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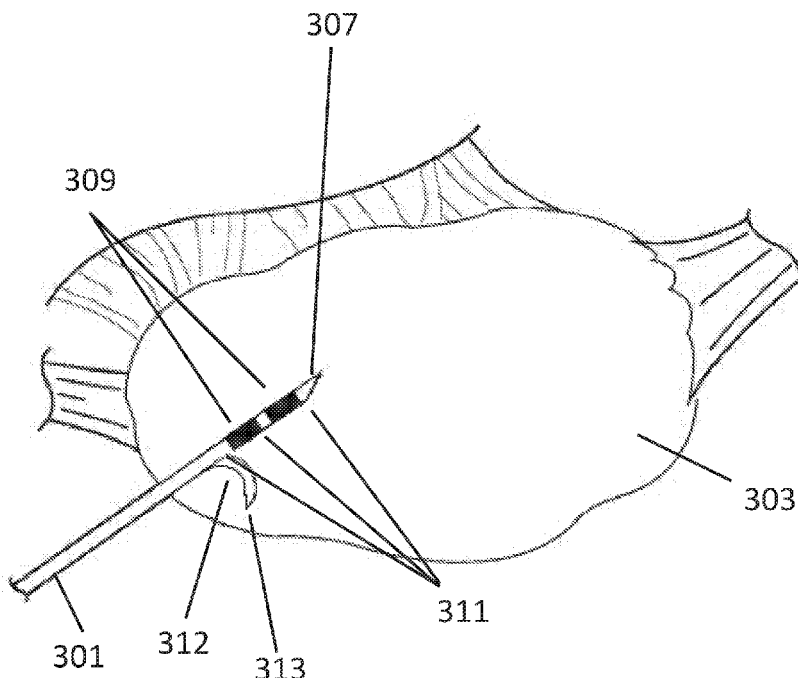


FIG. 31C

(57) Abstract: Described here are methods and systems for the manipulation of ovarian tissues. The methods and systems may be used in the treatment of polycystic ovary syndrome (PCOS). The systems and methods may also be useful in the treatment of infertility associated with PCOS.



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METHODS AND SYSTEMS FOR THE MANIPULATION OF OVARIAN TISSUES

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Application Serial No. 62/141,134 filed on March 31, 2015 and U.S. Provisional Application Serial No. 62/141,138 filed on March 31, 2015, each of which is incorporated by reference herein in its entirety.

FIELD

[0002] Described here are methods and systems for the manipulation of ovarian tissues. The methods and systems may be used in the treatment of polycystic ovary syndrome (PCOS), infertility, and other diseases/disorders involving the ovaries, or for modulating ovulation.

BACKGROUND

[0003] In instances of disease in the ovaries and/or in the case of certain types of infertility, there may be a need to manipulate ovarian tissues, retrieve tissues, or deliver agents within a patient's ovaries. For some time, physicians have used direct surgical access, laparoscopic access, or transvaginal ultrasound-directed needle-based methods for accessing ovaries. Direct surgical access is typically obtained under anesthesia and involves a skin incision to directly expose and operate on the tissue. Laparoscopic access is typically obtained under anesthesia, involves two or more skin incisions, and further entails inflating the space surrounding the ovaries with either gas or fluid and using a camera and laparoscopic tools to visualize and operate on the tissue. Transvaginal ultrasound-directed needle-based access is often employed for oocyte retrieval as a part of *in vitro* fertilization (IVF). These current approaches have some limitations: the surgical and laparoscopic access methods are generally more invasive and thus require more anesthesia and a higher acuity of care. Moreover, the surgical and laparoscopic access methods allow for direct visualization of the surface of the ovaries, but they provide less ability to visualize where a specific device is deployed within the tissue of the ovary. Because transvaginal needle access is typically performed under ultrasound, it allows for delivery of the tip of the needle into specific locations within the ovary, and these can be visualized in real-time; current systems however are limited because the needles used to access the tissue are only single

or dual lumen needles and are not able to do more than simply aspirate. Moreover, while needles are suitable for navigating in ovaries that are enlarged from stimulation by gonadotropins or other drugs, navigating needles through unstimulated ovaries is more difficult. Current systems are not ideally suited for the instance where it would be desirable to either deliver or remove specific tissue or other factors from the ovaries via the transvaginal ultrasound guided needle route. Current systems are also not ideally suited for delivery of specific agents to unstimulated ovaries.

[0004] Manipulation of ovarian tissues may be to treat Polycystic Ovary Syndrome (PCOS). PCOS is an endocrine disorder that was initially characterized in the 1930s by Stein & Leventhal. Features of the syndrome may include: oligo/amenorrhea, oligo/anovulation, hirsutism, acne, obesity, and characteristic polycystic appearance of the ovaries. PCOS generally has significant effects on reproductive health (e.g., oligo/amenorrhea and oligo/anovulation, bleeding, endometrial hyperplasia, infertility, and increased risk of endometrial cancers) as well as non-reproductive health (e.g., hyperandrogenism, carcinoma, insulin resistance, hypercholesterolemia, hypertension, obesity, sleep apnea, and cardiovascular disease). PCOS has historically been considered in the context of hormonal dysregulation characterized by alterations in gonadotropin secretion, increased androgen production, increased insulin resistance, increased cortisol production, and obesity. It has also been shown that PCOS is often accompanied by increased activity of the sympathetic nervous system.

[0005] Treatment of PCOS can be costly to the health care system. Key non-infertility treatments include: oral contraceptives (for hormonal normalization), endometrial ablation (for anovulatory bleeding), insulin sensitizing agents, anti-hypertensive agents, statins, and treatments for severe acne and hirsutism.

[0006] Many women with PCOS may also require infertility treatment during their lifetime. Treatment for PCOS infertility typically follows a step-wise approach. For example, clomiphene citrate is generally the first-line treatment with second-line treatment being either gonadotropin administration or ovarian drilling (also sometimes referred to as ovarian diathermy). If these treatments are unsuccessful, *in vitro* fertilization (IVF) is attempted. However, multiple pregnancies and live births (e.g., twins) are common with clomiphene citrate, gonadotropin, and IVF treatments. In infertility treatment, multiple pregnancies and live births

is often considered an undesirable result due to the associated perinatal and neonatal morbidity and the associated elevated costs. Furthermore, ovarian hyperstimulation syndrome (OHSS) may be more common in women with PCOS undergoing gonadotropin or IVF treatment. While OHSS is often mild and easily treated, more severe cases may require aggressive treatment.

[0007] Alternatively, ovarian drilling may be an option in treating PCOS, PCOS-associated symptoms/disorders, and PCOS related infertility. Prior to the development of ovarian drilling, other types of surgery were performed on the ovaries for the treatment of infertility. Ovarian wedge resection, a well-established procedure first described in the late 1940s, involves surgically removing wedge-shaped pieces of ovarian tissue from polycystic ovaries. Despite the effectiveness of the procedure, ovarian wedge resection has generally been abandoned in favor of new techniques because of the frequent occurrence of adhesions with the technique. Other ovarian surgeries for infertility in PCOS that have been performed are ovarian electrocautery, ovarian laser vaporization, multiple ovarian biopsies, and others.

[0008] Ovarian drilling / diathermy (OD) was developed in the 1970s and 1980s by Gjønnaess. Recently, OD has been the most frequently described ovarian surgery for infertility in women with PCOS. In this laparoscopic procedure, radiofrequency energy, or other techniques, is used to bore multiple holes in the ovary. The physiologic mechanism is not well documented, but there are common findings following the surgery including acute changes in ovarian and pituitary hormones followed by a prolonged reduction of circulating androgens. In randomized trials, rates of pregnancy and live birth have been shown to be similar to those associated with gonadotropin treatment, but with significantly reduced rates of multiple pregnancies.

[0009] Despite this evidence, ovarian drilling is not used as frequently in clinical practice as other treatments for PCOS infertility. This may be due to: (1) the lack of standardized, consistent methods of targeting and performing surgeries on the ovary; (2) the invasive nature of current OD technologies; (3) the theoretical risk of adhesions from intervention on the ovaries; (4) the surgical route of access is not a good fit for the clinical practice patterns of fertility physicians; and (5) the uncertainty of the mechanism of action. Accordingly, it would be useful to have systems and methods that overcome the limitations of current surgical procedures. Such systems may be designed to consistently target ovarian tissues, reduce the level of invasiveness

of the procedure, reduce the risk of adhesions, and potentially target specific tissue types to act more specifically on tissues responsible for the disease. Moreover, given that the ovaries or elements therein may play an important role in governing other female health issues such as timing of menopause, hot-flashes, fibroids, hormonal dysregulation, endometriosis, adnexal pain, risk of endometrial cancer, disturbances in glucose metabolism, or cardiovascular health, it would be beneficial to have improved methods and systems for treating these conditions as well as targeting of structures within or nearby the ovaries that may enable treatment of these conditions.

SUMMARY

[0010] The present invention provides a system for performing an ovarian procedure in combination with a transvaginal probe comprising a handle, the system comprising: an ovarian tissue apparatus, the ovarian tissue apparatus comprising a docking device having an elongate body, a proximal end, a distal portion having an opening and a distal end comprising one or more attachment elements for releasably securing an ovary, and defining a lumen therethrough, an anchoring member disposed for reciprocation within the lumen and having a distal region, the distal region transitioning to a curved shape when extended through the opening, and a therapeutic element disposed on the distal region of the anchoring member; an alignment adapter configured to be removeably affixed to the handle of the transvaginal probe, the alignment adapter further configured to couple the docking device to the transvaginal probe; and a generator configured to supply energy to the therapeutic element.

[0010A] Described here are methods and systems for manipulating ovarian tissues. The manipulation of ovarian tissues may include mechanical manipulation and/or removal, by delivery of chemical, biologic, or pharmaceutical agents, by delivery of energy, or by applying cooling/cold to the tissues. Exemplary treatment modalities may include without limitation, delivery of one or more of the following: a radiofrequency energy element; a direct heating element; a cryoablation element; a cooling element; a mechanical disruption and/or removal element; laser; a microwave antenna; an unfocused ultrasound element; a partially-focused ultrasound element; a focused (HIFU) ultrasound element; and/or an element for delivering heated water/saline, steam, a chemical ablation agent, a biologic or pharmaceutical agent, implantable pulse generator, a passive or active (e.g., electronic drug delivery unit) drug-eluting implant, a radioisotope seed, or a mechanical implant, which may be either passive or active via application of remote energy (e.g., ultrasound to induce vibration). In some variations, the manipulation of ovarian tissues may include delivering or applying energy, e.g., radiofrequency energy, to tissues to ablate the tissues. In other variations, the manipulation of ovarian tissues may include retrieving tissues, e.g., via aspiration. In yet further variations, manipulation of ovarian tissues may include delivering agents within a patient's ovaries. Exemplary ovarian tissues include without limitation, the ovaries (e.g., medulla/stroma and/or cortex), ovarian follicles/cysts, nerves associated with the ovaries, suspensory ligaments, ovarian ligaments, broad ligaments, the mesovarium, endometrial tissue within the ovary, tumor or neoplastic cells, or a combination thereof. In this application, the terms "medulla" and "stroma" are used interchangeably. Stromal tissue generally comprises the middle or medullary region of the

ovary. The cortex (or outer region) of the ovary is generally where follicles of different degrees of maturity tend to reside. In this application, the term “follicle” includes the oocyte that is contained within the follicle, and use of the term follicle may refer to the entire follicular structure or the oocyte specifically. These follicles are sometimes called “cysts” in the setting of PCOS. In other settings, cysts may refer to a collection of fluid that may or may not be a follicle. The methods and systems may be used to modulate ovulation, treat one or more symptoms of, or disorders associated with, polycystic ovary syndrome, including infertility, or treat other diseases/disorders involving the ovaries.

