and/or other shape.

[0049] Moreover, while some features of the catheter tips 200 shown in Figures 2A-2E may be shown in combination with each other, such features need not be used in combination and may be independently implemented. For example, a catheter tip 200 may comprise any combination of a distal end 202, lumen 203, proximal end 204, elongate body 205, one or more indentations 206, one or more peak portions 208, base 210, and/or various other features and may include only a subset of such features.

[0050] Figure 3 shows a delivery system including a catheter tip 301 and a catheter 311 in accordance with some embodiments. In some embodiments, the proximal end 304 of the catheter tip 301 may have an at least partially rounded surface that may be configured to attach to and/or otherwise contact the catheter 311 and/or a tension line 312. For example, the proximal end 304 may be a partial sphere, such as an approximately half-

sphere attached to and/or extending from the elongate body 305. In some embodiments, the proximal end 304 may align with a slope of the elongate body 305 where the elongate body 305 meets the proximal end. For example, the elongate body 305 may have a sloped surface that may form a gapless and/or otherwise continuous surface with the proximal end 304.

[0051] The catheter 311 may have a hollow interior 314 configured to fit the tension line 312 and/or various devices. Moreover, the tension line 312 may have a hollow interior 316 configured to fit a guidewire and/or other devices. At least a portion of the proximal end 304 may be configured to fit at least partially into the hollow interior 314 and/or through an end of the catheter 311. As the catheter tip 301 rotates (e.g., in a first direction 324 and/or second direction 326), different portions of the proximal end 304 may be situated within the hollow interior 314 of the catheter 311. Rotation of the catheter tip 301 may cause the tension line 312 to move (e.g., in the first direction 324 and/or the second direction 326). For example, the tension line 312 may be configured to be attached to the catheter tip 301 and may move with the catheter tip 301.

[0052] The tension line 312 may be configured to attach to and/or extend from the catheter tip 301. In some embodiments, the tension line 312 may be tensioned to apply backward 322 force on the catheter tip 301 towards the catheter 311. The catheter 311 may not be attached to the catheter tip 301 and/or may be capable of being dislodged/disconnected from the catheter tip 301 as the catheter tip 301 and/or catheter 311 moves forward 320 through a vessel. An amount of backward 322 force applied by the tension line 312 to the catheter tip 301 may be lesser than a force propelling the catheter tip 301 and/or catheter 311 forward 320. Accordingly, by applying backward 322 force on the catheter tip 301, the catheter tip 301 may be held against the catheter 311 without preventing forward 320 movement of the catheter tip 301 and/or catheter 311. An amount of backward 322 force applied to the catheter tip 301 may be determined on a process-dependent basis. For example, the amount of backward 322 force may increase with an increase in forward 320 momentum of the catheter tip 301 and/or catheter 311 and/or may decrease with a decrease in forward 320 momentum of the catheter tip 301 and/or catheter 311.

[0053] In some embodiments, the catheter tip 301 may be configured to twist, rotate, turn, bend, and/or otherwise freely move (e.g., in a first direction 324, second direction 326, and/or any other direction) with respect to the catheter 311. For example, as the catheter tip 301 turns around a curve/bend in a vessel, the catheter tip 301 may be configured to roll, yaw, pitch, and/or otherwise turn with the vessel in various axes without causing the catheter 311 to turn. Despite the movement of the catheter tip 301, contact between the catheter tip

301 and the catheter 311 may be maintained, due at least in part to the rounded structure of the proximal end 304. The freedom of movement of the catheter tip 301 with respect to the catheter 311 may advantageously allow the catheter tip 301 and/or catheter 311 to more easily navigate curved vessels.

[0054] Due at least in part to the backward 322 force applied by the tension line 312, the catheter tip 301 may be configured to maintain contact with the catheter 311 while the catheter tip 301 twists and/or otherwise moves with respect to the catheter 311. The catheter 311 may have an at least partially hollow interior 314 such that an end of the catheter 311 that may be configured to contact the catheter tip 301 may be an elliptical (e.g., circular) surface. The proximal end 304 of the catheter tip 301 may be rounded such that the elliptical surface of the end of the catheter 311 can establish a full ellipse of contact with the proximal end 304 catheter tip 301. In other words, there may be no gaps between the proximal end 304 of the catheter tip 301 and the end of the catheter 311. Moreover, the circular surface of the end of the catheter 311 can maintain full contact with the proximal end 304 while the catheter tip 301 moves with respect to the catheter 311. In this way, the proximal end 304 of the catheter tip 301 and the end of the catheter 311 may operate similarly to a ball-joint.

[0055] As the catheter tip 301 moves with respect to the catheter 311, the tension line 312 may maintain an attachment to the catheter tip 301 (e.g., around a lumen at a midpoint of the proximal end 304). Accordingly, movement of the catheter tip 301 may cause movement of the tension line 312 toward a wall of the catheter 311. For example, the tension line 312 may be situated at a midpoint of the hollow interior of the catheter 311 and as the catheter tip 301 moves, the tension line 312 (particularly an end of the tension line 312 attached to the catheter tip 301) may move away from the midpoint of the hollow interior of the catheter 311 and toward a wall of the catheter 311 (e.g., in the first direction 324 and/or the second direction 326).

[0056] Tension may be applied to the catheter tip 301 and/or the tension line 312 in a variety of ways. In some embodiments, the tension line 312 may be connected to a tension spring or similar device. For example, a first end and/or end portion of the tension line 312 may be attached to the catheter tip 301 and a second end of the tension line 312 (e.g., situated outside the body) may be attached to a tension spring (or to a block or similar device attached to a tension spring). In some embodiments, a tension spring and/or similar device attached to the tension line 312 may be configured to apply varying levels of tension to the catheter tip 301.

[0057] In some embodiments, the tension line 312 may be composed of a braided material, such as a bio-compatible plastic, metal, and/or polymer. The tension line 312 may be at least partially elastic and may be configured to stretch as the catheter tip 301 moves through a vessel. The elasticity of the tension line 312 may cause resistive force on the catheter tip 301 to press the catheter tip 301 against the catheter 311.

[0058] Tension force applied to the catheter tip 301 may be reduced and/or removed to facilitate delivery of various implants into a patient's body. For example, as the catheter tip 301 and/or catheter 311 moves through a vessel, a first amount of tension may be applied to the catheter tip 301 (e.g., by the tension line 312) to hold the catheter tip 301 against the catheter 311. When the catheter tip 301 arrives at a desired location within the vessel, the applied tension may be reduced to a second amount of tension that is less than the first amount of tension to allow the catheter 311 to be moved away from the catheter tip 301 and/or to allow the catheter tip 301 to be moved away from the catheter 311 to create a separation between the catheter tip 301 and the catheter 311. An implant may be inserted through the catheter 311 and may be exposed to the patient's body via the separation created between the catheter tip 301 and the catheter 311.

[0059] In some embodiments, the catheter tip 301 may be at least partially elastic and/or may be configured to at least partially bend. Due at least in part to the grooved/indented structure of the catheter tip 301, the catheter tip 301 may comprise a reduced and/or minimal amount of material. Accordingly, the structure of the catheter tip 301 may be less resistive to being bent and/or otherwise shaped. As the catheter tip 301 moves through curved and/or bent vessels, the catheter tip 301 may therefore be configured to bend with the vessels. In some embodiments, the catheter tip 301 may be composed of polyether block amide (PEBA) or other material with a relatively soft and/or elastic structure.

[0060] While some features of the delivery system shown in Figure 3 may be shown in combination with each other, such features need not be used in combination and may be independently implemented. For example, the delivery system may comprise any combination of a catheter tip 301, distal end 302, proximal end 304, elongate body 305, one or more indentations 306, one or more peak portions 308, catheter 311, tension line 312, hollow interior 314, 316 and/or various other features and may include only a subset of such features.

[0061] Figures 4A-4C illustrate components of delivery systems for delivering one or more implants in accordance with one or more embodiments. Figure 4A illustrates a delivery (e.g., closed) state of the delivery systems, in which an implant 430 may be situated

within an outer shaft lumen 414 of an outer shaft 411 (e.g., a catheter) and/or may be attached to a tension line 412 (e.g., a guidewire tube). The outer shaft 411 may be in contact with a proximal end 404 of a catheter tip 401. For example, the outer shaft 411 may form a complete ellipse of contact with the rounded end 404. At delivery, the implant 430 may be in a collapsed state. For example, the outer shaft 411 may be configured to press against the implant 430 to prevent the implant 430 from expanding to an expanded state (shown in Figure 4B).

