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(54) Title: ABLATION GRASPER

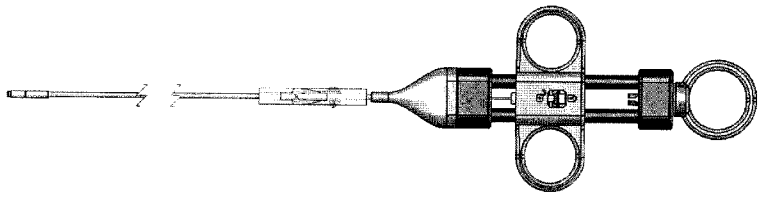

Figure 1B

(57) Abstract: The present invention provides improved catheters for ablative procedures for biological tissue, e.g., in the heart. The catheters allow active fixation to the tissue using a pair of jaws, and a sheath actuates the jaws, simplifying actuation. In particular embodiments, the pair of jaws provides additional stability in attachment to difficult ablation sites, e.g., along the ridges of cardiac structures.

ABLATION GRASPER

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims benefit of U.S. provisional application no. 61/482,408, filed May 4, 2011, which is hereby incorporated by reference.

BACKGROUND OF THE INVENTION

The invention relates to the fields of medical devices and methods of their use.

Ablation catheters generally consist of tubular structures with circumferential electrodes placed along the shaft and at the tip. These catheters also include a pull-wire or other steering mechanism that allows the physician to manipulate the angle of the tip with respect to the shaft of the catheter. Typically, the tip of the catheter is positioned under fluoroscopic or non-fluoroscopic control against the target of interest. To maintain the tip's position while the heart is beating, a steering mechanism guides the catheter and exerts torque on the tip against the myocardial tissue to optimize effective contact. In most cases, this is adequate in order to maintain proper contact during ablation. However, maintaining contact with some cardiac structures, in particular along ridges, is extremely challenging. Ablation near these structures often fails because the ablation catheter slips away from the site after the ablation has started.

Accordingly, there is a need for new catheters capable of maintaining proper contact with biological tissues during ablation.

SUMMARY OF THE INVENTION

In general, the invention provides improved catheters that are actively fixated to biological tissue and will not slip or lose contact during an ablation procedure. In particular, this catheter is simple to manufacture using currently available proven technology.

In one aspect, the invention features a device for tissue ablation including a catheter having a proximal and distal end; a pair of jaws comprising an ablation electrode disposed at the distal end of the catheter; and a sheath movable with respect to the catheter, wherein, when the sheath is disposed proximally, the pair of jaws is biased to an open position, and, when the sheath is disposed distally, the pair of jaws is biased to a closed position. The catheter or sheath can further include an irrigation lumen and a port for the release of irrigating fluid at the distal end. Such a port can be disposed, e.g., in the pair of jaws or proximal to the pair of jaws. In certain embodiments, the sheath or pair of jaws can further include mapping electrodes. In certain embodiments, the pair of jaws is the ablation electrode. The device can further include a mechanical element, e.g., a spring, to bias the pair of jaws open when the sheath is disposed proximally. In other embodiments, the pair of jaws is shaped to be biased open when the sheath is disposed proximally, e.g., where the pair of jaws is shaped from a single piece of flexible material. In other embodiments, the pair of jaws further includes a return electrode. The distal end of

said catheter and/or sheath can be deflectable. The device can further include a lock that maintains the jaws in a closed state when the sheath is disposed proximally, wherein releasing the lock when the sheath is disposed distally results in opening of the jaws.

In another aspect, the invention provides a method of ablating a tissue by inserting any device of the invention into a subject, e.g., a human patient; placing the pair of jaws adjacent to a tissue of interest; actuating the pair of jaws by moving the sheath to grasp the tissue of interest; and actuating the ablation electrode to ablate the tissue. Ablation may be unipolar or bipolar as described herein. In the methods of the invention, a device described herein may be inserted into any appropriate lumen. Exemplary lumens include intravascular spaces and spaces within organs (e.g., the heart, lungs and/or bronchi, stomach, rectum, and urinary bladder). An exemplary tissue of interest is in the heart, e.g., along a ridge of a cardiac structure. The method may further include irrigating the tissue of interest, e.g., through a port in the device or by a separate irrigation source. For devices in which the pair of jaws is locked, the methods may include the step of unlocking the jaws prior to grasping the tissue. Positioning of the device may also include actuating a deflectable catheter and/or sheath, when present in the device.