[0011] In general, the methods and systems are configured to access ovarian tissue or a target region proximate the ovarian tissue transvaginally, laparoscopically, percutaneously, via a natural orifice route through the vagina-uterus-fallopian tubes, through an open surgical approach or via an entirely non-invasive approach. The methods and systems may treat ovarian tissues by mechanical manipulation and/or removal, by delivery of chemical, biologic, or pharmaceutical agents, by delivery of energy, or by applying cooling/cold to the tissues. Exemplary treatment modalities may include without limitation, delivery of one or more of the following: a radiofrequency energy element; a direct heating element; a cryoablation element; a cooling element; a mechanical disruption and/or removal element; laser; a microwave antenna; an unfocused ultrasound element; a partially-focused ultrasound element; a focused (HIFU) ultrasound element; and/or an element for delivering heated water/saline, steam, a chemical ablation agent, a biologic or pharmaceutical agent, implantable pulse generator, a passive or active (e.g., electronic drug delivery unit) drug-eluting implant, a radioisotope seed, or a mechanical implant, which may be either passive or active via application of remote energy (e.g., ultrasound to induce vibration).

[0012] The systems described here generally comprise an ovarian tissue apparatus, where the ovarian tissue apparatus comprises an engagement device, e.g., a docking device, and an anchoring member, the docking device comprising an elongate body having a proximal end, a distal end, and defining a lumen therethrough, and a therapeutic element disposed on the distal end of the docking device; a transvaginal probe comprising a handle and an ultrasound transducer; and a generator configured to supply energy to the therapeutic element. The ovarian tissue apparatus may be capable of being advanced proximate to or within an ovary, and in the

case of PCOS, an ovarian follicle/cyst or other target tissue (e.g., stroma). The ovarian tissue apparatus may also include an engagement device, e.g., a docking device, as previously stated, which is configured to engage ovarian tissue. The engagement device may be configured to engage the outside surface of the ovary (e.g., the capsule), the outer regions of tissue within the ovary (e.g., the cortex), or the tissue inside the ovary (e.g., medulla, one or more follicles or cysts). One or more therapeutic elements can be advanced and/or deployed via the devices to apply one treatment or multiple treatments to the ovarian follicle or cyst and/or ovarian tissue. Alternatively, the one or more therapeutic elements can be mounted on the docking device. The therapeutic elements may deliver energy, e.g., radiofrequency energy, to effect treatment. The devices and therapeutic elements may be advanced, deployed, or otherwise positioned under image guidance, (e.g., transvaginal ultrasound, transabdominal ultrasound, endoscopic visualization, direct visualization, computed tomography (CT), or magnetic resonance imaging (MRI), optical coherence tomography (OCT), an ultrasound element on the device, or virtual histology). Pre-treatment planning may also be completed prior to performance of the procedure on the target tissue. For example, one or more of the following may be obtained: the size, volume, and/or location of the ovary; the size, volume and/or location of one or more ovarian follicles or cysts; and the size, volume, and/or location of the medulla, hormone levels, etc.

[0013] According to some embodiments described herein, which may partially or as a whole combine with other embodiments, systems for performing an ovarian procedure may include an ovarian tissue apparatus, the ovarian tissue apparatus comprising a docking device and a therapeutic element, the docking device comprising an elongate body and having a proximal end, a distal end, and defining a lumen therethrough, and the therapeutic element being slidable within and deployable from the lumen of the docking device; a transvaginal probe comprising a handle and an ultrasound transducer; a mechanical guide, lock or a visual identifier on a part of the system; and a generator configured to supply energy to the therapeutic element, where the mechanical guide, lock or visual identifier is configured to maintain planar orientation of the therapeutic element relative to the ultrasound transducer and during a procedure on an ovary. In some instances a non-linear (e.g., curved) therapeutic element may be employed, which allows the therapeutic element to be fully visualized under 2-dimensional ultrasound during therapy delivery, thereby ensuring that non-target tissues are not treated. The curved structure may further aid in anchoring the device in the target tissue, limiting the risk of the device moving

during treatment due to patient movement or user error. The curved structure may also be configured to match the contour of the ovary, allowing for improved positioning within a variety of sized or shaped ovaries. Additionally or alternatively, the curved structure may allow for longer or additional electrodes to be delivered and used simultaneously, allowing for larger ablation volumes per energy application. This feature may limit pain experienced by the patient and reduce procedure time. Anchoring either the docking device and/or the therapeutic element in the target tissue may help the user to move the ovary relative to surrounding non-ovary tissues to improve and/or confirm visualization. Moving the ovary may also allow the user to more easily reposition the device for subsequent treatments. Additionally or alternatively, the docking device may be configured to aid in anchoring the device in the target tissue.

[0014] According to some embodiments described herein, which may partially or as a whole combine with other embodiments, systems for performing an ovarian procedure may include an ovarian tissue apparatus, the ovarian tissue apparatus comprising a docking device and a therapeutic element, the docking device comprising an elongate body and having a proximal end, a distal end, and defining a lumen therethrough; the docking device further comprising a therapeutic element on or near the distal end; an anchoring member being slidable within and deployable from the lumen of the docking device; a transvaginal probe comprising a handle and an ultrasound transducer; a mechanical guide, lock or a visual identifier on a part of the system; and a generator configured to supply energy to the therapeutic element, where the mechanical guide, lock or visual identifier is configured to aid in deployment of the anchoring member and/or maintain planar orientation of the anchoring member relative to the ultrasound transducer and during a procedure on an ovary. In some instances a non-linear (e.g., curved) anchoring member may be employed, which allows the anchoring member to be fully visualized under 2-dimensional ultrasound during therapy delivery, thereby ensuring that non-target tissues are not injured. In other instances, it may not be necessary to maintain planar orientation of the anchoring member (e.g. a relatively short anchor). In this case, the mechanical guide, lock or visual identifier is configured to aid in deployment of the anchoring member but may not maintain planar orientation of the anchoring member relative to the ultrasound transducer. The curved structure may further aid in anchoring the device in the target tissue, limiting the risk of the device moving during treatment due to patient movement or user error. Anchoring either via the docking device, the therapeutic element, and/or the anchoring member in the target tissue

may help the user to move the ovary relative to surrounding non-ovary tissues to improve and/or confirm visualization. Moving the ovary may also allow the user to more easily reposition the device for subsequent treatments. Additionally or alternatively, the docking device may be configured to aid in anchoring the device in the target tissue.

[0015] According to embodiments described herein, which may partially or as a whole combine with other embodiments, systems for performing an ovarian procedure may include a docking device, the docking device comprising an elongate body and having a proximal end, a distal end, and defining a lumen therethrough; a radiofrequency energy element slidable within and deployable from the lumen of the docking device; a transvaginal probe comprising a handle and an ultrasound transducer; a mechanical guide or lock for releasably coupling the docking device to the probe handle to maintain planar orientation of the radiofrequency energy element relative to the ultrasound transducer during the ovarian procedure; and a generator configured to supply radiofrequency energy to the radiofrequency energy element. In some instances a non-linear (e.g., curved) therapeutic element may be employed, which allows the therapeutic element to be fully visualized under 2-dimensional ultrasound during therapy delivery, thereby ensuring that non-target tissues are not treated. As previously stated, the curved structure may further aid in anchoring the device in the target tissue, limiting the risk of the device moving during treatment due to patient movement or user error. The curved structure may also be configured to match the contour of the ovary, allowing for improved positioning within a variety of sized or shaped ovaries. Additionally or alternatively, the curved structure may allow for longer or additional electrodes to be delivered and used simultaneously, allowing for larger ablation volumes per energy application. This feature may limit pain experienced by the patient and reduce procedure time.

[0016] According to embodiments described herein, which may partially or as a whole combine with other embodiments, systems for performing an ovarian procedure may include a docking device, the docking device comprising an elongate body and having a proximal end, a distal end, and defining a lumen therethrough; the docking device further comprising a radiofrequency energy element on or near the distal end; an anchoring member slidable within and deployable from the lumen of the docking device; a transvaginal probe comprising a handle and an ultrasound transducer; a mechanical guide, lock or a visual identifier on a part of the

system; and a generator configured to supply radiofrequency energy to the radiofrequency energy element, wherein the mechanical guide or lock for releasably coupling the docking device to the probe handle to aid in deployment of the anchoring member and/or maintain planar orientation of the anchoring member relative to the ultrasound transducer during the ovarian procedure. In some instances a non-linear (e.g., curved) anchoring member may be employed, which allows the anchoring member to be fully visualized under 2-dimensional ultrasound during therapy delivery, thereby ensuring that non-target tissues are not injured. In other instances, it may not be necessary to maintain planar orientation of the anchoring member (e.g. a relatively short anchor). In this case, the mechanical guide, lock or visual identifier is configured to aid in deployment of the anchoring member but may not maintain planar orientation of the anchoring member relative to the ultrasound transducer. As previously stated, the curved structure may further aid in anchoring the device in the target tissue, limiting the risk of the device moving during treatment due to patient movement or user error. Instead of being releasably coupled to the docking device, in some embodiments the mechanical guide or lock is fixedly attached to the docking device.