[0062] The outer shaft 411 may pass through and/or attach to a handle 432, which may be situated outside the body. An inner support shaft 434 may attach to the handle 432 to provide support to the handle 432. In some embodiments, the inner support shaft 434 may be fixed with respect to the handle 432 while the outer shaft 411 may be movable with respect to the handle 432. The inner support shaft 434 may be situated at least partially within an outer shaft lumen 414. In some embodiments, the outer shaft 411 may be controllable via one or more control knobs 436. The control knobs 436 may pass through openings in the handle 432. For example, the handle 432 may include one or more elongate openings (e.g., sliding tracks) and the control knobs 436 may be configured to slide along and/or through the elongate openings.

[0063] Figure 4B illustrates an open state of the delivery systems. As shown in Figure 4B, the control knobs 436 may be pressed/pulled in a backward direction 438 (e.g., along one or more elongate openings in the handle 432) to create a separation 440 between the proximal end 404 of the catheter tip 401 and the outer shaft 411. The implant 430 may be situated along the tension line 412 near the proximal end 404 such that the separation 440 may expose the implant 430. For example, after the separation 440 is created, the implant 430 may not be in contact with the outer shaft 411. In some embodiments, the implant 430 may be configured to expand when the implant is exposed.

[0064] The outer shaft 411 may be held in the closed state (shown in Figure 4A) at least in part by a tension spring 442 or similar device. Figure 4C provides a detailed view of the tension spring 442 and various other delivery system components. In some embodiments, the tension spring 442 may be configured to apply pressure to the tension line 412 and/or to a spacer 444 in contact with and/or bonded to the tension line 412. In some embodiments, a gear 446 may be configured to press against the tension spring 442 to build up tension in the tension spring 442 and thereby causing pressure against the spacer 444 and/or tension line 412. The gear 446 may be controlled through use of a gear control knob 448 which may be configured to be twisted or otherwise engaged to cause motion of the gear

446. For example, the gear 446 may comprise a threaded nut configured to move along a threaded surface 450 of the control knob 448. When the control knob 448 is twisted, the gear 446 may move along the threaded surface 450 and/or may be configured to increase and/or decrease an amount of pressure on the tension spring 442. In this way, the amount of pressure on the tension spring 442 (and similarly, on the tension line 412) may be controllable via the gear control knob 448. In some embodiments, the tension line 412 may be configured to pass through a lumen of the gear control knob 448.

[0065] In some embodiments, the outer shaft 411 may be configured to move along guiderails 452 within the handle 432. An amount of tension at the tension spring 442 may be reduced before the outer shaft 411 is moved in the backward direction 438. For example, the tension spring 442 may be configured to hold the catheter tip 401 against the outer shaft 411. In order to create the separation 440, the tension at the tension spring 442 may be reduced (e.g., by moving the gear 446 away from the tension spring 442). When the amount of tension on the tension spring 442 is sufficiently low, the outer shaft 411 may be moved along the guiderails 452 in the backward direction 438 to create the separation 440.

[0066] While some features of the delivery systems shown in Figures 4A-4C may be shown in combination with each other, such features need not be used in combination and may be independently implemented. For example, the delivery systems may comprise any combination of a catheter tip 401, proximal end 404, outer shaft 411, tension line 412, hollow interior 414, implant 430, handle 432, inner support shaft 434, control knobs 436, tension spring 442, spacer 444, gear 446, gear control knob 448, threaded surface 450, guiderails 452, and/or various other features and may include only a subset of such features.

[0067] Figure 5 illustrates another delivery system in accordance with one or more embodiments. In some embodiments, a tension spring 542 may be configured to apply pressure to an outer shaft 511. For example, an adjustment knob 560 may be moveable and/or may be configured to press against the tension spring 542. The tension spring 542 may be configured to press against the outer shaft 511 to hold the outer shaft 511 against a proximal end 504 of a catheter tip 501. In this way, there may be no gap between an end of the outer shaft 511 and the proximal end 504. When the catheter tip 501 and/or outer shaft 511 reaches a desired location within a patient's body, the adjustment knob 560 and/or tension spring 542 may be adjusted to remove an amount of tension on the outer shaft 511. In this way, the outer shaft 511 may be pulled away from the catheter tip 501 to create a separation between the outer shaft 511 and the catheter tip 501 to expose an implant 530. The outer shaft 511 may then be removed from the patient's body.

[0068] A tension line 512 and/or inner support shaft 534 may be configured to pass through the outer shaft 511. In some embodiments, the tension line 512 and/or inner support shaft 534 may be configured to attach to a handle 532, which may at least partially house the adjustment mechanism 560 and/or the tension spring 542. The tension line 512 may be configured to pass through the handle 532.

[0069] Delivery systems as described herein may be used to position catheter tips and/or catheters to various areas of a human heart. For example, a catheter tip and/or catheter may be configured to pass from the right atrium into the coronary sinus. However, it will be understood that the description can refer or generally apply to positioning of catheter tips and/or catheters from a first body chamber or lumen into a second body chamber or lumen, where the catheter tips and/or catheters may be bent when positioned from the first body chamber or lumen into the second body chamber or lumen. A body chamber or lumen can refer to any one of a number of fluid channels, blood vessels, and/or organ chambers (e.g., heart chambers). Additionally, reference herein to “catheters,” “tubes,” “shafts,” “sheaths,” “steerable sheaths,” and/or “steerable catheters” can refer or apply generally to any type of elongate tubular delivery device comprising an inner lumen configured to slidably receive instrumentation, such as for positioning within an atrium or coronary sinus, including for example delivery catheters and/or cannulas. It will be understood that other types of medical implant devices and/or procedures can be delivered to the coronary sinus using a delivery system as described herein, including for example ablation procedures, drug delivery and/or placement of coronary sinus leads.

[0070] While some features of the delivery system shown in Figure 5 may be shown in combination with each other, such features need not be used in combination and may be independently implemented. For example, the delivery system may comprise any combination of a catheter tip 501, proximal end 504, outer shaft 511, tension line 512, implant 530, handle 532, inner support shaft 534, tension spring 542, adjustment mechanism 560, and/or various other features and may include only a subset of such features.

[0071] Figure 6 is a flow diagram of an example of a process 600 for deploying a delivery system including a catheter tip into and/or through a blood vessel. In block 602, the process 600 involves providing a catheter tip tethered to a tension line. In some embodiments, the tension line may be further attached/tethered to a tension spring and/or other device configured to facilitate application of varying or stable tension force to the catheter tip. The tension line may be any wire and/or tubular device (e.g., a sheath and/or guidewire tube)

configured to provide tension to the catheter tip. In some embodiments, the tension line may have an inner lumen configured to receive various guidewires and/or other delivery devices.

[0072] In block 604, the process 600 involves attaching an implant to the tension line. For example, the implant may have a circular shape with an at least partially hollow interior and the tension line may fit through the at least partially hollow interior of the implant. In some embodiments, the implant may have an expandable structure. For example, during delivery, the implant may be in a compressed form in order to fit within a catheter. When the catheter is delivered to a desired location, the implant may be exposed by pulling back the catheter and the implant may expand to a greater surface area than the compressed form. In some embodiments, the implant may be attached to the tension line at a point near the end of the tension line that is attached to the catheter tip.

[0073] In block 606, the process 600 involves advancing a catheter (i.e., a shaft) over the tension line and into contact with the catheter tip. The catheter may be any tubular device and/or may comprise an inner lumen. In some embodiments, the catheter may have a circular and/or otherwise elliptical form in which an end of the catheter forms a circle and/or ellipse. The catheter may be configured to form a complete ellipse of contact with the catheter tip at an end portion of the catheter and a proximal end of the catheter tip. In some embodiments, the catheter may be attached to or otherwise in contact with a tension spring or similar device configured to apply pressure to the catheter. The applied pressure may hold the catheter against the catheter tip until the catheter arrives at a desired location within a patient's body. When the catheter arrives at the desired location, the applied pressure at the catheter may be reduced such that the catheter may be moved away from the catheter tip to form a separation between the catheter tip and the catheter.