Exemplary size, lengths, and uses of devices of the invention are provided herein.

Other features and advantages will be apparent from the following description, the drawings, and the claims.

By "subject" is meant any animal, e.g., a human, other primate, other mammal, a bird, a reptile, or an amphibian.

BRIEF DESCRIPTION OF THE DRAWINGS

Figures 1A-1E are schematic depictions of an exemplary intraluminal catheter having a pair of jaws with flexible material construction. Figures 1A and 1B are top and side views of the catheter and sheath, which illustrate that the jaws remain open without the sheath. Figures 1C and 1D are side and end views of the pair of jaws, and Figure 1E is a depiction of the open, half closed, and closed positions of the pair of jaws.

Figures 2A-2D are schematic depictions of another exemplary intraluminal catheter having a pair of jaws biased by a spring. Figures 2A and 2B are top and side views of the catheter and sheath, which illustrate that the jaws remain open without the sheath. Figure 2C is a set of end views of the pair of jaws, and Figure 2D is a depiction of the open, half closed, and closed positions of the pair of jaws.

Figures 3A-3C are schematic depictions of the use of a device of the invention to map, grasp, and ablate tissue.

DETAILED DESCRIPTION OF THE INVENTION

The present invention provides improved catheters for ablative procedures for biological tissue, e.g., in the heart. The catheters allow active fixation to the tissue using a pair of jaws, and a sheath actuates the jaws, simplifying actuation. In particular embodiments, the pair of jaws provides additional stability in attachment to difficult ablation sites, e.g., along the ridges of cardiac structures.

Device

The device includes an ablation catheter with jaws at the distal end. The jaws include or act as at least one ablating electrode. The jaws are biased into an open state and actuated by a sheath that slides over the catheter and mechanically compresses the jaws. Importantly, the device does not employ a pull wire to actuate the jaws. An advantage of this method is that grip force can be applied in a graded fashion by both pushing the catheter and progressively sliding the sheath over the catheter.

As discussed above, the jaws are biased in an open state, so that in the absence of force from the sheath, the jaws do not close or grasp. The jaws may be biased open by any suitable mechanism. Exemplary mechanisms include the use of a spring-loaded hinge or fabrication of the jaws in an open state from a material having a mechanical memory, e.g., a metal such as a shape memory alloy. In one embodiment, the pair of jaws is constructed from a single piece of a flexible material, where actuation of a sheath over the single piece results in folding. The jaws may be smooth or have texture to aid in gripping a tissue. Any texture may be present on only a portion of one or both of the jaws. For example, the jaws may be serrated, grooved, or have a hook-like end or series of bumps. Typically, any texture on the jaws will not have a surface for cutting of tissue. One or both of the pair of jaws may be made of a metal or other conductive material and act as an ablation electrode. Alternatively, an electrode is integrated into one or both of the pair of jaws. Materials for electrodes are known in the art (see, e.g., U.S. Patent No. 5,916,213).

In one embodiment, the jaws stay closed in the sheath and open when the sheath is moved sufficiently proximally. In a second embodiment, the jaws are locked together even when the sheath is moved proximally. In this embodiment, the locked jaws could be used as a conventional ablation catheter until grasping is required. Various mechanisms may be used to lock and unlock the jaws, including a magnetic coupling, a mechanical lock controlled from the catheter handle, or an unlocking mechanism located at a distance proximal to the jaws that is activated by the sheath. Once the jaws are unlocked, the sheath would be used to close the jaws by sliding the sheath distally as described above. The catheter could also be used with the jaws in the open position to extend the effective electrode surface area in contact with muscle, e.g., for facilitating ablation lines.