[0017] These system embodiments may have a variety of effects on therapy. These system embodiments, for example, may allow for a minimally-invasive, transvaginal approach, wherein the ovary would be accessed using the docking device. By having the docking device resemble a sharp needle, the docking device may be used to puncture through the vaginal wall and into the ovary under transvaginal image guidance. In some cases, this may allow for a single entry point or fewer entry points into the ovary, reducing the risk of adhesions as compared to surgical and laparoscopic approaches with tissue dissection and entry points for each ablation in the ovary. Once in position, the radiofrequency energy element may be advanced or deployed into the tissue. In the case where a mechanical guide or lock is used to maintain planar orientation of the radiofrequency element, the radiofrequency element may be non-linear (e.g., curved in a single plane). Here the releasably securable mechanical guide or lock allows the therapeutic element to be flipped 180 degrees so in the case of an asymmetrically shaped therapeutic element, additional regions of the ovary could be accessed and treated without moving the docking device. The non-releasable version of the guide or lock simplifies the user experience when a therapeutic element does not need to be flipped 180 degrees. Since transvaginal ultrasound imaging provides a 2-dimensional image, it is important to maintain the orientation of the

radiofrequency element to ensure that the user can see the entire structure. This allows the user to visually observe advancement and/or deployment and confirm position within the ovary or target tissue, adding to the safety and/or effectiveness of the procedure. The advantages of a transvaginal approach over surgical or laparoscopic approaches generally include one or more of the following: (a) conscious sedation vs. general anesthesia which reduces cost and patient risk, (b) no external scars, (c) less tissue manipulation resulting in lower risk of adhesions, (d) fewer access points into the ovary resulting in lower risk of adhesions, (e) faster recovery time, and (f) it is a familiar access route for OB/GYN and fertility physicians, and fits within existing care pathways.

[0018] According to some embodiments described herein, which may partially or as a whole combine with other embodiments, systems described herein may comprise additionally or alternatively an ultrasound imaging and/or therapeutic element configured to be placed in contact with the abdomen of a patient; an element(s) for operatively connecting the ultrasound imaging and/or therapeutic element to a console, comprised of a user interface, an element(s) for delivering ultrasound for imaging, an element(s) for targeting desired tissue, an element(s) for delivering energy (e.g., partially-focused ultrasound, HIFU), and an element(s) for a feedback control system.

[0019] Methods for manipulating ovarian tissue of a patient may include delivering pain management medications systemically and/or locally (e.g., the vaginal wall, the ovary, the mesovarium), accessing a target region proximate an ovarian tissue within the patient; advancing an ovarian tissue apparatus to the target region, the ovarian tissue apparatus comprising a docking device and one or more therapeutic elements, the docking device comprising a proximal end, a distal end, and a distal tip; moving the docking device proximate to or within the ovarian tissue; deploying the one or more therapeutic elements on or within the ovarian tissue; assessing intra-procedural success; and minimizing the occurrence of adhesions as seen with surgical approaches used in the past. The docking device may or may not require physical contact with ovarian tissues.

[0020] Methods for manipulating ovarian tissue of a patient may include delivering pain management medications systemically and/or locally (e.g., the vaginal wall, the ovary, the mesovarium), accessing a target region proximate an ovarian tissue within the patient; advancing

an ovarian tissue apparatus to the target region, the ovarian tissue apparatus comprising a docking device and one or more therapeutic elements, the docking device comprising a proximal end, a distal end, and a distal tip, the docking device further comprising a therapeutic element at or near the distal end; moving the docking device proximate to or within the ovarian tissue; deploying the one or more anchoring members on or within the ovarian tissue; assessing intra-procedural success; and minimizing the occurrence of adhesions as seen with surgical approaches used in the past. The docking device may or may not require physical contact with ovarian tissues.

[0021] In some instances, it may be useful to employ methods that minimize the occurrence of adhesion such as performing the procedure via a single entry point or fewer entry points in the ovary (the severity of adhesions may correlate with the number and size of damage to the ovary surface); avoiding injury to the cortex or regions of the cortex closest to the surface (e.g., several millimeters) of the ovary; and leaving behind material anti-adhesive barriers to improve healing at the ovary surface and further reduce adhesion formation. It may also be beneficial to include features for visualizing various portions of the system using imaging as a guide. Depending upon the approach taken (e.g., transvaginal, percutaneous, laparoscopic), the apparatus may include various mechanisms for improving visualization of the portions of the system, e.g., the therapeutic elements.

[0022] Methods described herein for delivering energy for the treatment of infertility, modulating ovulation, or for treating other diseases/disorders of an ovary, e.g., polycystic ovary syndrome, may include advancing a probe comprising a handle, an ultrasound transducer, and a needle guide into the vaginal canal; advancing an ovarian tissue apparatus into the needle guide, the ovarian tissue apparatus comprising a docking device and a therapeutic element; advancing the docking device through a vaginal wall; penetrating an ovary at a single entry point with the docking device or the therapeutic element; advancing the therapeutic element from the docking device into the ovary; and delivering energy to affect a volume of tissue within the ovary using the therapeutic element to treat a symptom of infertility, to modulate ovulation, or treat other diseases/disorders of the ovary such as polycystic ovary syndrome; retracting the therapeutic element into the docking device; and removing the ovarian tissue apparatus. For example, the energy that is delivered may be radiofrequency energy useful in ablating a volume of tissue.

[0023] Other methods described herein for delivering energy for the treatment of infertility, modulating ovulation, or treating diseases/disorders involving the ovary, e.g., polycystic ovary syndrome, may include advancing a probe comprising a handle, an ultrasound transducer, and a needle guide into the vaginal canal; advancing an ovarian tissue apparatus into the needle guide, the ovarian tissue apparatus comprising a docking device, a therapeutic element, and an anchoring member; advancing the docking device through a vaginal wall; penetrating an ovary at a single entry point with the docking device or the therapeutic element; advancing the anchoring member from the docking device into the ovary; and delivering energy to affect a volume of tissue within the ovary using the therapeutic element to treat a symptom of infertility, to modulate ovulation, or treat other diseases/disorders of the ovary such as polycystic ovary syndrome; retracting the anchoring member into the docking device; and removing the ovarian tissue apparatus. For example, the energy that is delivered may be radiofrequency energy useful in ablating a volume of tissue.

[0024] Alternative methods for the treatment of infertility, modulating ovulation, or for treating other diseases/disorders of an ovary, e.g., polycystic ovary syndrome, as described herein may include advancing an ovarian ablation system into the vaginal canal, the ovarian ablation system comprising a docking device, a radiofrequency energy element, and a transvaginal probe comprising a handle and an ultrasound transducer; advancing the docking device through a vaginal wall under image guidance using the ultrasound transducer; entering an ovary through a single entry point using the docking device or the radiofrequency energy element; advancing the radiofrequency energy element within the ovary; and delivering radiofrequency energy to ablate a volume of tissue within the ovary using the radiofrequency energy element to treat a symptom of infertility, to modulate ovulation, or treat other diseases/disorders of the ovary such as polycystic ovary syndrome.

[0025] Yet further methods that may be useful for the treatment of infertility, modulating ovulation, or for treating other diseases/disorders of an ovary, e.g., polycystic ovary syndrome, may generally include advancing an ovarian tissue apparatus proximate an ovary or a polycystic ovary within a patient, the ovarian tissue apparatus comprising a docking device and one or more therapeutic elements, the docking device comprising a proximal end, a distal end, and a distal tip; deploying the one or more therapeutic elements from the docking device proximate to

or within a target tissue, e.g., an ovarian follicle or cyst; and manipulating the ovary or the polycystic ovary to effect a change in the target tissue, treat a symptom on infertility, modulate ovulation, treat other diseases/disorders of the ovary, or treat one or more symptoms or physiological parameters indicative of polycystic ovary syndrome or its related symptoms, diseases, disorders, or a combination thereof.

[0026] Methods useful in treating infertility, modulating ovulation, or treating diseases/disorders involving the ovary, e.g., polycystic ovary syndrome, may also generally include advancing an ovarian tissue apparatus proximate an ovary or a polycystic ovary within a patient, the ovarian tissue apparatus comprising a docking device, one or more therapeutic elements, and/or an anchoring member, the docking device comprising a proximal end, a distal end, and a distal tip; deploying the anchoring member from the docking device proximate to or within a target tissue, e.g., an ovarian tissue; and manipulating the ovary or the polycystic ovary to effect a change in the target tissue, treat a symptom on infertility, modulate ovulation, treat other diseases/disorders of the ovary, or treat one or more symptoms or physiological parameters indicative of polycystic ovary syndrome or its related symptoms, diseases, disorders, or a combination thereof.

[0027] Alternatively, methods useful in treating infertility, modulating ovulation, or treating diseases/disorders involving the ovary, e.g., polycystic ovary syndrome, may also generally include advancing a probe comprising a handle, an ultrasound transducer, and a needle guide into the vaginal canal; advancing an ovarian tissue apparatus into the needle guide, the ovarian tissue apparatus comprising a docking device, a therapeutic element on a portion of the docking device, e.g., the on the distal end of the docking device, and an anchoring member; advancing the docking device through a vaginal wall; penetrating an ovary at a single entry point with the docking device; advancing the therapeutic element into the ovary; advancing the anchoring member from the docking device, e.g., through a distal tip or a side opening of the docking device; and delivering energy to affect a volume of tissue within the ovary using the therapeutic element to treat a symptom of polycystic ovary syndrome. In some instances, the delivered energy is radiofrequency energy. The radiofrequency energy may be pulsed or continuous. The method may further include the step of repositioning the therapeutic element and repeating energy delivery through the single entry point.

[0028] Methods that may be useful in controlling pain associated with non-surgical procedures are also described herein. Such methods generally include delivering systemic pharmacologic sedation (e.g., monitored anesthesia care (MAC) or conscious sedation); delivering local anesthesia to the vaginal wall to reduce discomfort in a transvaginal procedure; delivering local anesthesia to the ovary, target tissue, mesovarium, or nerve tissue proximate to the ovary to minimize discomfort associated with application of the therapy; and delivering an epidural to minimize discomfort and patient movement during the procedure.

[0029] Methods that may be useful in determining the intra-procedural or post-procedural effect of the procedure are also described herein. Such methods generally include comparing pre-treatment planning parameters (e.g., the size, volume, and/or location of the ovary; the size, volume and/or location of one or more ovarian follicles or cysts; the size, volume, and/or location of the medulla; hormone levels) with intra-procedurally-measured parameters or post-procedurally-measured parameters. Examples include: a visible reduction in ovary size or volume, a reduction in the number of follicles or cysts, or a reduction in hormone levels, such as anti-müllerian hormone.