[0074] In block 608, the process 600 involves establishing and/or maintaining tension on the tension line and/or catheter to press the catheter tip against the end of the catheter and/or to press the end of the catheter against the catheter tip. In block 610, the process 600 involves introducing the catheter tip, tension line, and/or catheter into a vessel (e.g., a blood vessel) and/or chamber of the body. The catheter tip may be in contact with the catheter and/or the tension line may be situated within an inner lumen of the catheter at introduction into the body. In block 612, the process 600 involves advancing the catheter tip, tension line, and/or catheter through the vessel while maintaining a sufficient level of tension on the tension line to maintain the full ellipse of contact between the catheter tip and an end of the catheter.

[0075] In block 614, the process 600 involves reducing and/or removing tension on the tension line and/or catheter and creating separation between the catheter tip and the catheter. In block 616, the process 600 involves delivering and/or exposing the implant through the separation created between the catheter tip and the catheter.

[0076] Depending on the embodiment, certain acts, events, or functions of any of the processes or algorithms described herein can be performed in a different sequence, may be added, merged, or left out altogether. Thus, in certain embodiments, not all described acts or events are necessary for the practice of the processes.

[0077] Conditional language used herein, such as, among others, “can,” “could,” “might,” “may,” “e.g.,” and the like, unless specifically stated otherwise, or otherwise understood within the context as used, is intended in its ordinary sense and is generally intended to convey that certain embodiments include, while other embodiments do not include, certain features, elements and/or steps. Thus, such conditional language is not generally intended to imply that features, elements and/or steps are in any way required for one or more embodiments or that one or more embodiments necessarily include logic for deciding, with or without author input or prompting, whether these features, elements and/or steps are included or are to be performed in any particular embodiment. The terms “comprising,” “including,” “having,” and the like are synonymous, are used in their ordinary sense, and are used inclusively, in an open-ended fashion, and do not exclude additional elements, features, acts, operations, and so forth. Also, the term “or” is used in its inclusive sense (and not in its exclusive sense) so that when used, for example, to connect a list of elements, the term “or” means one, some, or all of the elements in the list. Conjunctive language such as the phrase “at least one of X, Y and Z,” unless specifically stated otherwise, is understood with the context as used in general to convey that an item, term, element, etc. may be either X, Y or Z. Thus, such conjunctive language is not generally intended to imply that certain embodiments require at least one of X, at least one of Y and at least one of Z to each be present.

[0078] It should be appreciated that in the above description of embodiments, various features are sometimes grouped together in a single embodiment, Figure, or description thereof for the purpose of streamlining the disclosure and aiding in the understanding of one or more of the various inventive aspects. This method of disclosure, however, is not to be interpreted as reflecting an intention that any claim require more features than are expressly recited in that claim. Moreover, any components, features, or steps illustrated and/or described in a particular embodiment herein can be applied to or used with

any other embodiment(s). Further, no component, feature, step, or group of components, features, or steps are necessary or indispensable for each embodiment. Thus, it is intended that the scope of the inventions herein disclosed and claimed below should not be limited by the particular embodiments described above, but should be determined only by a fair reading of the claims that follow.

[0079] It should be understood that certain ordinal terms (e.g., “first” or “second”) may be provided for ease of reference and do not necessarily imply physical characteristics or ordering. Therefore, as used herein, an ordinal term (e.g., “first,” “second,” “third,” etc.) used to modify an element, such as a structure, a component, an operation, etc., does not necessarily indicate priority or order of the element with respect to any other element, but rather may generally distinguish the element from another element having a similar or identical name (but for use of the ordinal term). In addition, as used herein, indefinite articles (“a” and “an”) may indicate “one or more” rather than “one.” Further, an operation performed “based on” a condition or event may also be performed based on one or more other conditions or events not explicitly recited.

[0080] Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which example embodiments belong. It be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

[0081] Although certain preferred embodiments and examples are disclosed below, inventive subject matter extends beyond the specifically disclosed embodiments to other alternative embodiments and/or uses and to modifications and equivalents thereof. Thus, the scope of the claims that may arise herefrom is not limited by any of the particular embodiments described below. For example, in any method or process disclosed herein, the acts or operations of the method or process may be performed in any suitable sequence and are not necessarily limited to any particular disclosed sequence. Various operations may be described as multiple discrete operations in turn, in a manner that may be helpful in understanding certain embodiments; however, the order of description should not be construed to imply that these operations are order dependent. Additionally, the structures, systems, and/or devices described herein may be embodied as integrated components or as separate components. For purposes of comparing various embodiments, certain aspects and advantages of these embodiments are described. Not necessarily all such aspects or

advantages are achieved by any particular embodiment. Thus, for example, various embodiments may be carried out in a manner that achieves or optimizes one advantage or group of advantages as taught herein without necessarily achieving other aspects or advantages as may also be taught or suggested herein.

[0082] The spatially relative terms “outer,” “inner,” “upper,” “lower,” “below,” “above,” “vertical,” “horizontal,” and similar terms, may be used herein for ease of description to describe the relations between one element or component and another element or component as illustrated in the drawings. It be understood that the spatially relative terms are intended to encompass different orientations of the device in use or operation, in addition to the orientation depicted in the drawings. For example, in the case where a device shown in the drawing is turned over, the device positioned “below” or “beneath” another device may be placed “above” another device. Accordingly, the illustrative term “below” may include both the lower and upper positions. The device may also be oriented in the other direction, and thus the spatially relative terms may be interpreted differently depending on the orientations.

[0083] Unless otherwise expressly stated, comparative and/or quantitative terms, such as “less,” “more,” “greater,” and the like, are intended to encompass the concepts of equality. For example, “less” can mean not only “less” in the strictest mathematical sense, but also, “less than or equal to.”

WHAT IS CLAIMED IS:

1. A delivery system comprising:
 - a tension line;
 - a catheter; and
 - a catheter tip comprising:
 - a distal end portion;
 - a proximal end portion having an at least partially rounded surface, the proximal end portion configured to attach to the tension line; and
 - an elongate body extending from the distal end portion to the proximal end portion;wherein the tension line is configured to apply force to the catheter tip, and the catheter tip is configured to rotate independently of the catheter.
2. The delivery system of claim 1, wherein the catheter tip further comprises an inner lumen extending through the elongate body, the distal end portion, and the proximal end portion, and wherein the inner lumen is configured to receive one or more instruments.
3. The delivery system of claim 2, wherein the elongate body has an at least partially uneven surface in which one or more first portions of the elongate body have a maximal radial distance from the inner lumen and all other portions of the elongate body have a lesser radial distance from the inner lumen than the maximal radial distance.
4. The delivery system of claim 3, wherein each of the one or more first portions is in a first plane around the inner lumen.
5. The delivery system of claim 4, wherein approximately half of a surface area of the elongate body in the first plane has the maximal radial distance from the inner lumen and wherein approximately half of the surface area has less than the maximal radial distance from the inner lumen.
6. The delivery system of any of claims 3-5, wherein the elongate body has an at least partially tapered surface.

7. The delivery system of claim 6, wherein radius measurements of the elongate body gradually decrease from the one or more first portions to the distal end portion.

8. The delivery system of claim 6 or claim 7, wherein radius measurements of the elongate body gradually decrease from the one or more first portions to the proximal end portion.

9. The delivery system of any of claims 3-8, wherein the elongate body has one or more indentations.

10. The delivery system of claim 9, wherein each of the one or more indentations is between two of the one or more first portions.

11. The delivery system of claim 9 or claim 10, wherein each of the one or more indentations has an ellipse shape.

12. The delivery system of any of claims 1-11, wherein the catheter tip is configured to move in a first direction through a vessel and the tension line is configured to apply force in a second direction to the catheter tip.

13. The delivery system of any of claims 1-12, wherein the proximal end portion is configured to fit at least partially into an inner lumen of the catheter.

14. The delivery system of any of claims 1-13, wherein the proximal end portion is configured to establish a complete ellipse of contact with a tubular end portion of the catheter.