Ablation catheters are known in the art (e.g., U.S. Patent No. 5,916,213) and can be adapted to include jaws having or being an ablation electrode. The electrical connections required to activate the ablation electrodes will typically be located within the catheter, e.g., in a lumen or on the surface. The catheter may also include additional recording electrodes mounted on its shaft. For example, one or more sensors, e.g., mapping electrodes (see, e.g., US 4,960,134) or pressure or temperature transducers (see, e.g., US 2008/0275367), may be positioned at the distal portion of the catheter. Electrodes allow the measurement of electrograms in order to confirm correct placement of the catheter.

It could also contain a lumen for the delivery of fluids to the site of ablation or to the electrodes, e.g., as a cooling mechanism for the ablation electrodes using the delivery of sterile saline. Other fluids that can be delivered include imaging agents and pharmaceutical agents. Ablation is controlled by the

user with controls attached to the proximal end of the catheter or a separate voltage source electrically coupled to the catheter. Exit ports for lumens can be at or near the distal end of the catheter and may or may not be present in the jaws themselves, as shown herein.

Sheaths for use with ablation catheters are known in the art. Such sheaths can be adapted to allow for controlled movement of the sheath relative to the jaws to control the gripping force exerted by the jaws. Preferably, the sheath allows for the removal of a particular ablation catheter and replacement with another ablation catheter. Sheaths of the invention may also include a lock to prevent axial and/or longitudinal movement of the catheter relative to the sheath. Exemplary locks include a tab or slot that mates with a corresponding tab or slot on a catheter. Another lock is a clamp capable of applying radial pressure to a catheter. Such a lock may have a high degree of static friction between the sheath and the catheter, e.g., via a detent. The sheath may also include fiducial marks that show the axial position of the sheath relative to the catheter. As with the catheter, the sheath could also include electrodes or other sensors. The sheath may also include one or more lumens for the delivery of fluids at or near the location of the jaws.

Either the ablation catheter or the sheath could be steerable. For example, the sheath may be fixed curve or variably deflectable, and the catheter may be fixed curve or variably deflectable, e.g., as described in U.S. 4,601,705, 4,960,134, 6,066,126, and 2005/0267462. If both are steerable, the combination could be used to deflect the tip of the catheter in multiple planes to enhance its versatility. The catheter or sheath will also either include any additional elements required to control the motion or use of the device or be attached to an external component for control of the device.

Methods

In use, the physician guides the distal end of the catheter within the sheath to the desired ablation site under fluoroscopic, mapping system, magnetic, or other control. The physician would then move the sheath backwards to open the jaws, which are biased open. The sheath could then be moved forward to tighten the jaws progressively to allow the desired grabbing force /contact of the jaws on the tissue to be ablated (Figure 3). The ablation tip would then move with the myocardium during the heart cycle and would not slip or dislodge during the ablation.

Ablation is performed in either a unipolar or bipolar fashion. In a unipolar fashion, the ablation energy is delivered between an electrode or group of electrodes and a return electrode positioned on the skin of the patient. In a bipolar fashion, the ablation energy is delivered between two different electrodes on the same catheter, for example using an electrode on the upper jaw portion as the ablation electrode, and an electrode on the lower jaw portion as the return electrode.

The devices described herein may be inserted into any appropriate lumen. Exemplary lumens include intravascular spaces and spaces within organs (e.g., the heart, lungs and/or bronchi, stomach, rectum, and urinary bladder). The intended use of the sheath will be used to determine the overall dimensions, the number and position of exits for catheters, and the materials employed in its manufacture, all of which are well known in the art. Typically, a sheath may accommodate catheters and other

instruments having diameters between 3 and 34 French, e.g., 4-16 French. A preferred catheter diameter is about 4 mm, with a corresponding lumen diameter of about 5-6 mm. The overall length of the sheath is typically between 10 and 100 cm. In a preferred embodiment, the sheath is sized for percutaneous access to the interior of a human heart or sized for access to the epicardium via an introducer of 10 gauge or smaller diameter.