[0030] According to some embodiments described herein, and which may partially or as a whole combine with other embodiments, systems for manipulating ovarian tissues, retrieving tissues, and/or delivering agents within a patient's ovaries generally include an ovarian tissue apparatus configured for advancement through the vaginal wall and proximate an ovarian tissue; and an energy generator electrically coupled to the ovarian tissue apparatus, where the ovarian tissue apparatus comprises a docking device and one or more therapeutic elements, the docking device comprising an elongate body having a proximal end, a distal end, a lumen extending from the proximal end through or until the distal end, and a distal tip. In some instances a non-linear (e.g., curved) therapeutic element may be employed, which allows the therapeutic element to be fully visualized under 2-dimensional ultrasound during therapy delivery, thereby ensuring that non-target tissues are not treated. As previously stated, the curved structure may further aid in anchoring the device in the target tissue, limiting the risk of the device moving during treatment due to patient movement or user error. The curved structure may also be configured to match the contour of the ovary, allowing for improved positioning within a variety of sized or shaped ovaries. Additionally or alternatively, the curved structure may allow for longer or additional

electrodes to be delivered and used simultaneously, allowing for larger ablation volumes per energy application. This feature may limit pain experienced by the patient and reduce procedure time. Anchoring either the docking device and/or the therapeutic element in the target tissue may help the user to move the ovary relative to surrounding non-ovary tissues to improve and/or confirm visualization. Moving the ovary may also allow the user to more easily reposition the device for subsequent treatments. Additionally or alternatively, the docking device may be configured to aid in anchoring the device in the target tissue.

[0031] In some embodiments, a cooling or cryogenic console may be operatively coupled to the ovarian tissue apparatus instead of or in addition to an energy generator. Use of cooling or cryotherapy may limit the amount of pain the patient experiences and may be used in combination with energy to aid in controlling lesion size (e.g., limit conductive heating). Further, combining cooling or cryotherapy with energy may allow for thermally cycling target tissue from cold to hot, resulting in additional cellular injury.

[0032] According to some embodiments described herein, and which may partially or as a whole combine with other embodiments, systems for manipulating ovarian tissues, retrieving tissues, and/or delivering agents within a patient's ovaries generally include an ovarian tissue apparatus configured for advancement through the vaginal wall and proximate an ovarian tissue; and an energy generator electrically coupled to the ovarian tissue apparatus, where the ovarian tissue apparatus comprises a docking device, one or more therapeutic elements, and/or an anchoring member, the docking device comprising an elongate body having a proximal end, a distal end, a lumen extending from the proximal end through or until the distal end, and a distal tip. In some instances a non-linear (e.g., curved) anchoring member may be employed, which may enhance anchoring within the target tissue and/or may allow the anchoring member to be fully visualized under 2-dimensional ultrasound during therapy delivery, thereby ensuring that non-target tissues are not injured. As previously stated, a non-linear structure may further aid in anchoring the device in the target tissue, limiting the risk of the device moving due to patient movement or user error. Anchoring either the docking device and/or the therapeutic element in the target tissue may help the user to move the ovary relative to surrounding non-ovary tissues to improve and/or confirm visualization. Moving the ovary may also allow the user to more easily reposition the device for subsequent treatments. Additionally or alternatively, the docking

device may be configured to aid in anchoring the device in the target tissue. In some embodiments, a cooling or cryogenic console may be operatively coupled to the ovarian tissue apparatus instead of or in addition to an energy generator. Use of cooling or cryotherapy may limit the amount of pain the patient experiences and may be used in combination with energy to aid in controlling lesion size (e.g., limit conductive heating). Further, combining cooling or cryotherapy with energy may allow for thermally cycling target tissue from cold to hot, resulting in additional cellular injury. The use of cooling or cryotherapy may also aid in anchoring the device in the tissue by adhering the device to the tissue with ice.

[0033] According to some embodiments described herein, and which may partially or as a whole combine with other embodiments, the system may generally include an ovarian tissue apparatus configured for advancement through the vaginal wall and proximate an ovarian tissue; one or more mechanical disruption and/or removal elements; and means for removing target tissue from the body. Mechanical disruption elements may be manipulated manually or automatically (e.g., via a motor and/or drive system). Mechanical manipulations may include rotation, translation and/or vibration. Removal elements may include mechanical instruments for grasping or capturing tissue or a lumen of the apparatus coupled with aspiration or suction. The removed tissue may be used for diagnosis, or components of removed tissue (e.g., oocytes, immature oocytes, mitochondria, or other cellular factors) may be used in further care. In some embodiment, means for removing target tissue from the body may also include allowing the body's natural healing process to resorb destroyed tissue and/or produce a stable scar.

BRIEF DESCRIPTION OF THE DRAWINGS

[0034] FIG. 1A depicts a stylized, anatomic view of the ovaries, adnexa, uterus, and other nearby structures. FIG. 1B depicts a stylized anatomic view of the structural elements within the ovary.

[0035] FIGS. 2-5 depict embodiments of devices for creating space in the area adjacent to the ovary for facilitating a procedure on the ovaries.

[0036] FIGS. 6-10 and 11A-11B depict embodiments of guide/docking device and associated methods for facilitating access to the ovaries.

[0037] FIGS. 12A-12F, 13A-13D, 14A-14E, 15A-15B, 16A-16D, 17, 18A-18D, 19, 20A-20C, 21A-21B, and 22 depict embodiments of therapeutic elements and methods for deploying the therapeutic elements for treatment of the ovaries.

[0038] FIG. 23 depicts an embodiment of a system for energy delivery via a transvaginal, laparoscopic, percutaneous, or surgical procedure.

[0039] FIG. 24 depicts an embodiment of a device for providing planar orientation of therapeutic element(s) during transvaginal ultrasound-guided procedures.

[0040] FIG. 25 shows various views of an embodiment of a magnetic needle guide.

[0041] FIG. 26 illustrates an exemplary method for providing planar orientation of a curvilinear therapeutic element.

[0042] FIGS. 27A-27F depict another exemplary method and device for providing planar orientation of therapeutic element(s) during transvaginal ultrasound-guided procedures.

[0043] FIG. 28 depicts a further embodiment of a device for providing planar orientation of therapeutic element(s) during transvaginal ultrasound-guided procedures.

[0044] FIG. 29 illustrates an exemplary method of accessing ovarian tissue transvaginally.

[0045] FIG. 30 illustrates an exemplary method of accessing ovarian tissue laparoscopically.

[0046] FIGS. 31A-31D depict additional embodiments of a system and method for ablating ovarian tissue.

[0047] FIG. 32 depicts an exemplary Power/Temperature Curve.

[0048] FIG. 33 depicts another exemplary Power/Temperature Curve.

[0049] FIG. 34 depicts an embodiment of a system including a neutral electrode for measurement of impedance.

[0050] FIGS. 35A-35C depict the system of FIG. 34 in varying portions of the ovary.

[0051] FIGS. 36A-36C illustrates an exemplary method of limiting travel of a therapeutic element into the ovary.

[0052] FIG. 37 depicts an embodiment of a non-invasive treatment system.

[0053] FIGS. 38A-38D depict embodiments for enhancing echogenicity under ultrasound visualization.

[0054] FIG. 39 depicts an exemplary method and system for enhancing echogenicity under ultrasound guidance.

[0055] FIG. 40 depicts an example of cross-sections with non-circular geometry.

[0056] FIG. 41 depicts an embodiment of therapeutic element and method for deploying the therapeutic element for treatment of the ovaries.

[0057] FIGS. 42A-42F depict an exemplary method for treating ovarian tissue.

DETAILED DESCRIPTION

[0058] Described here are methods and systems for manipulating ovarian tissues within a patient. The manipulation of ovarian tissues may include the delivery of energy to the tissues, retrieving tissues, e.g., via aspiration, or delivering tissues and/or agents within tissues, e.g., within an ovary. For example radiofrequency energy may be delivered to ablate a volume of ovarian tissue. The methods and systems may be used in the treatment of polycystic ovary syndrome (PCOS), and may be particularly useful in the treatment of infertility, modulating ovulation, or treating other diseases/disorders of the ovary. As previously stated, exemplary ovarian tissues include without limitation, the ovaries, ovarian follicles or cysts, nerves associated with the ovaries, suspensory ligaments, ovarian ligaments, broad ligaments, the mesovarium, endometrial tissue within the ovary, tumor or neoplastic cells, or a combination thereof.

[0059] The manipulation of ovarian tissues may include mechanical manipulation and/or removal, by delivery of chemical, biologic, or pharmaceutical agents, by delivery of energy, or by applying cooling/cold to the tissues. Exemplary treatment modalities may include without

limitation, delivery of one or more of the following: a radiofrequency energy element; a direct heating element; a cryoablation element; a cooling element; a mechanical disruption and/or removal element; laser; a microwave antenna; an unfocused ultrasound element; a partially-focused ultrasound element; a focused (HIFU) ultrasound element; and/or an element for delivering heated water/saline, steam, a chemical ablation agent, a biologic or pharmaceutical agent, implantable pulse generator, a passive or active (e.g., electronic drug delivery unit) drug-eluting implant, a radioisotope seed, or a mechanical implant, which may be either passive or active via application of remote energy (e.g., ultrasound to induce vibration).

[0060] In general, the methods and systems are configured to access ovarian tissue or a target region proximate the ovarian tissue transvaginally, laparoscopically, percutaneously, via a natural orifice route through the vagina-uterus-fallopian tubes, through an open surgical approach, or via an entirely non-invasive approach. It may be beneficial to access the ovarian tissue or a target region proximate the ovarian tissue transvaginally. The advantages of a transvaginal approach over surgical or laparoscopic approaches may include one or more of the following: (a) conscious sedation vs. general anesthesia which reduces cost and patient risk, (b) no external scars, (c) less tissue manipulation resulting in lower risk of adhesions, (d) fewer access points into the ovary resulting in lower risk of adhesions, (e) faster recovery time, and (f) it is a familiar access route for OB/GYN and fertility physicians, and fits within existing care pathways. As used herein, the term “transvaginal” or “transvaginally” refers to access through the vagina and into the peritoneal space, through the vaginal wall. The methods and systems may treat ovarian tissues by delivery of one or more of the following: a radiofrequency energy element; a direct heating element; a cryoablation element; a cooling element; a mechanical disruption element; laser; a microwave antenna; an unfocused ultrasound element; a partially-focused ultrasound element; a focused (HIFU) ultrasound element; and/or an element for delivering heated water/saline, steam, a chemical ablation agent, a biologic or pharmaceutical agent, implantable pulse generator, a passive or active (e.g., electronic drug delivery unit) drug-eluting implant, or a mechanical implant, which may be either passive or active via application of remote energy (e.g., ultrasound to induce vibration).

[0061] When the methods and systems employ an image guided energy delivery element (therapeutic element) or anchoring member, it may be useful to maintain planar orientation of

the energy delivery element or anchoring member with an imaging plane of view, as further described below. In the case of a non-linear (e.g., curved) therapeutic element or anchoring member, this allows for the therapeutic element or anchoring member to be fully visualized under 2-dimensional imaging during therapy delivery, thereby ensuring that non-target tissues are not treated or injured. Furthermore, when performing an ovarian procedure with the systems described herein, it may be beneficial to minimize the number of entry points into the ovary (the severity of adhesions may correlate with the number and size of damage to the ovary surface). After accessing the ovary through the single entry point, energy may be delivered from inside the ovary (instead of from outside the ovary) to affect a volume of tissue and/or treat a disease/disorder affecting the ovary, e.g., polycystic ovary syndrome. For example, the number of ablations needed to affect the desired volume of tissue may vary, but could range from 1-10 ablations.