15. The delivery system of claim 14, wherein the catheter tip is configured to rotate in at least three axes while maintaining the complete ellipse of contact with the tubular end portion of the catheter.

16. The delivery system of claim 15, wherein the tension line is configured to apply force to the catheter tip to press the catheter tip against the tubular end portion of the catheter.

17. A delivery system comprising:

a tension line;

a catheter; and

a catheter tip comprising:

a distal end portion;

a proximal end portion having an at least partially rounded surface, the proximal end portion configured to fit at least partially into a lumen of the catheter and attach to the tension line, wherein the tension line is configured to apply force to the catheter tip to press the catheter tip against a tubular end portion of the catheter;

an elongate body extending from the distal end portion to the proximal end portion; and

an inner lumen extending through the elongate body, the distal end portion, and the proximal end portion, wherein the inner lumen is configured to receive one or more instruments;

wherein the elongate body has an at least partially uneven surface in which one or more first portions of the elongate body have a maximal radial distance from the inner lumen and all other portions of the elongate body have a lesser radial distance from the inner lumen than the maximal radial distance.

18. The delivery system of claim 17, wherein each of the one or more first portions is in a first plane around the inner lumen.

19. The delivery system of claim 18, wherein approximately half of a surface area of the elongate body in the first plane has the maximal radial distance from the inner lumen and wherein approximately half of the surface area has less than the maximal radial distance from the inner lumen.

20. The delivery system of any of claims 17-19, wherein the elongate body has an at least partially tapered surface.

21. The delivery system of claim 20, wherein radius measurements of the elongate body gradually decrease from the one or more first portions to the distal end portion.

22. The delivery system of claim 20 or claim 21, wherein radius measurements of the elongate body gradually decrease from the one or more first portions to the proximal end portion.

23. The delivery system of any of claims 17-22, wherein the elongate body has one or more indentations.

24. The delivery system of claim 23, wherein each of the one or more indentations is between two of the one or more first portions.

25. The delivery system of claim 23 or claim 24, wherein each of the one or more indentations has an ellipse shape.

26. The delivery system of any of claims 17-25, wherein the catheter tip is configured to move in a first direction through a vessel and the tension line is configured to apply force in a second direction to the catheter tip.

27. The delivery system of any of claims 17-26, wherein the proximal end portion is further configured to establish a complete ellipse of contact with the tubular end portion of the catheter.

28. The delivery system of claim 27, wherein the catheter tip is configured to rotate independently of the catheter while maintaining the complete ellipse of contact with the tubular end portion of the catheter.

29. The delivery system of claim 27 or claim 28, wherein the catheter tip is configured to rotate in three axes while maintaining the complete ellipse of contact with the tubular end portion of the catheter.

30. A method of accessing a heart location, the method comprising:
attaching a first end portion of a tension line to a rounded end portion of a catheter tip;
attaching one or more implants to the tension line near the rounded end portion of the catheter tip;

advancing a catheter over the tension line and into contact with the rounded end portion of the catheter tip, the catheter having an elliptical end portion;

applying tension at the tension line to press the rounded end portion of the catheter tip against the elliptical end portion of the catheter to form a complete ellipse of contact between the rounded end portion of the catheter tip and the elliptical end portion of the catheter; and

creating a separation between the rounded end portion of the catheter tip and the elliptical end portion of the catheter to expose the one or more implants.

31. The method of claim 30, wherein a second end portion of the tension line is attached to a tension spring.

32. The method of claim 30 or claim 31, wherein a second end portion of the catheter is attached to a tension spring.

33. The method of any of claims 30-32, wherein the tension line has an inner lumen configured to receive one or more instruments.

34. The method of any of claims 30-33, further comprising:
inserting at least the rounded end portion of the catheter tip, a portion of the tension line, and the elliptical end portion of the catheter into a blood vessel; and
advancing the rounded end portion of the catheter tip, the first end portion of the tension line, and the elliptical end portion of the catheter through the blood vessel while maintaining the complete ellipse of contact between the rounded end portion of the catheter tip and the elliptical end portion of the catheter.

35. A catheter tip comprising:
a distal end portion;
a proximal end portion having an at least partially rounded surface, the proximal end portion configured to connect to a tubular end of a catheter and rotate independently of the catheter while connected to the tubular end of the catheter; and
an elongate body extending from the distal end portion to the proximal end portion.

36. The catheter tip of claim 35, further comprising an inner lumen extending through the elongate body, the distal end portion, and the proximal end portion, and wherein the inner lumen is configured to receive one or more instruments.

37. The catheter tip of claim 36, wherein the elongate body has an at least partially uneven surface in which one or more first portions of the elongate body have a maximal radial distance from the inner lumen and all other portions of the elongate body have a lesser radial distance from the inner lumen than the maximal radial distance.