Example 1

A specific device of the invention is shown in Figures 1A-1E. As shown in Figure 1A, the device includes a catheter disposed within a sheath. The sheath includes an entry port and a lumen to deliver irrigation fluid to the site of ablation. The handle of the catheter includes an electrical connection to control for electrical mapping and ablation. Figure 1B shows more detail of the handle for the catheter. As shown in Figure 1C, the jaws in this device are made of a single piece of flexible material that is biased in the open position. As shown in Figure 1D, the jaws may include mapping electrodes in addition to ablation electrodes. The jaws also may or may not include ports for delivery of irrigation fluids. Use of the device is shown in Figure 1E, when movement of the sheath distally results in closure of the jaws.

Example 2

Another device of the invention is shown in Figures 2A-2D. Figures 2A-2B show generally the same configuration of the catheter and sheath as in Example 1. The jaws in this device are biased open by use of a spring. As with the device of Example 1, this device may include mapping electrodes and/or irrigation delivery ports in the jaws. In Figure 2D, movement of the sheath distally results in closure of the jaws. Figure 2D also illustrates how mapping electrodes may be disposed on the sheath.

Example 3

Figures 3A-3C illustrate use of a device of the invention. In Figure 3A, the jaws in an open state are pressed against a tissue for mapping. In Figure 3B, the sheath is moved distally to close the jaws and grasp the tissue. In Figure 3C, the grasped tissue is ablated.

Other Embodiments

All publications, patents, and patent applications mentioned in the above specification are hereby incorporated by reference. Various modifications and variations of the described method and system of the invention will be apparent to those skilled in the art without departing from the scope and spirit of the invention. Although the invention has been described in connection with specific embodiments, it should be understood that the invention as claimed should not be unduly limited to such specific embodiments. Indeed, various modifications of the described modes for carrying out the invention that are obvious to those skilled in the art are intended to be within the scope of the invention.

Other embodiments are in the claims.

What is claimed is:

CLAIMS

1. A device for tissue ablation comprising:

(i) a catheter having a proximal and distal end;

(ii) a pair of jaws comprising an ablation electrode disposed at the distal end of the catheter; and

(iii) a sheath movable with respect to the catheter,

wherein, when the sheath is disposed proximally, the pair of jaws is biased to an open position, and, when the sheath is disposed distally, the pair of jaws is biased to a closed position.

2. The device of claim 1, wherein the catheter or sheath further comprises an irrigation lumen and a port for the release of irrigating fluid at the distal end.

3. The device of claim 2, wherein the port is disposed in the pair of jaws.

4. The device of claim 2, wherein the port is disposed proximal to the pair of jaws.

5. The device of claim 1, wherein the sheath further comprises mapping electrodes

6. The device of claim 1, wherein the pair of jaws further comprises mapping electrodes.

7. The device of claim 1, wherein the pair of jaws is the ablation electrode.

8. The device of claim 1, further comprising a mechanical element to bias the pair of jaws open when the sheath is disposed proximally.

9. The device of claim 8, wherein the mechanical element is a spring.

10. The device of claim 1, wherein the pair of jaws is shaped to be biased open when the sheath is disposed proximally.

11. The device of claim 10, wherein the pair of jaws is shaped from a single piece of flexible material.

12. The device of claim 1, wherein the pair of jaws further comprises a return electrode.

13. The device of claim 1, wherein the distal end of said catheter is deflectable.

14. The device of claim 1, wherein the distal end of said sheath is deflectable.

15. The device of claim 1, further comprising a lock that maintains the jaws in a closed state when the sheath is disposed proximally, wherein releasing the lock when the sheath is disposed distally results in opening of the jaws.

16. A method of ablating a tissue in a subject, said method comprising the steps of:
(i) inserting a device of any of claims 1-15 into the subject;
(ii) placing the pair of jaws adjacent to a tissue of interest in the subject;
(iii) actuating the pair of jaws by moving the sheath to grasp the tissue of interest; and (iv) actuating the ablation electrode to ablate the tissue.