[0062] To further understand the methods and systems described herein, a brief overview of female reproductive anatomy is provided. Referring to FIG. 1A, the paired ovaries (2) lie within the pelvic cavity, on either side of the uterus (3), to which they are attached via a fibrous cord called the ovarian ligament (4). The ovaries (2) are uncovered in the peritoneal cavity but are tethered laterally to the body wall via the suspensory ligament (5) of the ovary. The part of the broad ligament (6) of the uterus that suspends the ovary is known as the mesovarium (7). FIG. 1B is an expanded, cross-sectional view of the ovary (2) and surrounding structures shown in FIG. 1A. Referring to FIG. 1B, the stroma or medulla (8) comprises the middle or medullary region of the ovary; the cortex (9) (or outer region) of the ovary tends to be where follicles (10) of different degrees of maturity reside; primordial follicles (12), which are very small and immature follicles, comprise a reserve of future follicles for ovulation; a capsule (14) encases the ovary (2), which is tethered to the broad ligament (6) by the mesovarium (7); small blood vessels (16) and nerves (18) enter the ovary (2) through the mesovarium (7), the ovarian ligament (4), and the suspensory ligament (5) of the ovary.

[0063] A brief overview of several approaches to accessing ovarian tissue is also provided, as depicted in FIG. 29. Referring to the figure, a system for performing transvaginal ultrasound is shown. An ultrasound probe (101) is placed inside the vagina (103) of the patient (105). A cable (107) connects the handle (109) of the probe to a monitor (111), allowing the user to

visualize the ultrasound images. A typical laparoscopic procedure is illustrated in FIG. 30. The laparoscopic approach typically employs 2 or 3 small incisions (201), through which various imaging and surgical tools (203) can be introduced. Imaging is performed with a laparoscope (205), which allows for direct visualization of tissues. The abdominal cavity is filled with gas (207) to expand the field of view and allow for manipulation of tissues.

I. METHODS

[0064] Disclosed herein are various methods for manipulating the ovarian tissues of a patient. The manipulation of ovarian tissues may include mechanical manipulation and/or removal, by delivery of chemical, biologic, or pharmaceutical agents, by delivery of energy, or by applying cooling/cold to the tissues. Exemplary treatment modalities may include without limitation, delivery of one or more of the following: a radiofrequency energy element; a direct heating element; a cryoablation element; a cooling element; a mechanical disruption and/or removal element; laser; a microwave antenna; an unfocused ultrasound element; a partially-focused ultrasound element; a focused (HIFU) ultrasound element; and/or an element for delivering heated water/saline, steam, a chemical ablation agent, a biologic or pharmaceutical agent, implantable pulse generator, a passive or active (e.g., electronic drug delivery unit) drug-eluting implant, a radioisotope seed, or a mechanical implant, which may be either passive or active via application of remote energy (e.g., ultrasound to induce vibration).

[0065] In some instances, manipulation of ovarian tissues may include the delivery of energy to the tissues. Here it may be useful to deliver radiofrequency energy or thermal energy to the tissues. In other instances, manipulation of ovarian tissues may include retrieving tissues, e.g., via aspiration. The removed tissue may be used for diagnosis, or components of removed tissue (e.g., oocytes, immature oocytes, mitochondria, or other cellular factors) may be used in further care. In yet further instances, manipulation of ovarian tissues may include delivering agents within the ovary of a patient. Manipulation of ovarian tissues may occur by mechanical manipulation of the tissues, by delivery of chemical, biologic or pharmaceutical agents, cooling/cryotherapy, or by delivery of energy to the tissues. Although the ovarian tissues may be accessed using any suitable approach, the methods described here generally use a transvaginal approach. The type of approach utilized may depend on factors such as a patient's age, comorbidities, need for other concomitant procedures, and prior surgical history.

[0066] Furthermore, in some instances it may be desirable to provide protective elements and/or spacing devices configured to spare or separate non-target tissues, or to prevent excessive damage to the tissues. In some cases, for example thermal treatment, the protective element can be the use of a temperature sensor (e.g. a thermocouple or thermistor), and/or an active cooling member (e.g., internally cooled electrode, irrigated electrode, irrigated guide/docking device, etc., if heat is generated). Embodiments of spacing devices may include mechanical features incorporated into an apparatus and/or fluid infusion into the region proximate to the ovary (e.g., the peritoneal space). In some embodiments, the aspiration and irrigation functions are performed via the same lumen within the apparatus.

[0067] In one variation, the method includes accessing a target region proximate to ovarian tissue within the patient; advancing an ovarian tissue apparatus to the target region, the ovarian tissue apparatus comprising a docking device and one or more therapeutic elements, the docking device comprising a proximal end, a distal end, and a distal tip; contacting the ovarian tissue with the docking device; and deploying the one or more therapeutic elements on or within the ovarian tissue.

[0068] In another variation, the method includes accessing a target region proximate to ovarian tissue within the patient; advancing an ovarian tissue apparatus to the target region, the ovarian tissue apparatus comprising a docking device, one or more therapeutic elements, and/or an anchoring member, the docking device comprising an elongate body having a proximal end, a distal end, a lumen extending from the proximal end through or until the distal end, and a distal tip, the docking device further comprising a therapeutic element at or near the distal end; an anchoring member being slidable within and deployable from the lumen of the docking device; contacting the ovarian tissue with the docking device; and deploying the anchoring member onto or within the ovarian tissue.

[0069] Methods useful in treating infertility, modulating ovulation, or treating diseases/disorders involving the ovary, e.g., polycystic ovary syndrome, may also generally include advancing a probe comprising a handle, an ultrasound transducer, and a needle guide into the vaginal canal; advancing an ovarian tissue apparatus into the needle guide, the ovarian tissue apparatus comprising a docking device, a therapeutic element on a portion of the docking device, e.g., the on the distal end of the docking device, and an anchoring member; advancing

the docking device through a vaginal wall; penetrating an ovary at a single entry point with the docking device; advancing the therapeutic element into the ovary; advancing the anchoring member from the docking device, e.g., through a distal tip or a side opening of the docking device; and delivering energy to affect a volume of tissue within the ovary using the therapeutic element to treat a symptom of polycystic ovary syndrome. In some instances, the delivered energy is radiofrequency energy. The radiofrequency energy may be pulsed or continuous. The method may further include the step of repositioning the therapeutic element and repeating energy delivery through the single entry point.

[0070] The docking device of the ovarian tissue apparatus may be advanced using image guidance. Image guidance may be accomplished using techniques such as but not limited to, transvaginal ultrasound, transabdominal ultrasound, endoscopic visualization, direct visualization, computed tomography (CT), or magnetic resonance imaging (MRI), optical coherence tomography (OCT), an ultrasound element on the device, virtual histology, or a combination thereof. In some embodiments, for example alternatively or in conjunction with image guidance, advancement and navigation of the docking device may be accomplished using a steering mechanism at least partially disposed within the distal end of the docking device. For example, one or more steerable wires may be disposed within the docking device running from the proximal end to the distal tip of the device. Actuation of the steerable wires may occur by manipulation of a mechanism on a handle at the proximal end of the docking device. In some embodiments, the docking device comprises a flexible distal end, or one or more flexible segments to aid with navigation to the target ovarian tissue. In other embodiments, the docking device comprises a rigid member, which may have a sharpened tip. Proximal portions of the docking device may be reinforced, e.g., with a braided shaft, material of increased durometer, to provide improved pushability and torque control.

[0071] The ovarian tissue may be engaged in various different ways. In some variations, the step of contacting comprises applying vacuum to the ovarian tissue using the distal tip of the docking device. In other variations, the step of contacting comprises releasably securing one or more attachment elements to the ovarian tissue. The attachment elements may comprise any suitable element capable of releasably securing ovarian tissue. Embodiments of such attachment elements include a hook, needle, barb, or combination thereof. When vacuum is used to help

engage the docking device to an ovary or a polycystic ovary, the vacuum may also be used to aspirate fluid from one or more follicles or cysts. Aspiration of follicle or cyst fluid may reduce the size of the follicle or cyst or reduce the total number of follicles or cysts on the ovary. By reducing the size of the follicle or cyst, the tissue may be drawn closer to or into contact with the therapeutic element(s), which may allow for improved targeting of tissue (e.g., medulla, cortex, nerves, thecal or luteal cells, endometrial tissue, tumor or neoplastic cells, etc.) and/or shorter treatments times. Aspiration of fluid may also aid in the assessment that bleeding has been controlled after delivery of the therapy.

[0072] According to some embodiments described herein, which may partially or as a whole combine with other embodiments, the distal end of the docking device comprises a tissue engagement element, and the ovarian tissue is contacted using the tissue engagement element. In some embodiments, the tissue engagement element comprises a preformed shape, e.g., a predetermined curvature. The preformed shape may conform to the shape of the ovarian tissue, and aid in the deployment of the treatment elements from the docking device. One or more therapeutic elements may be deployed from the docking device on, into, or proximate to the ovarian or mesovarian tissue. When the ovarian tissue is an ovary, the size of the ovary may range from about 1 to 7 cm in length, about 1 to 4 cm in width, and about 0.5 to 4 cm in thickness. Ovaries stimulated by pharmaceutical agents such as gonadotropins may often be larger.

[0073] According to embodiments described herein, which may partially or as a whole combine with other embodiments, the therapeutic element may comprise one or more of the following: a radiofrequency energy element; a direct heating element; a cryoablation element; a cooling element; a mechanical disruption element; laser; a microwave antenna; an unfocused ultrasound element; a partially-focused ultrasound element; a focused (HIFU) ultrasound element; and/or means for delivering heated water/saline, steam, a chemical ablation agent, a biologic, or pharmaceutical agent, implantable pulse generator, a passive or active (e.g., electronic drug delivery unit) drug-eluting implant, a radioisotope seed, or a mechanical implant, which may be either passive or active via application of remote energy (e.g., ultrasound to induce vibration). In some embodiments, the therapeutic element comprises a radiofrequency energy element, e.g., a radiofrequency electrode. In some embodiments, the therapeutic element

may comprise one or more curved needle electrodes, or may comprise one or more electrodes configured linearly. Additionally or alternatively, the therapeutic element may comprise one or more electrodes configured in a non-linear (e.g., curved) arrangement. According to embodiments described herein, which may partially or as a whole combine with other embodiments, the therapeutic element may comprise one or more active electrodes on an elongate body (e.g., on the docking device, on a curved structure). Here a return electrode may be provided on the distal end of the docking device, or be deployable from the docking device. Alternatively, a return electrode may be placed on the outside of the patient. For example, in one variation, a return electrode may be affixed to the ultrasound probe proximate the transducer. In another variation, a return electrode may be incorporated into a needle guide. In the case of a plurality of electrodes, any pair may be activated in a bipolar manner or individually via a return electrode. With regards to the use of the various types of ultrasound, it could include variations that use ultrasound to create thermal heating or non-thermal ultrasound to induce acoustic cavitation.