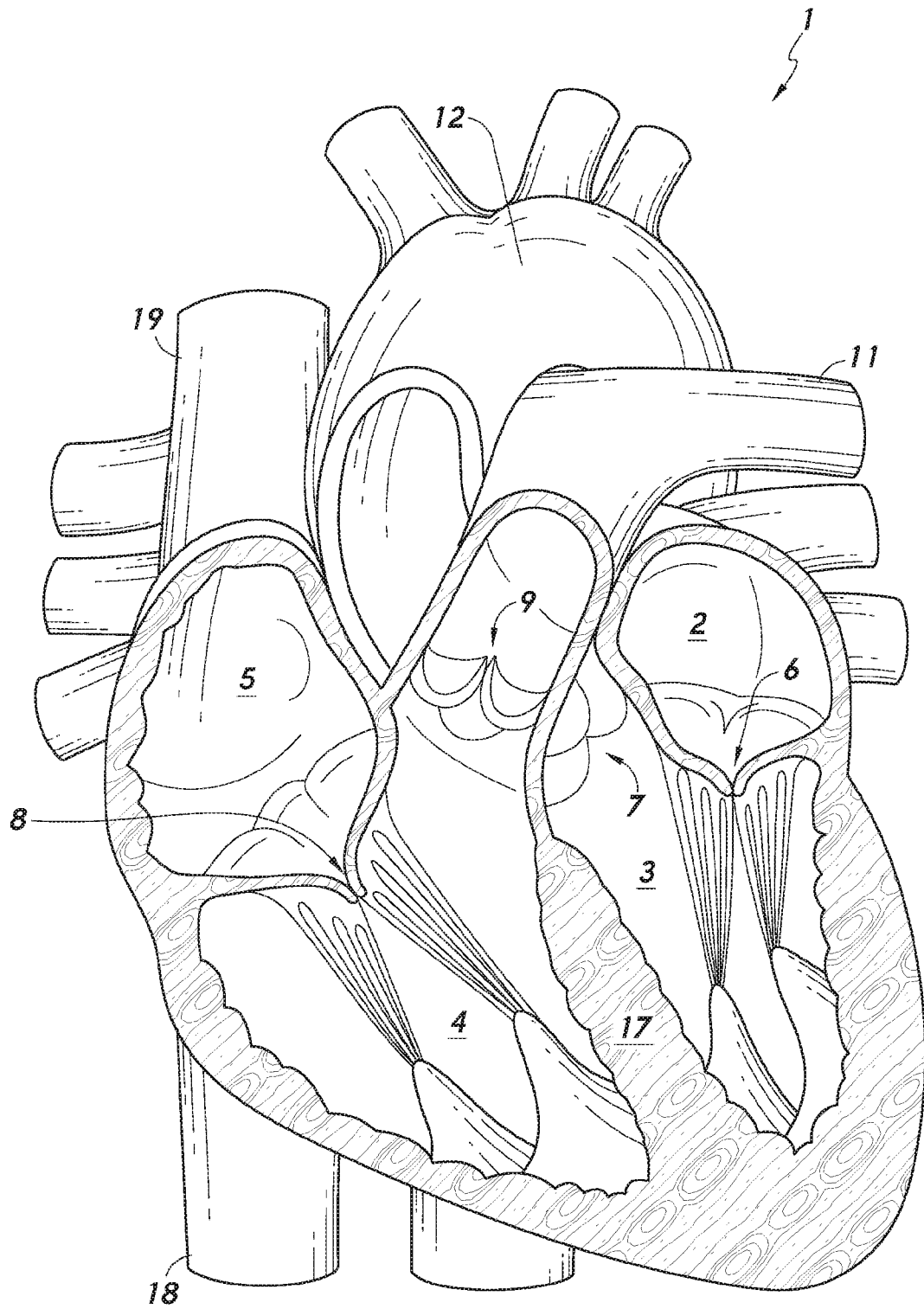


FIG. 1

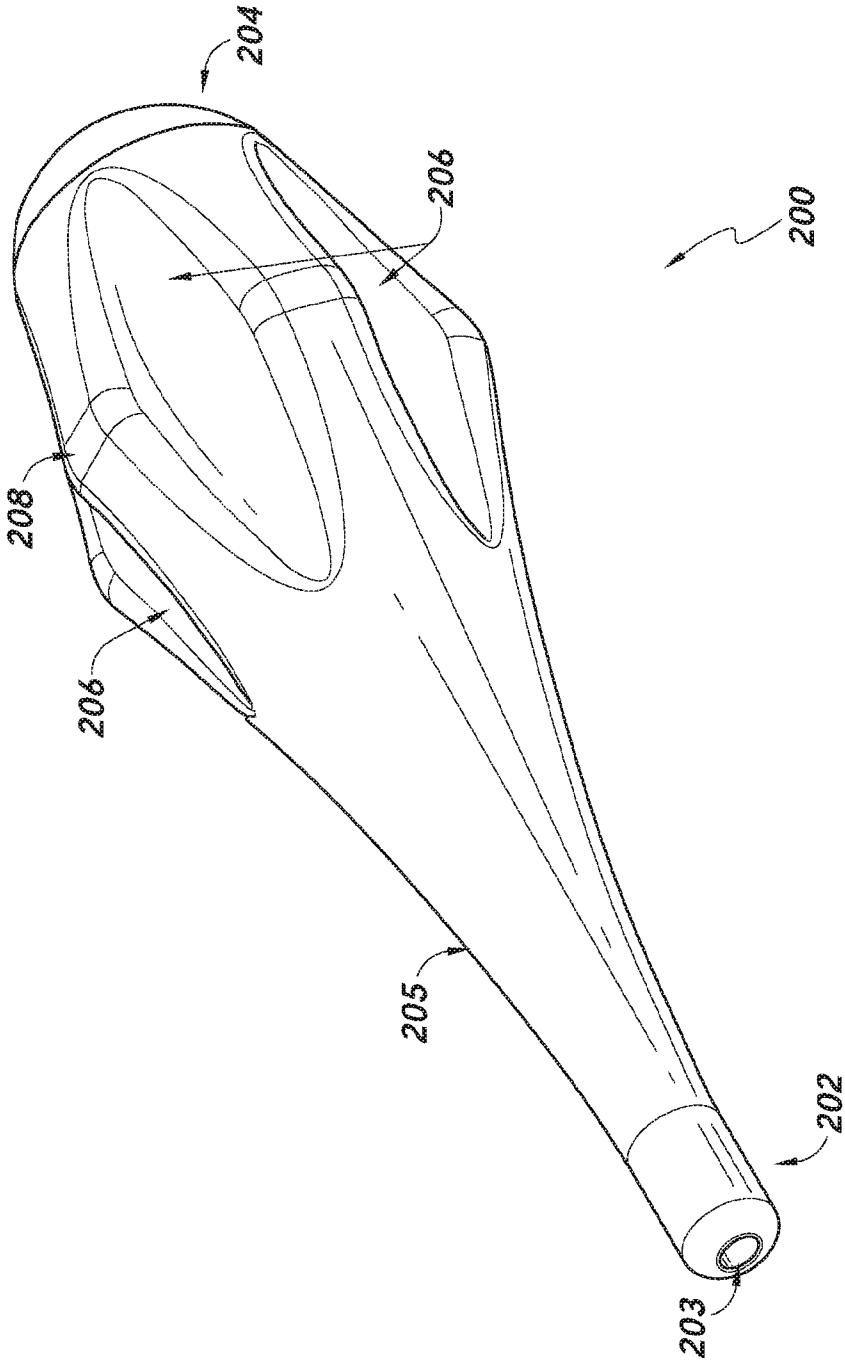


FIG. 2A