17. The method of claim 16, wherein the tissue of interest is along a ridge of a cardiac structure.

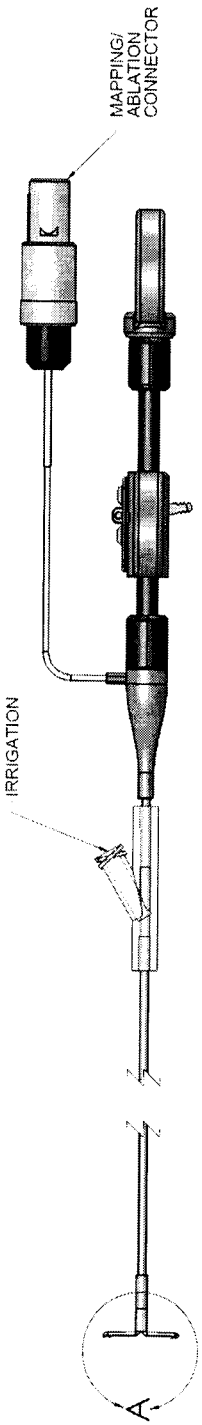

Figure 1A

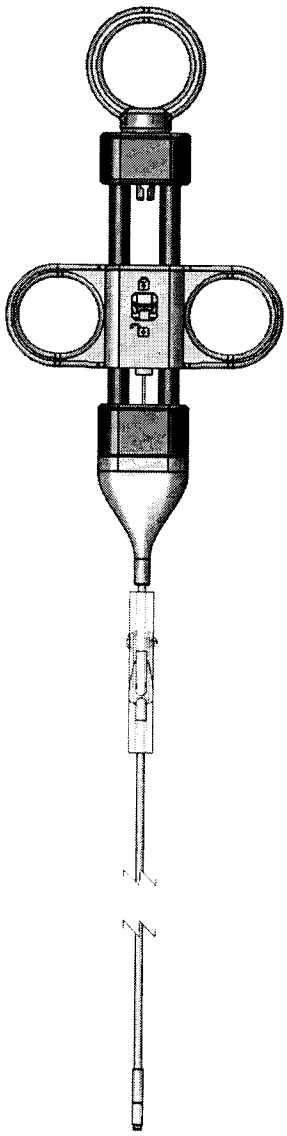

Figure 1B

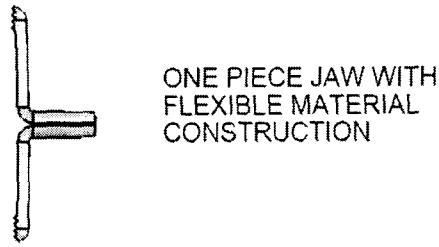

Figure 1C

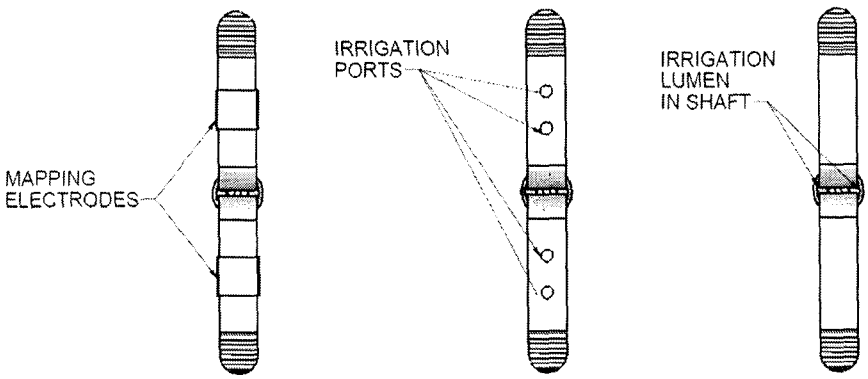

Figure 1D

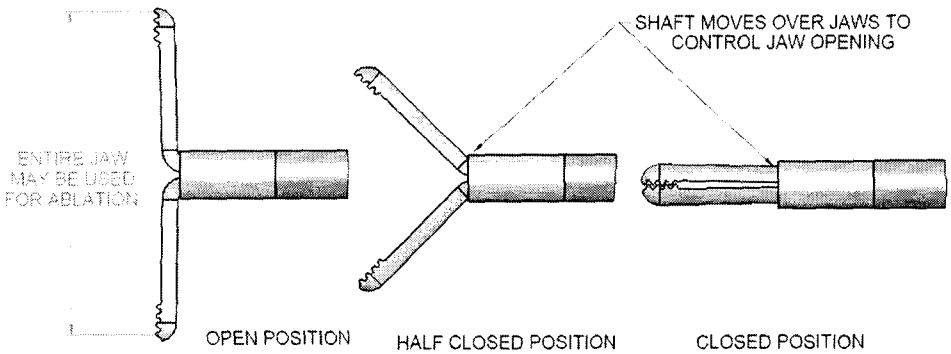

Figure 1E

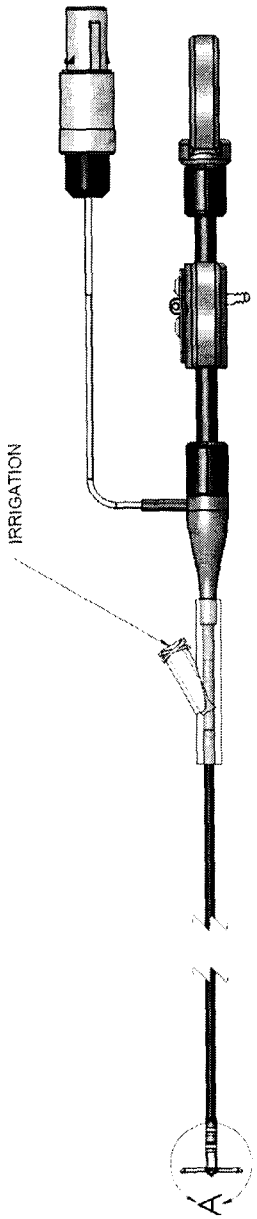

Figure 2A

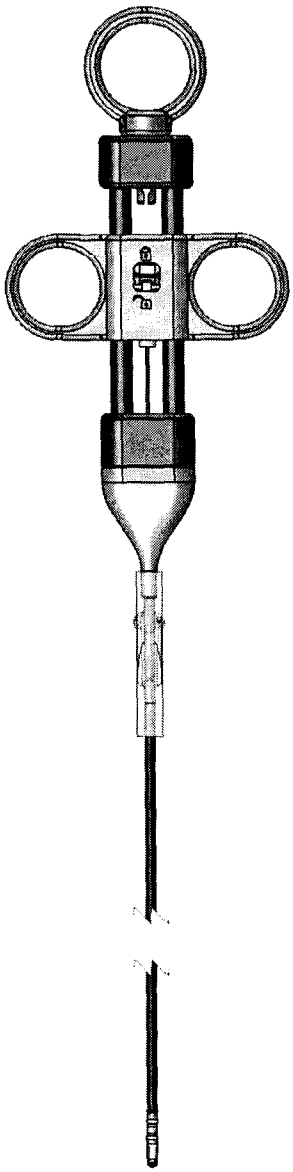

Figure 2B

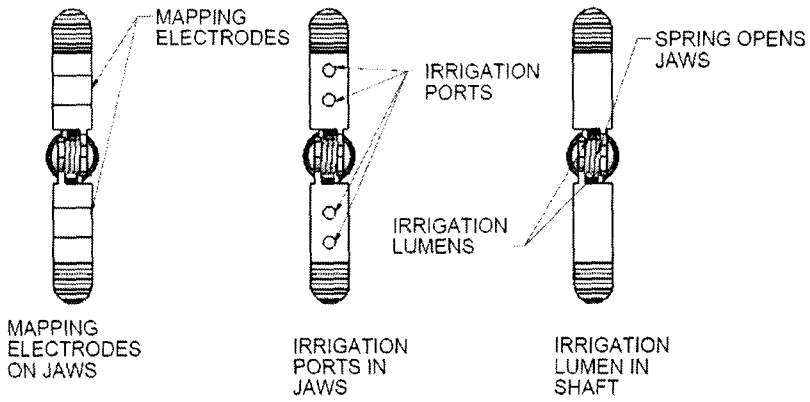

Figure 2C

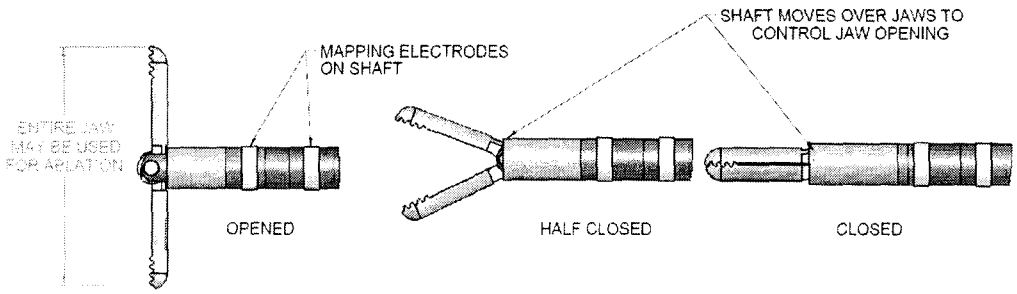

Figure 2D

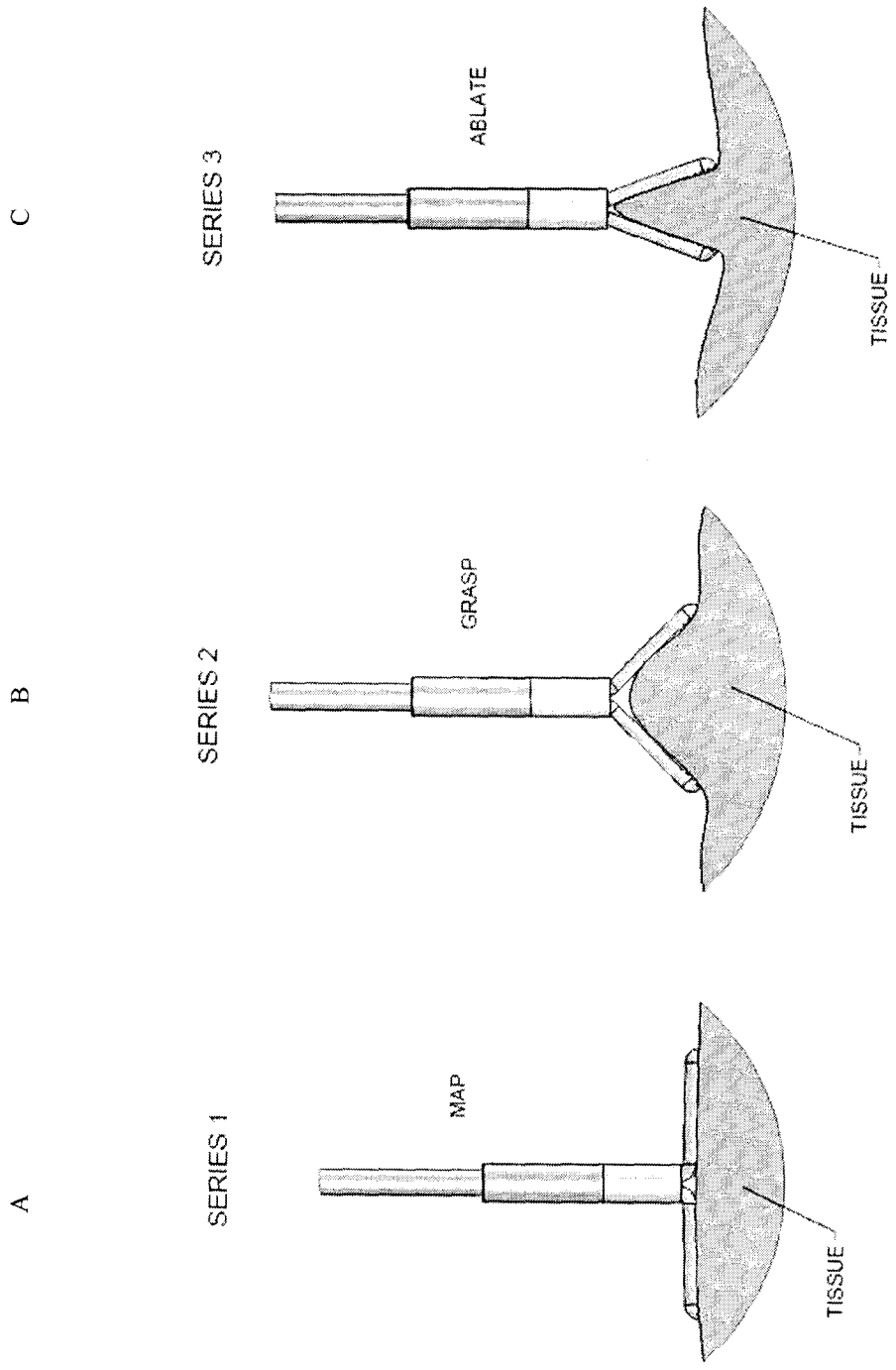
A
B
C
SERIES 1
SERIES 2
SERIES 3
MAP
GRASP
ABLATE
TISSUE
TISSUE
TISSUE

Figure 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2012/000420

A. CLASSIFICATION OF SUBJECT MATTER
IPC: ***A61B 18/14*** (2006.01) , ***A61M 25/04*** (2006.01)
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)
IPC: A61B*(2006.01)(in combination with keywords)

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