[0074] An implantable pulse generator could be used to apply periodic electric energy to modulate the neurohormonal environment of the ovary. The implantable pulse generator could be used to deliver energy proximate to various ovarian structures (e.g. cortex, stroma, nerves, mesovarium).

[0075] Mechanical disruption elements could include mechanical disruption of one or more target tissues (e.g., medulla, cortex, nerves, thecal or luteal cells, follicles or cysts, endometrial tissue, tumor or neoplastic cells, etc.). The mechanical disruption may include morcellating, tearing, compressing, stretching or otherwise destroying tissue or causing it to alter its function (e.g., induce apoptosis, trigger increased blood flow, trigger a healing response, trigger maturation of oocytes, or trigger ovulation). Injured/destroyed tissue may be removed mechanically or left within the body, allowing the body's natural healing process to resorb the destroyed tissue. The morcellated tissue may also be retrieved in some instances if it can be used for diagnosis, or if components of the removed tissue (e.g., tumor or neoplastic cells, oocytes, immature oocytes, mitochondria, or other cellular factors) are to be used in further care. Pharmacologic or biologic agents could be delivered either as a one-time delivery, part of a slow-release preparation, or implanted as a part of a biodegradable or non-biodegradable device.

These agents could also be implanted within a casing (e.g., an electronic drug delivery unit) configured to remotely control delivery of the casing's contents using a controller external to the body. Exemplary biologic or pharmacologic agents that could be employed include without limitation: beta-blockers, anti-androgens (e.g., finasteride, flutamide, nilutamide, bicalutamide, spironolactone, cyproterone), follicular stimulating hormone, luteinizing hormone, other hormones, neurotoxins or tissue toxins (e.g., botox, guanethidine, ethanol), 5-alpha-reductase inhibitors (e.g., finasteride, dutasteride, izonsteride, turosteride, and epristeride), insulin modulating agents, aromatase inhibitors (e.g., letrozole, exemestane, anastrozole), VEGF modulating agents, agents modulating inhibin, agents modulating interleukins, anti-cancer agents, pluripotent or multipotent stem cell preparations, or cellular components. Furthermore, an agent (e.g., radiopaque material, echogenic material, etc.) may be left behind to tag the location(s) in which the therapeutic agent(s) are delivered.

[0076] In one variation, one or more therapeutic elements are advanced on or into an ovary. In another variation, the one or more therapeutic elements are advanced on or into an ovarian follicle or cyst. The one or more therapeutic elements may also be advanced from the mesovarium on or into an ovary or an ovarian follicle or cyst. In one variation, the one or more therapeutic elements are delivered to multiple, predetermined areas on or within the ovarian tissue. In other instances, a pattern of treatment is delivered on or into the ovarian tissue. These patterns of treatment within the tissue could be linear, curvilinear, helical, interrupted, continuous, arbor-like (e.g., with a trunk and multiple offshoots), or may comprise other suitable patterns. The therapeutic elements may be utilized such that multiple treatments may be delivered through a single outer entry point in the ovary. The therapeutic elements may be delivered to treat any suitable medical condition of the female reproductive anatomy, and may be particularly beneficial in the treatment of infertility, polycystic ovary syndrome, or for modulating ovulation.

[0077] Some variations of the method deliver thermal energy to the ovarian tissues. The thermal energy may increase the temperature of the ovarian tissue (e.g., by heating) and/or ablate/coagulate and/or desiccate/char the tissue. The thermal energy may also be delivered to reduce the temperature of the ovarian tissue (e.g. by cooling) or may cryoablate the tissue. Mechanically disrupting the ovarian tissues with the one or more therapeutic elements is also

contemplated. For example, a steerable device could be used under image guidance to maximize the number of ovarian cysts that are ruptured as it was advanced in a path through the ovarian tissue, this could be done alone or in combination with some form of thermal energy. The mechanically disrupting portion of the device could rupture a cyst, then imaging could identify rupturing a subsequent cyst, and the process could be repeated.

[0078] Methods useful in treating infertility or modulating ovulation may include advancing an ovarian tissue apparatus proximate an ovary within a patient, the ovarian tissue apparatus comprising a docking device and one or more therapeutic elements, the docking device comprising a proximal end, a distal end, and a distal tip; deploying the one or more therapeutic elements from the docking device proximate to or within an ovarian follicle; and manipulating the ovary or ovarian follicle to effect a change in the ovarian follicle, one or more symptoms or physiological parameters indicative of infertility or ovulation, or a combination thereof. In some variations of the method, the one or more therapeutic elements are deployed from the docking device proximate to or within an additional ovarian follicle. When the polycystic ovary or ovarian follicle is manipulated, symptoms such as infertility, anovulation, acne, obesity, abdominal pain, hirsutism, or psychological symptoms may be treated or improved. Physiological parameters of the patient that can be affected by manipulation of the ovary or ovarian follicle may include androgen levels, number or size of ovarian follicles, size of the ovary, levels of anti-müllerian hormone (AMH), sex hormone binding globulin, level of luteinizing hormone (LH), ratio of luteinizing hormone (LH) to follicular stimulating hormone (FSH), lipid levels, fasting blood glucose, fasting blood insulin levels, response to oral glucose tolerance testing, blood glucose level, or measures of sympathetic nervous system activity (e.g., microneurography, norepinephrine spillover testing, or heart rate variability). In one aspect of the treatment described herein, a test of physiologic parameters can be performed pre-procedurally, peri-procedurally or post-procedurally to guide therapy and/or confirm clinical success of the treatment.

[0079] Methods useful in treating PCOS may include advancing an ovarian tissue apparatus proximate a polycystic ovary within a patient, the ovarian tissue apparatus comprising a docking device and one or more therapeutic elements, the docking device comprising a proximal end, a distal end, and a distal tip; deploying the one or more therapeutic elements from the docking

device proximate to or within an ovarian cyst; and manipulating the polycystic ovary or ovarian cyst to effect a change in the ovarian cyst, one or more symptoms or physiological parameters indicative of polycystic ovary syndrome, or a combination thereof. In some variations of the method, the one or more therapeutic elements are deployed from the docking device proximate to or within an additional ovarian cyst. When the polycystic ovary or ovarian cyst is manipulated, symptoms such as infertility, anovulation, acne, obesity, abdominal pain, hirsutism, or psychological symptoms may be treated or improved. Physiological parameters of the patient that can be affected by manipulation of the polycystic ovary or ovarian cyst may include androgen levels, number or size of ovarian cysts, size of the ovary, levels of anti-müllerian hormone (AMH), sex hormone binding globulin, level of luteinizing hormone (LH), ratio of luteinizing hormone (LH) to follicular stimulating hormone (FSH), lipid levels, fasting blood glucose, fasting blood insulin levels, response to oral glucose tolerance testing, blood glucose level, or measures of sympathetic nervous system activity (e.g., microneurography, norepinephrine spillover testing, or heart rate variability). In one aspect of the PCOS treatment described herein, a test of physiologic parameters can be performed pre-procedurally, peri-procedurally or post-procedurally to guide therapy and/or confirm clinical success of the treatment.

[0080] Methods useful in treating PCOS may include advancing an ovarian tissue apparatus proximate a polycystic ovary within a patient, the ovarian tissue apparatus comprising a docking device, one or more therapeutic elements, and/or an anchoring member, the docking device comprising a proximal end, a distal end, and a distal tip; deploying the one or more anchoring members from the docking device proximate to or within an ovarian cyst; and manipulating the polycystic ovary or ovarian cyst to effect a change in the ovarian cyst, one or more symptoms or physiological parameters indicative of polycystic ovary syndrome, or a combination thereof. In some variations of the method, the one or more anchoring members are deployed from the docking device proximate to or within an additional ovarian cyst. When the polycystic ovary or ovarian cyst is manipulated, symptoms such as infertility, anovulation, acne, obesity, abdominal pain, hirsutism, or psychological symptoms may be treated or improved. Physiological parameters of the patient that can be affected by manipulation of the polycystic ovary or ovarian cyst may include androgen levels, number or size of ovarian cysts, size of the ovary, levels of anti-müllerian hormone (AMH), sex hormone binding globulin, level of luteinizing hormone

(LH), ratio of luteinizing hormone (LH) to follicular stimulating hormone (FSH), lipid levels, fasting blood glucose, fasting blood insulin levels, response to oral glucose tolerance testing, blood glucose level, or measures of sympathetic nervous system activity (e.g., microneurography, norepinephrine spillover testing, or heart rate variability). In one aspect of the PCOS treatment described herein, a test of physiologic parameters can be performed pre-procedurally, peri-procedurally or post-procedurally to guide therapy and/or confirm clinical success of the treatment.

[0081] The ovarian tissue apparatus, including the docking device, may be advanced transvaginally, laparoscopically, percutaneously, via a natural orifice route through the vagina-uterus-fallopian tubes, through an open surgical approach, or via an entirely non-invasive approach. The steps of advancing, deploying, and manipulating may be accomplished using image guidance, including but not limited to transvaginal ultrasound, transabdominal ultrasound, endoscopic visualization, direct visualization, computed tomography (CT), or magnetic resonance imaging (MRI), optical coherence tomography (OCT), an ultrasound element on the device, virtual histology, or a combination thereof. In the case of an entirely non-invasive approach, the steps may include positioning an imaging and/or therapeutic element on the abdomen of a patient, identifying target tissue, targeting said tissue, and applying energy (e.g., partially-focused or focused ultrasound). Hybrid approaches may also be utilized. For example, transvaginal ultrasound may be used for imaging and/or targeting, while an external therapeutic element could deliver energy. Further, having ultrasound visualization in both the vagina and on the abdomen may enhance targeting.

[0082] Alternatively, or in conjunction with image guidance, and as previously described, advancement and navigation of the docking device may be accomplished using a steering mechanism at least partially disposed within the distal end of the docking device. For example, one or more steerable wires may be disposed within the docking device running from the proximal end to the distal tip of the device. Actuation of the steerable wires may occur by manipulation of a mechanism on a handle at the proximal end of the docking device. In some embodiments, the docking device comprises a flexible distal end, or one or more flexible segments to aid with navigation to the target tissue. Proximal portions of the docking device

may be reinforced, e.g., with a braided shaft, material of increased durometer, to provide improved pushability and torque control.