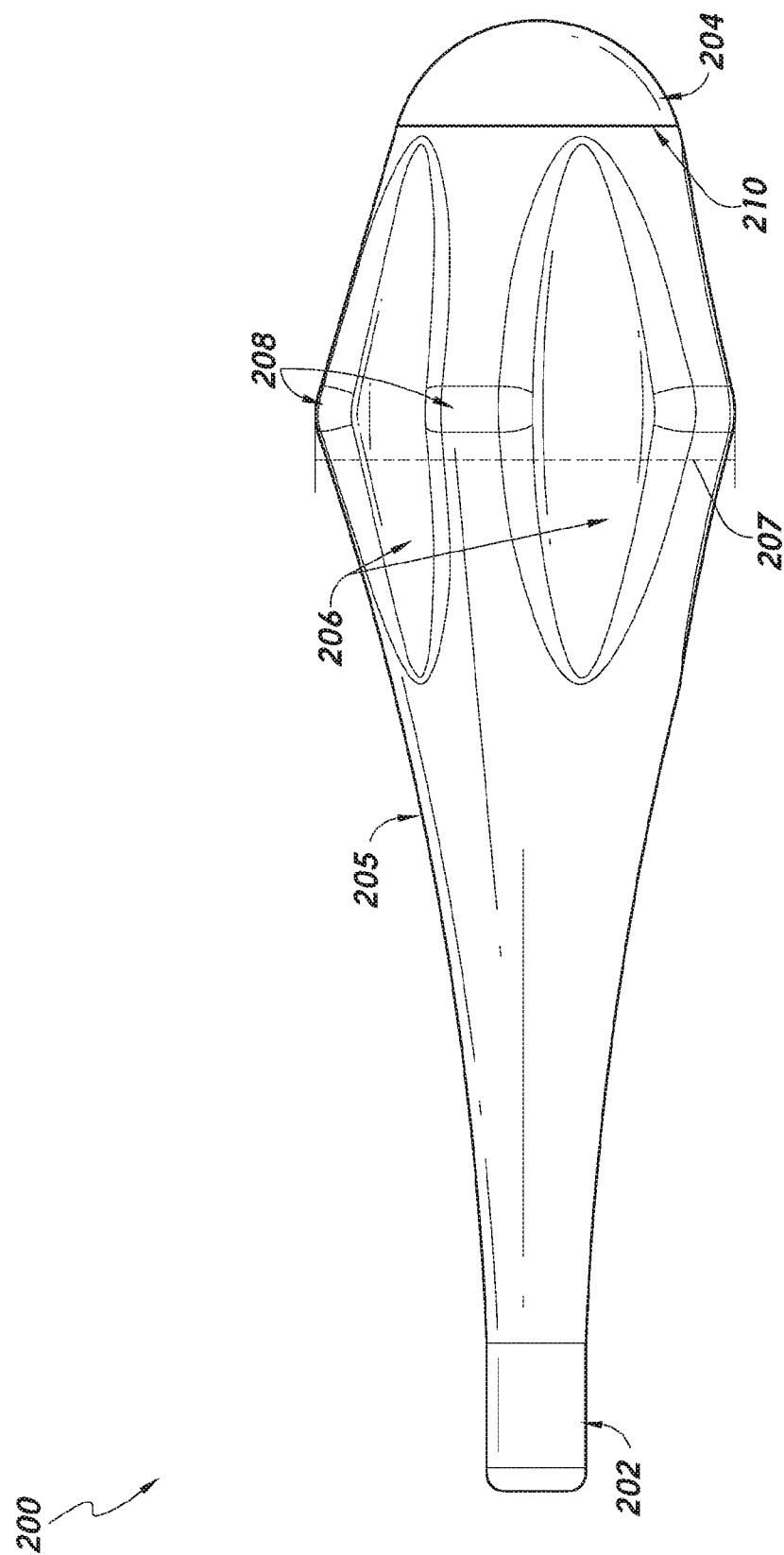
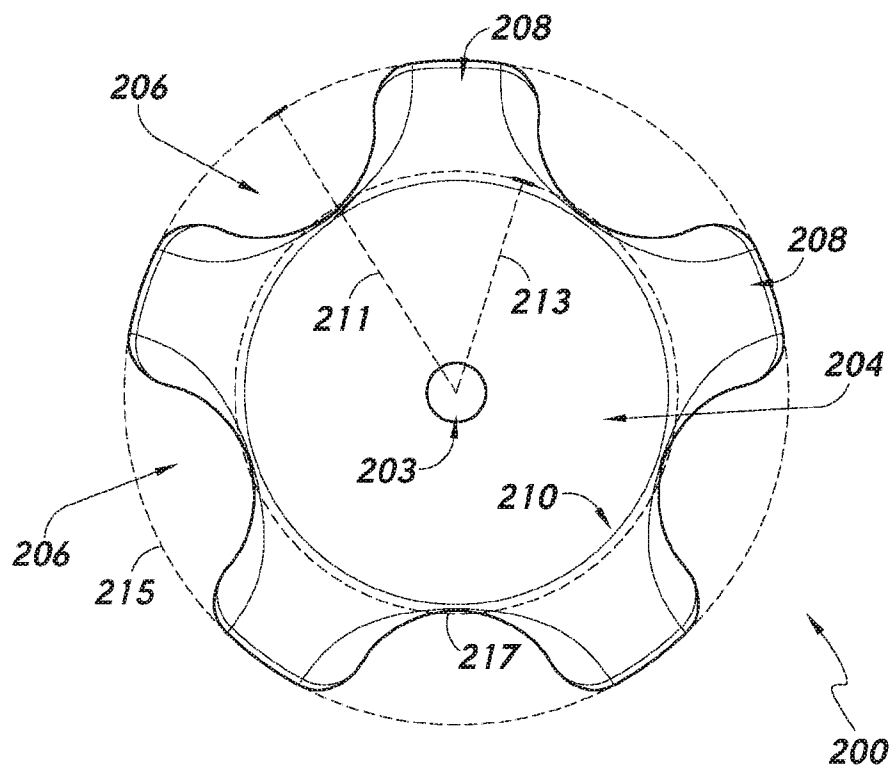
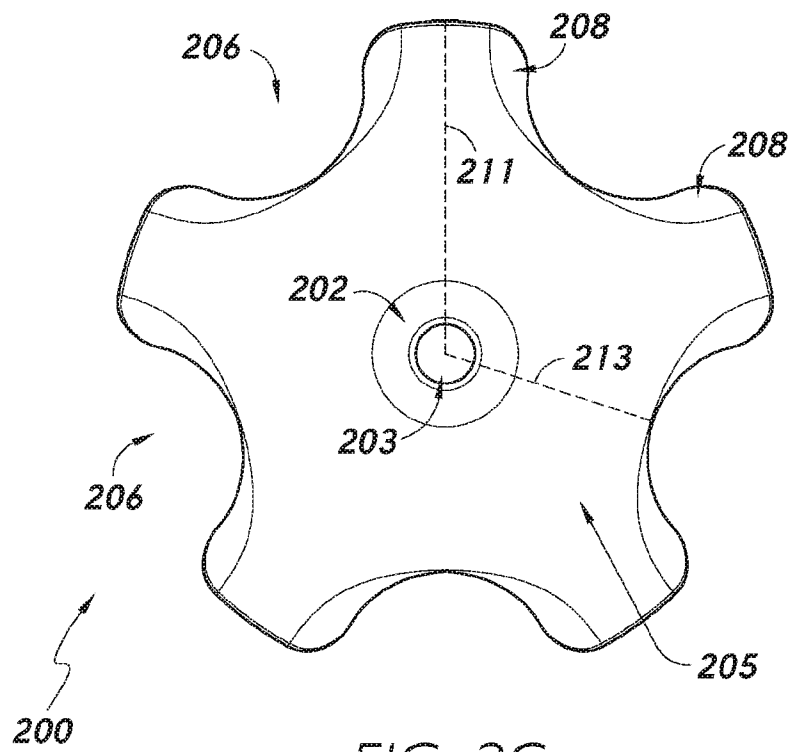