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
Canadian Patent Database, TotalPatent, Google Patent (keywords: catheter, ablation, jaws, sheath)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	EP 0 910 284 B1 (Sutton) 28 April 1999 (28-04-1999) * paragraphs 11, 35 * figure 8	1, 3-5, 7, 10-14 2, 6, 8, 9, 15
Y	US 2008/0306333 A1 (Chin) 11 December 2008 (11-12-2008) * paragraphs 167, 237 * figure 26	2, 8, 9, 15
Y	US 2008/0058836 (Moll et al.) 6 March 2008 (06-03-2008) * paragraphs 80, 162 * figure 109	2, 6, 8, 9
A	US 2010/0145331 (Christian et al.) 10 June 2010 (10-06-2010) * see entire document	1-15
A	US 6 083 222 (Klein et al.) 4 July 2000 (04-07-2000) * see entire document	1-15

[ ] Further documents are listed in the continuation of Box C.

[X] 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	Date of mailing of the international search report
03 August 2012 (03-08-2012)	06 August 2012 (06-08-2012)

Name and mailing address of the ISA/CA	Authorized officer
Canadian Intellectual Property Office Place du Portage I, C114 - 1st Floor, Box PCT 50 Victoria Street Gatineau, Quebec K1A 0C9 Facsimile No.: 001-819-953-2476	Saadia Khan (819) 934-6752

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2012/000420

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of the 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. [X] Claim Nos. : 16, 17

because they relate to subject matter not required to be searched by this Authority, namely :

Claims 16, 17 are considered to be directed to a method of medical treatment which the International Search Authority is not required to search under PCT Article 17(2)(a)(i) and PCT Rule 39.1 (iv).

2. [ ] Claim 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. [ ] Claim 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 :

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 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 claim 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 claim Nos. :

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.

Patent Document Cited in Search Report	Publication Date	Patent Family Member(s)	Publication Date
EP0910284A1	28 April 1999 (28-04-1999)	AT352256T	15 February 2007 (15-02-2007)
		CA2253643A1	13 November 1997 (13-11-1997)
		CA2253643C	21 October 2003 (21-10-2003)
		DE69737289D1	15 March 2007 (15-03-2007)
		DE69737289T2	06 September 2007 (06-09-2007)
		EP0910284B1	24 January 2007 (24-01-2007)
		JPH11509132A	17 August 1999 (17-08-1999)
		JP3220164B2	22 October 2001 (22-10-2001)
		US5762613A	09 June 1998 (09-06-1998)
		US6129683A	10 October 2000 (10-10-2000)
		WO9741776A1	13 November 1997 (13-11-1997)
US2008306333A1	11 December 2008 (11-12-2008)	EP1501430A1	02 February 2005 (02-02-2005)
		EP1501430A4	25 February 2009 (25-02-2009)
		EP1549233A1	06 July 2005 (06-07-2005)
		EP1583459A2	12 October 2005 (12-10-2005)
		EP1583459A4	07 April 2010 (07-04-2010)
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