[0083] The docking device may use a docking mechanism such that a portion of the device arrives proximate to or to engages the ovary, the polycystic ovary, an ovarian follicle or cyst, or the mesovarium. In some embodiments, the docking mechanism includes the application of vacuum to the ovarian tissue using the distal tip of the docking device. Alternatively or additionally, the docking mechanism comprises releasably securing one or more attachment elements to the ovary or the polycystic ovary. The attachment elements may comprise any suitable element capable of releasably securing the polycystic ovary. Exemplary attachment elements include a hook, needle, barb, or combination thereof. When vacuum is used to help engage the docking device to a polycystic ovary, the vacuum may also be used to aspirate fluid from one or more cysts. Aspiration of cyst fluid may reduce the size of the cyst or reduce the total number of cysts on the ovary. Aspiration may be used prior to, during, or after delivery of the therapeutic element so that the therapeutic element is more proximate to target tissue. Aspiration of fluid may also aid in the assessment that bleeding has been controlled after delivery of the therapy. The aspirated fluid could also be collected and analyzed for another purpose.

[0084] In some embodiments, the distal end of the docking device comprises a tissue engagement element, and the ovary or the polycystic ovary is contacted using the tissue engagement element. In some instances, the tissue engagement element comprises a preformed shape, e.g., a predetermined curvature. The preformed shape may conform to the shape of the ovary, and aid in the deployment of the treatment elements from the docking device.

[0085] In some embodiments, the guiding/docking device and the therapeutic element are combined into a single entity. In this case, the therapeutic element may be disposed at or near the distal end of the docking device and an anchoring member may be deployable from the lumen of the docking device into the ovary. In other embodiments, the guiding/docking device and the therapeutic element are different but the two are used in tandem to deliver therapy (e.g., the guiding/docking device has a therapeutic element such as an electrode that may be used in combination or separate from other deployed therapeutic elements). Alternatively, the electrode

located on the guiding/docking device may be used as a neutral electrode with little/no therapeutic effect (e.g., heat).

[0086] In some aspects, the methods employed herein include using a docking/guiding device to penetrate the ovary and permit delivery of one or multiple therapeutic elements out of one or more apertures in the guiding/docking device. In some embodiments, the docking/guiding device may comprise, for example, a needle, and the therapeutic element may comprise, for example, a shaft containing one electrode or a plurality of electrodes. In some embodiments, the shaft may be straight, but in other embodiments, the distal portion of the shaft may be processed to have a pre-set shape. The therapeutic element may be insulated along the majority of its length or a discrete portion(s) of its length to electrically isolate it from the docking device. In some embodiments, the electrodes may wrap around the entire circumference of the shaft or may only cover a portion of the shaft circumference in other embodiments. In each of the embodiments described in the present disclosure, the electrodes could be electrically isolated from each other and deliver energy in a monopolar or bipolar fashion. Monopolar configurations may allow for simpler device configuration, but they require a neutral electrode. Bipolar configurations may allow for energy to be contained within a more limited field of tissues. When a bipolar method is used, one electrode would serve as the active electrode and another electrode would serve as the return electrode. In further embodiments, multiple electrodes could deliver energy and the energy would return to a neutral electrode located elsewhere, such as on the skin of the patient, on the docking/guiding device, or on the ultrasound probe. In some embodiments, the electrodes could also be electrically connected to each other and deliver energy where the return or neutral electrode is located elsewhere, such as on the skin of the patient, on the docking/guiding device, or on the ultrasound probe. Placing the neutral electrode on the outside of the patient (e.g., skin) may allow for a simpler device configuration. Placing the neutral electrode on the docking/guiding device or the ultrasound transducer may help confine the energy delivery to a smaller field and also change the diagnostic information collected by impedance measurements. As shown in FIG. 31A, a docking/guiding device (301) can be used to penetrate into the ovary (303) and deliver a single therapeutic element (305) out of the distal end (307) of the docking/guiding device (301). Here the therapeutic element is delivered from the docking device at an angle away from the trajectory of the docking/guiding device but within the two-dimensional plane of an ultrasound field. Docking/guiding device

(301) may comprise a needle and the therapeutic element (305) may include a curved shaft with two electrodes (309) disposed thereon. The electrodes (309) may be comprised of metallic bands, coils, wires (e.g., wound or braided), laser cut tubing, or slotted tubular structures. They may wrap partially or entirely around the circumference of the therapeutic element shaft (305) and may be separated by discrete insulated areas (311). Additional detail relating to these devices and similar embodiments is provided below.

[0087] One or more therapeutic elements may be deployed from the docking device on or into the ovary or the polycystic ovary, proximate to or into an ovarian follicle or cyst, proximate to or into the mesovarium, or other target structure. The one or more therapeutic elements may also be advanced from a single docking location or multiple docking locations on or within the polycystic ovary or an ovarian cyst; or advanced from a single docking location or multiple docking locations proximate to an ovarian cyst, or proximate to the mesovarium. The docking location(s) could be on the medial and/or inferior aspect of the ovary. The guiding/docking device could also penetrate into the ovary. In one aspect of the methods, there may be a single entry point on the outside of the ovary (by either the guiding/docking device or the treatment element or the combination thereof) through which multiple treatments could be delivered thereby causing less damage to the outside of the ovary and reducing the risk for adhesion formation. In another variation, the energy is delivered to multiple areas on or within the ovary or the polycystic ovary, an ovarian follicle or cyst, proximate to an ovarian follicle or cyst, proximate to the junction of the ovarian stroma and cortex, or proximate to the mesovarium, allowing improved targeting or avoidance of certain tissues (e.g., nerves or vasculature). In other instances, a pattern of treatments is delivered on or within the ovary, the polycystic ovary, an ovarian follicle or cyst, proximate to an ovarian follicle or cyst, proximate to the junction of the ovarian stroma and cortex, or proximate to the mesovarium.

[0088] In another aspect, the methods employed herein include using a docking/guiding device to penetrate the ovary and permit delivery of one or multiple therapeutic elements into the ovary and one or more anchoring members out of one or more apertures in the guiding/docking device. As shown in FIG. 31B a docking/guiding device (301) can be used to penetrate into the ovary (303) and deliver a therapeutic element (305) disposed at or near the distal end (307) and an anchoring member (312) out of the distal end (307) of the docking/guiding device (301).

Here the anchoring member is delivered from the docking device at an angle away from the trajectory of the docking/guiding device but within the two-dimensional plane of an ultrasound field. Docking/guiding device (301) may comprise a needle and the therapeutic element (305) may include two electrodes (309) disposed thereon. The electrodes (309) may be comprised of metallic bands, coils, wires (e.g., wound or braided), laser cut tubing, or slotted tubular structures. They may wrap partially or entirely around the circumference of the docking device (301) and may be separated by discrete insulated areas (311) and further insulated from the docking device (301). The electrodes (309) may also be part of the docking device (301) in the event that the docking device is constructed from an electrically-conductive material such as metal; in this case, discrete portions of the docking device would be insulated (311) and the uninsulated portions could serve as electrodes. Additional detail relating to these devices and similar embodiments is provided herein.

[0089] Another aspect of the methods disclosed herein comprises orienting the therapeutic element(s) and/or anchoring member(s) with the transvaginal ultrasonic probe, which is generally limited to 2-dimensional (or planar) imaging. When the therapeutic element and/or anchoring member has a non-linear geometry, e.g., if it is curved or otherwise deploys away from the centerline of the docking device, it is desirable to maintain visualization of the therapeutic element and/or anchoring member via the transvaginal ultrasound probe. Here the method may include setting the orientation of the therapeutic element and/or anchoring member in plane with the ultrasonic probe such that as the therapeutic element and/or anchoring member is maneuvered or deployed, the operator can visualize it. This may be employed via the method of attaching or orienting the therapeutic device and/or anchoring member to the handle of the ultrasound probe and/or by employing a needle guide configured to attach to the ultrasound probe and provide a unique guiding interface with the guiding/docking device. The method may also involve a means to quickly decouple the orientation between the therapeutic element and/or anchoring member and the visualization plane of the probe. For example, the operator may choose to deploy the therapeutic element and/or anchoring member in one plane but then rotate the ultrasound probe into another plane (without changing plane of the therapeutic element and/or anchoring member) to verify placement or view other surrounding tissues. According to some embodiments, the coupling mechanism between the therapeutic element and/or anchoring member and probe could provide a means of sliding or rotating the probe into a new orientation

but then quickly realigning the therapeutic element and/or anchoring member and probe (such that the deployed element is back in the visualization plane of the probe). In some instances, it may be desirable to reorient the therapeutic element and/or anchoring member by approximately 180 degrees to allow for it to reach different regions of tissue in the same imaging plane.

[0090] Another aspect of the methods disclosed herein comprises enhancing the visualization (i.e., echogenicity) of the guiding/docking device, therapeutic elements, and/or the anchoring member while using ultrasound for visualization. The method may include providing a region of increased echogenicity on the guiding/docking device, therapeutic elements, and/or anchoring member. In some embodiments, the region of increased echogenicity is a region that traps gas. In some embodiments, the region of increased echogenicity includes a surface feature and/or echogenic material, such as a roughened surface covered by a polymer sheath or surface indentations covered by a polymer sheath, which traps gas between the grooves of the roughened/indented surface and the polymer sheath. The trapped gas enhances the echogenicity beyond using merely a roughened/indented surface. In other embodiments, gas may also be trapped by incorporating one or more lumens, pockets, or cavities within the therapeutic element, the docking device, and/or the anchoring member. It may be useful to have enhanced echogenicity only at the distal tip of the therapeutic element, docking device, and/or anchoring member, which could aid in ensuring that it is within the desired target tissue. For example, enhanced echogenicity at the distal tip may help with visualization of the tip within the ovary, and indicate that a region proximal to the tip is contained within the ovary. It may also be useful to have differential echogenicity of different parts of therapeutic element, docking device, and/or anchoring member to provide better assessment of device placement. In some instances it may be useful for the therapeutic element or a portion thereof to comprise an echogenic material and/or surface feature having greater echogenicity than the echogenic material of the docking device or other portions of the therapeutic element and/or anchoring member. For example, as shown in FIG. 39, the therapeutic element (3900) could contain a beveled needle tip (3901) that is angled and oriented in front of the ultrasonic transducer (3902) such that the tip maximizes its echogenicity by reflecting more sound back to the transducer. In FIG. 39, the ultrasound transducer (3902) has a field of view (3903) generated by the emission and detection of sound waves (3904); note that only some sound waves are illustrated in FIG. 39. Additionally or optionally, the portion of the therapeutic element (3900) located just proximal of the beveled

needle tip (3901) could be designed to allow more sound waves from the ultrasound system to pass by or scatter away and therefore reduce the echogenicity of that region. This less echogenic portion (3905) could be achieved by using or adding a different material, or by modifying the surface to absorb, scatter, and/or reflect sound away from the transducer. The difference in echogenicity between the tip and the portion just proximal of the tip would further differentiate the tip and provide the user enhanced feedback of the tip location within the ovary. The anchoring member or a portion thereof may also comprise an echogenic material. For example, as depicted in FIG. 31B, it may be useful for the tip (313) of the anchoring member (315) to comprise an echogenic material or surface feature.