FIG. 2B

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200

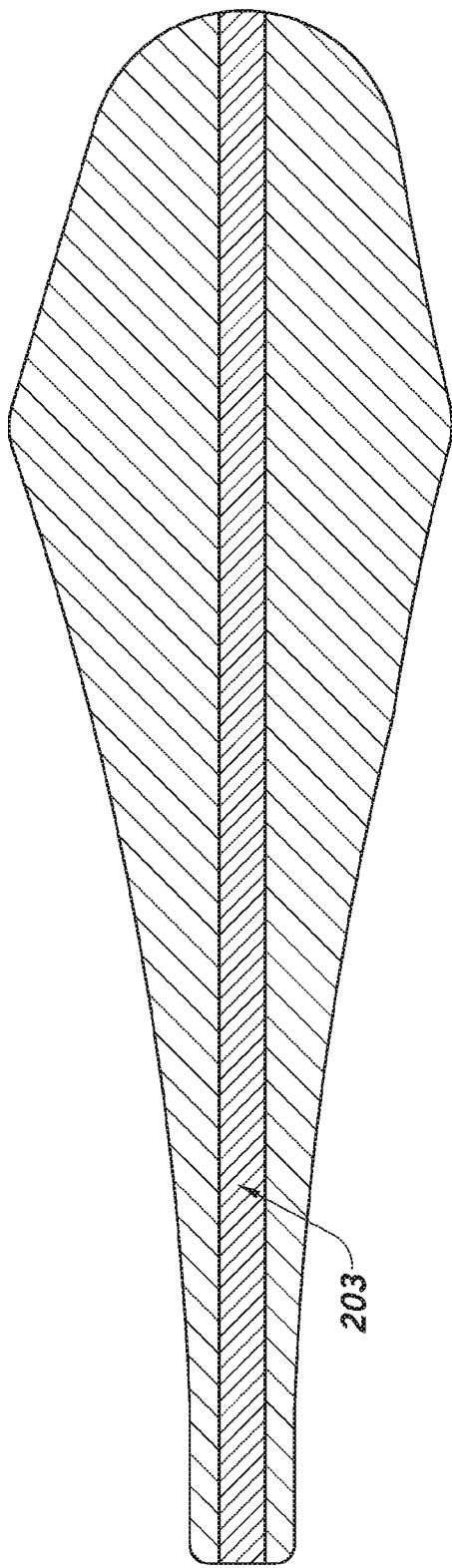


FIG. 2E

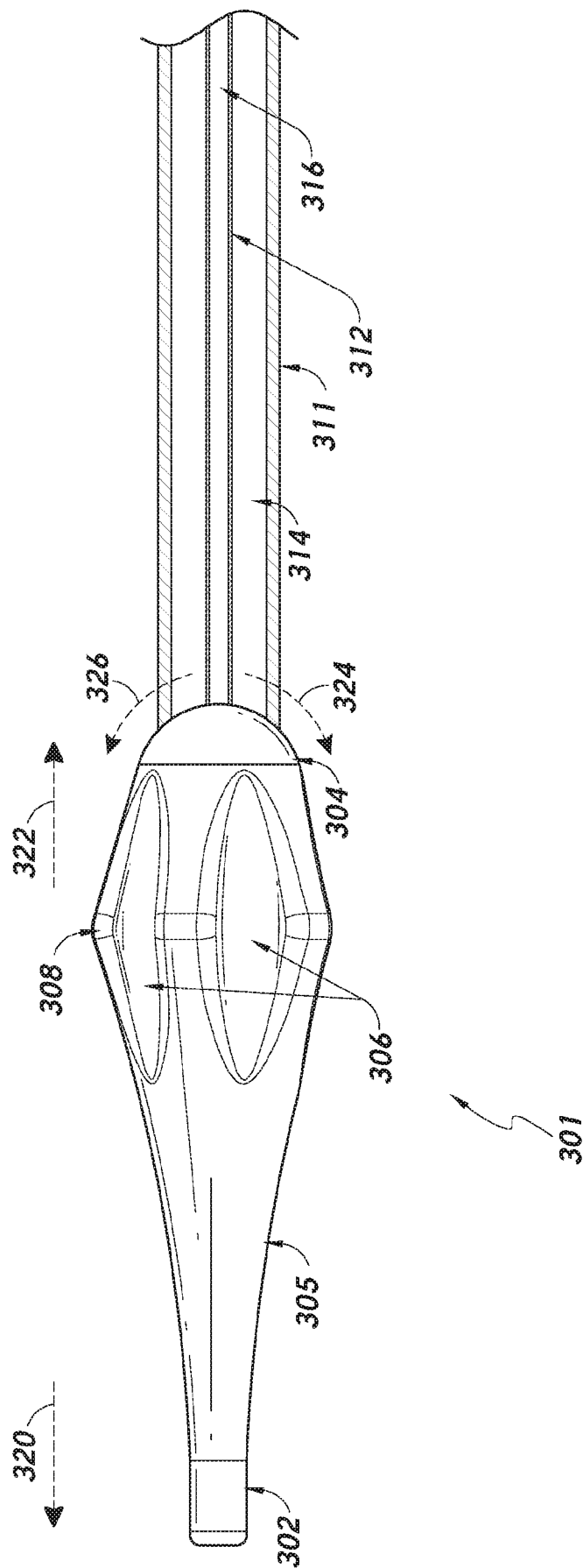
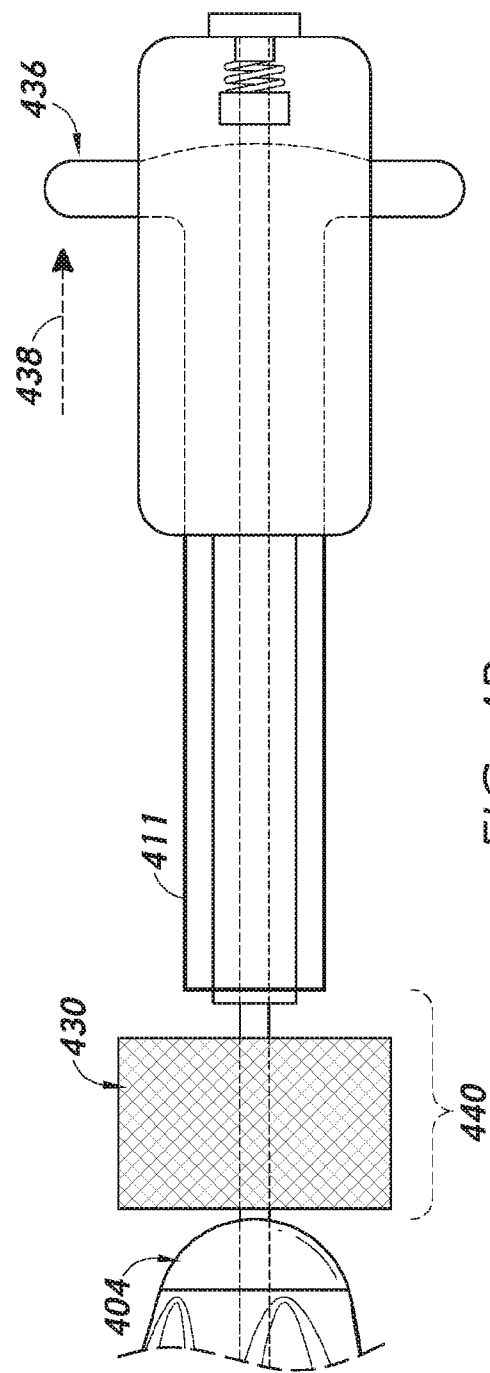
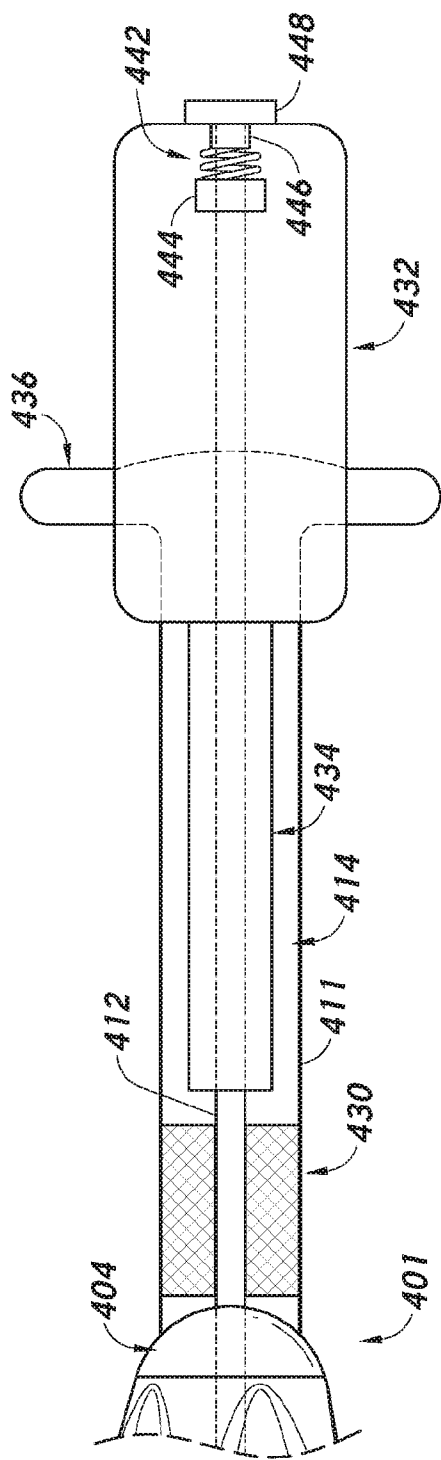


FIG. 3



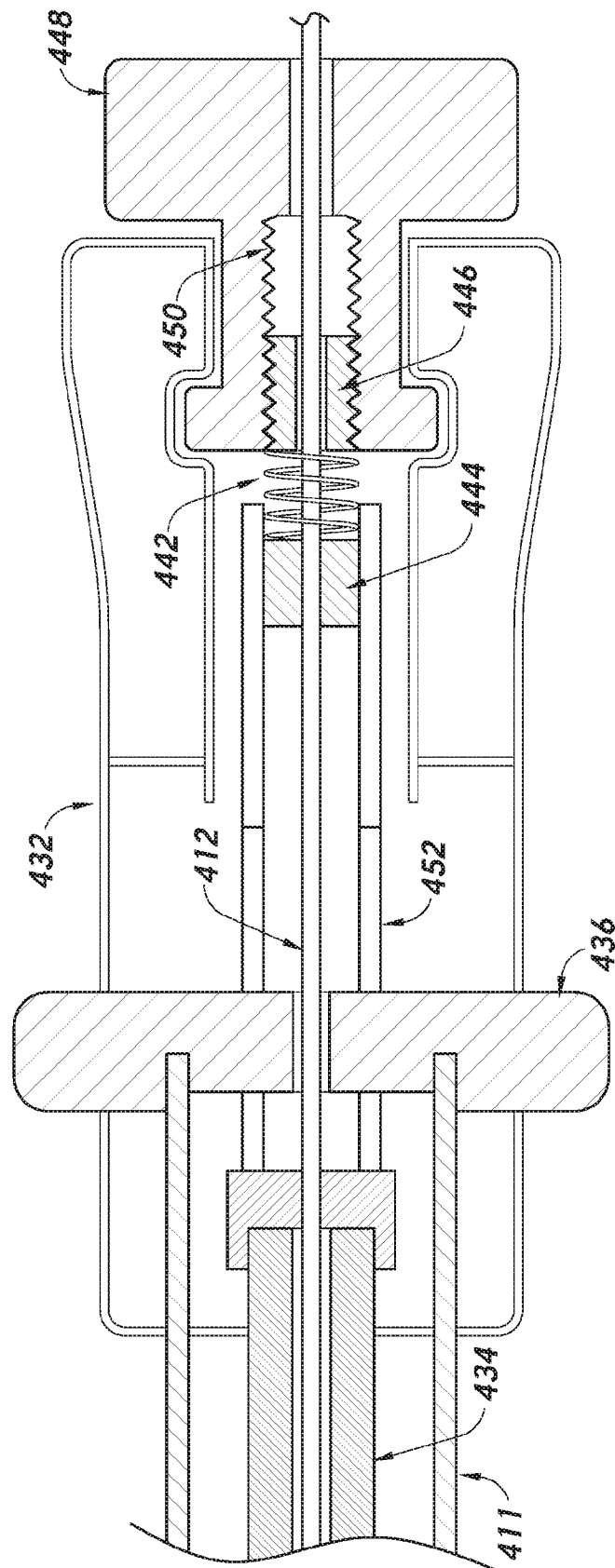


FIG. 4C

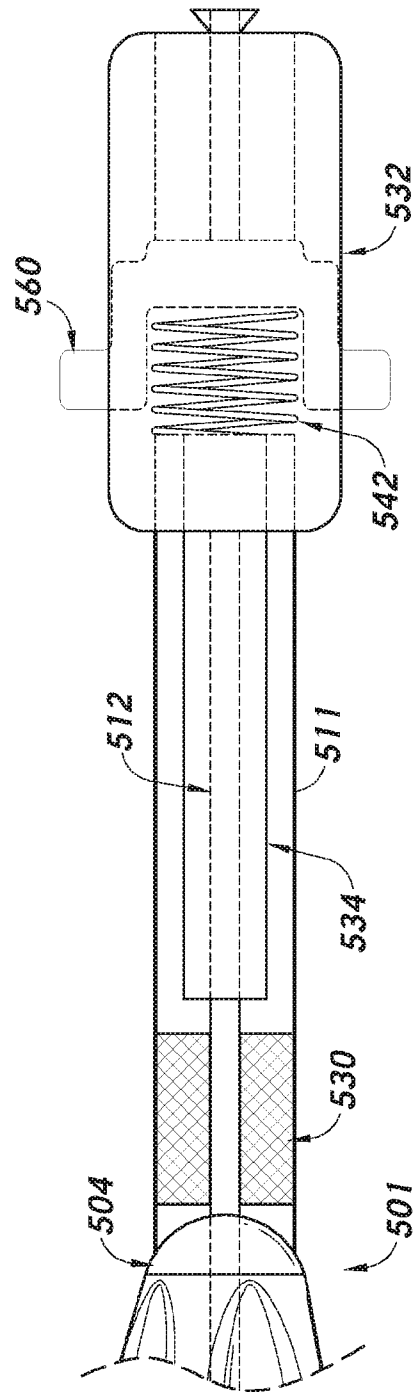


FIG. 5

10/10

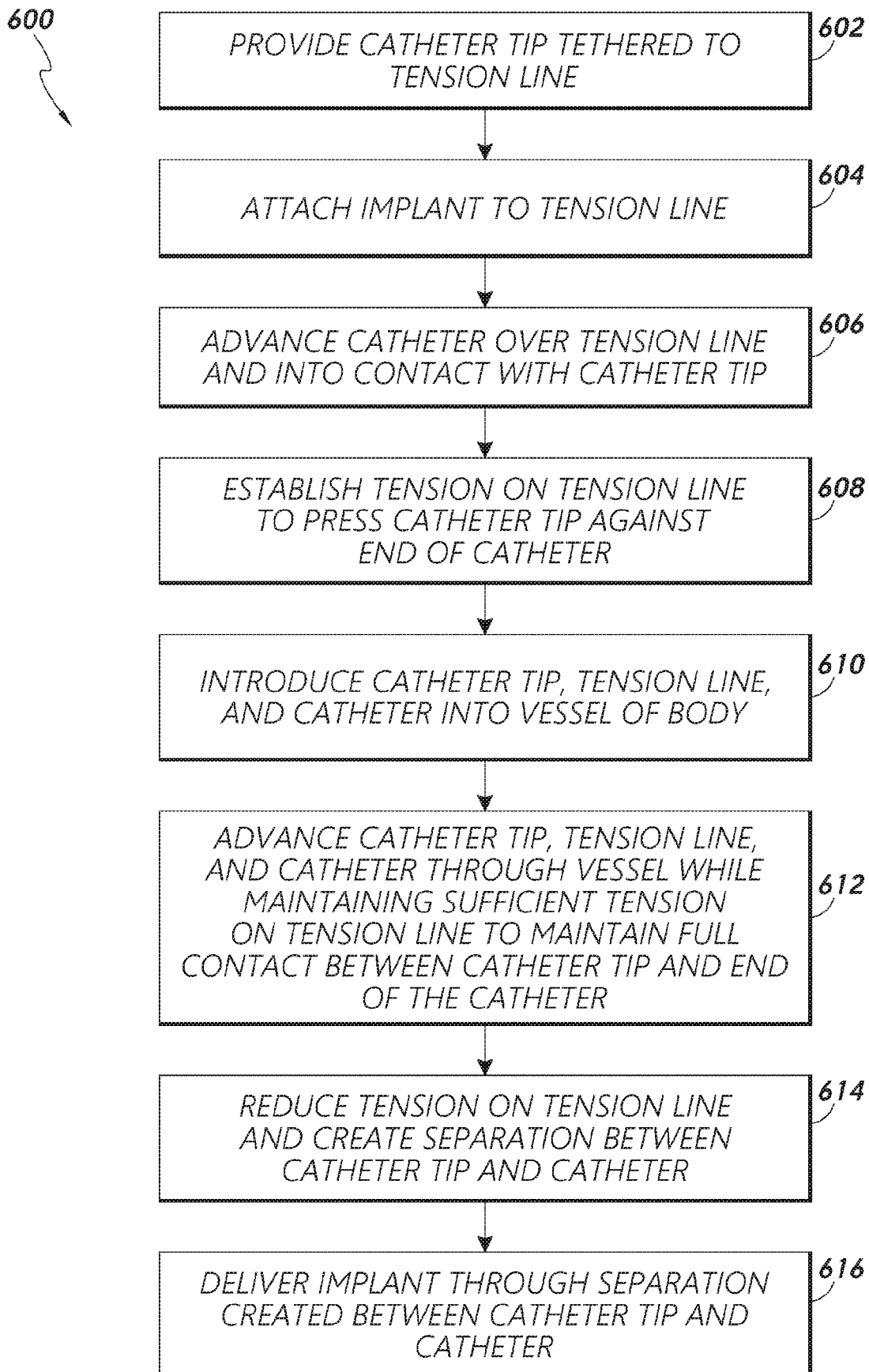


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2020/034846

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

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

1. ☒ Claims Nos.: 30-34
because they relate to subject matter not required to be searched by this Authority, namely:
Rule 39.1(iv) PCT - Method for treatment of the human or animal body by surgery
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

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

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

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-8, 12-22, 26-29, 35-37

Remark on Protest

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

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2020/034846

A. CLASSIFICATION OF SUBJECT MATTER

INV. A61B17/00 A61M25/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

A61B A61M

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2004/138525 A1 (SAADAT VAHID [US] ET AL) 15 July 2004 (2004-07-15)	1-5, 12-19, 26-29, 35-37
Y	paragraph [0111]; figures 27A, 27B, 28A, 28B	6-8, 20-22
Y	----- US 2018/200481 A1 (KRAFT DANIEL [US] ET AL) 19 July 2018 (2018-07-19) figure 4d	6,7,20, 21
Y	----- CA 3 067 813 A1 (WEISZ GIORA [US]; TOBIS IDAN [IL]) 3 January 2019 (2019-01-03) figure 3	8,22
A	-----	1,17



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

17 September 2020

Date of mailing of the international search report

17/11/2020

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Rapp, Alexander

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2020/034846

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			JP 2020525128 A 27-08-2020
			WO 2019005428 A1 03-01-2019

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-8, 12-22, 26-29, 35-37

Invention I relates to a catheter delivery system comprising as potential special technical features a catheter tip having a partially rounded proximal tip connected to tension lines. This feature has the technical effect of providing a compact hinge for maneuvering the tip around three axis, thereby solving the technical problem of improving the agility of the tip.

2. claims: 1, 9-11, 17, 23-25

Invention II relates to a catheter delivery system comprising as potential special technical features a catheter tip having indentations, as well as details of these indentations (forming longitudinal ribs). These features have the technical effect of reducing the friction between the catheter tip and the blood vessel, thereby solving the technical problem of reducing trauma during the intervention.