[0091] Another method for enhancing echogenicity near the proximal treatment zone is to configure the proximal electrode with an asymmetric geometry such that rotating the device would enhance the detectable motion, and thus enhance the echogenicity, of the asymmetric electrode. Mechanisms for creating the asymmetric electrode geometry include cutting a notch (1701) out of an edge of the electrode or adding a hole (1702) to the electrode (1703), as shown in FIG. 38A and FIG. 38B. Similarly, material, e.g., a thin rectangular bar (1704), could be added to a portion of the circumference of the shaft near the electrode (1703), as shown in FIG. 38C, or added to the electrode itself. Another example of added material may include a band (1705) that fully or partially surrounds the circumference of the docking/guiding device and/or electrode, as shown in FIG. 38D. Adding material could also include shaping the base material, e.g., the metal shaft carrying the electrode, by indenting it outwards to cause a protrusion in the shaft surface. Rotating the device would cause the added or raised material to enhance the detectable motion under ultrasound due to the asymmetry around the axis, and thus enhance the echogenicity. The enhanced echogenicity would provide the user more confidence that position of the electrode or electrodes are in the desired target area. The electrodes may wrap around the entire circumference of the shaft or may only cover a portion of the shaft circumference, in which case the electrodes may or may not be angularly offset from one another.

[0092] Alternatively, the methods provided herein may include limited rotation and/or translation of the guiding/docking device, therapeutic elements, and/or anchoring member while using ultrasound to enhance visualization. For example, rotation of plus or minus up to 20 degrees of rotation could significantly improve visualization. The limited rotation may be useful

in maintaining the therapeutic elements and/or anchoring member within the ultrasound visualization plane (if so desired) while allowing the operator to quickly rotate the device back and forth to enhance visualization. In other variations of the method, translation plus or minus up to 0.25 mm, or in other variations translations up to plus or minus 2.0 mm, may also significantly improve visualization. This subtle translation could be achieved, for example, by allowing the operator to easily shift the therapeutic elements and/or anchoring member a small distance distally and proximally, such as plus or minus up to 0.25 mm or 2.0 mm.

[0093] In another variation, the method may include enhancing the visualization of the treatment zone. The method may be to use energy delivery settings to ablate the tissue in a way that makes the ablated tissue appear differently on ultrasound. For example, it may be desirable to first ablate the tissue for approximately 5-15 seconds, followed by a short burst of higher power to then desiccate/char the tissue. The desiccated/charred tissue may be more echogenic, thus enhancing the visualization of the treatment zone. Additionally or alternatively, the method may also involve infusing air or other echogenic gas/material into a target zone to mark that area. This may be done after performing a treatment to mark the zone treated so that an overlapping treatment is not subsequently performed.

[0094] In another variation, the method may include affecting the target tissue in a fully non-invasive way. Here the method may include placement of an ultrasound imaging and/or therapeutic element onto the abdomen of a patient; operatively connecting the ultrasound imaging and/or therapeutic element to a console comprising a user interface, delivering ultrasound for imaging, targeting desired ovarian tissue, and delivering energy (e.g., partially-focused ultrasound, HIFU).

[0095] One aspect of the methods disclosed herein provides for pre-treatment planning prior to the manipulation of ovarian tissues. The manipulation of ovarian tissues may include mechanical manipulation and/or removal, by delivery of chemical, biologic, or pharmaceutical agents, by delivery of energy, or by applying cooling/cold to the tissues. Exemplary treatment modalities may include without limitation, delivery of one or more of the following: a radiofrequency energy element; a direct heating element; a cryoablation element; a cooling element; a mechanical disruption and/or removal element; laser; a microwave antenna; an unfocused ultrasound element; a partially-focused ultrasound element; a focused (HIFU)

ultrasound element; and/or an element for delivering heated water/saline, steam, a chemical ablation agent, a biologic or pharmaceutical agent, implantable pulse generator, a passive or active (e.g., electronic drug delivery unit) drug-eluting implant, a radioisotope seed, or a mechanical implant, which may be either passive or active via application of remote energy (e.g., ultrasound to induce vibration). More specifically, manipulation of ovarian tissues may include the delivery or application of energy (e.g., for ablating tissues), retrieval of tissues, e.g. via aspiration, or delivery of agents within a patient's ovary, as previously stated. For example, pre-treatment planning could be provided for the treatment of PCOS, including PCOS infertility. Here the method may include the step of performing non-invasive imaging to map the size, morphology and location of the ovary, the quantity and location of ovarian cysts, the location of ovarian cysts relative to other anatomical landmarks, and/or the volume of target tissue (e.g., stroma). Non-invasive imaging modalities may include magnetic resonance imaging (MRI), computed tomography (CT), transvaginal ultrasound, transabdominal ultrasound, or a combination thereof. The images and mapping performed may aid the caregiver in planning the therapeutic procedure and/or guide the caregiver while performing therapy. The mapping procedure may yield images, annotated images, and/or information related to the relationship between cysts or other target tissue and other anatomical landmarks.

[0096] Another aspect of the methods disclosed herein provides for harvesting available oocytes in conjunction with delivering therapy. In one variation, currently available tools and procedures may be used to first harvest available oocytes or tissue containing immature oocytes, which may then be stored for later use. For example, oocytes may be harvested using a transvaginal approach using transvaginal ultrasound and a needle. Alternatively, the therapy may be applied first. In yet another variation, the same tools utilized for providing the therapy may also be configured to also allow for oocyte harvesting. The therapy-providing tools may have improved features to aid in targeting, thus allowing for more oocytes to be harvested. These features may include methods for improved targeting, such as methods for steering, engaging the ovary and/or imaging.

II. SYSTEMS

[0097] Further described herein are embodiments of systems for manipulating ovarian tissues, including delivering energy to tissues, retrieving tissues, and/or delivering agents within the

tissues, and/or treating PCOS, wherein one or more features from any of these embodiments may be combined with one or more features from one or more other embodiments to form a new embodiment within the scope of this disclosure. The manipulation of ovarian tissues may include mechanical manipulation and/or removal, by delivery of chemical, biologic, or pharmaceutical agents, by delivery of energy, or by applying cooling/cold to the tissues. Exemplary treatment modalities may include without limitation, delivery of one or more of the following: a radiofrequency energy element; a direct heating element; a cryoablation element; a cooling element; a mechanical disruption and/or removal element; laser; a microwave antenna; an unfocused ultrasound element; a partially-focused ultrasound element; a focused (HIFU) ultrasound element; and/or an element for delivering heated water/saline, steam, a chemical ablation agent, a biologic or pharmaceutical agent, implantable pulse generator, a passive or active (e.g., electronic drug delivery unit) drug-eluting implant, a radioisotope seed, or a mechanical implant, which may be either passive or active via application of remote energy (e.g., ultrasound to induce vibration).

[0098] The systems may include an ovarian tissue apparatus configured for advancement through the vaginal wall (transvaginally), laparoscopically, percutaneously, via a natural orifice route through the vagina-uterus-fallopian tubes, or through an open surgical approach, and proximate an ovarian tissue; and an energy generator electrically coupled to the ovarian tissue apparatus, where the ovarian tissue apparatus typically comprises a docking device and one or more therapeutic elements, the docking device typically comprising an elongate body having a proximal end, a distal end, a lumen extending from the proximal end through the distal end, and a distal tip.

[0099] The systems may alternatively comprise an ovarian tissue apparatus, where the ovarian tissue apparatus comprises an engagement device, e.g., a docking device, and an anchoring member, the docking device comprising an elongate body having a proximal end, a distal end, and defining a lumen therethrough, and a therapeutic element disposed on the distal end of the docking device; a transvaginal probe comprising a handle and an ultrasound transducer; and a generator configured to supply energy to the therapeutic element. The ovarian tissue apparatus may be capable of being advanced proximate to or within an ovary, and in the case of PCOS, an ovarian follicle/cyst or other target tissue (e.g., stroma). The ovarian tissue apparatus may also

include an engagement device, e.g., a docking device, as previously stated, which is configured to engage ovarian tissue. The engagement device may be configured to engage the outside surface of the ovary (e.g., the capsule), the outer regions of tissue within the ovary (e.g., the cortex), or the tissue inside the ovary (e.g., medulla, one or more follicles or cysts). One or more therapeutic elements can be advanced and/or deployed via the devices to apply one treatment or multiple treatments to the ovarian follicle or cyst and/or ovarian tissue. Alternatively, the one or more therapeutic elements can be mounted on the docking device. The therapeutic elements may deliver energy, e.g., radiofrequency energy, to effect treatment. The devices and therapeutic elements may be advanced, deployed, or otherwise positioned under image guidance, (e.g., transvaginal ultrasound, transabdominal ultrasound, endoscopic visualization, direct visualization, computed tomography (CT), or magnetic resonance imaging (MRI), optical coherence tomography (OCT), an ultrasound element on the device, or virtual histology). Pre-treatment planning may also be completed prior to performance of the procedure on the target tissue. For example, one or more of the following may be obtained: the size, volume, and/or location of the ovary; the size, volume and/or location of one or more ovarian follicles or cysts; and the size, volume, and/or location of the medulla, hormone levels, etc.

[0100] The ovarian tissue apparatus, docking device, therapeutic element, anchoring member, etc., may be made from polymeric materials (e.g., PEEK, polyester, ABS, nylon), metals (e.g., stainless steel), metal alloys (e.g., platinum-iridium), and shape memory materials (e.g., nitinol, elgiloy) all of which are known in the art, and thus are not described in detail here. In some variations, the diameter of the elongate body of the docking device may range from about 3 Fr (1 mm) to about 15 Fr (5 mm). In other variations, the length of the elongate body of the docking device may range from about 15 cm to about 60 cm.

[0101] The docking device may be a relatively rigid member (e.g., needle, trocar) or flexible member (e.g., catheter, steerable catheter) with features configured to help with engagement of ovarian tissues. For example, the distal tip of the docking device may include one or more releasably securable attachment elements to aid in engaging the docking device to ovarian tissues. The releasably securable attachment elements may comprise one or more hooks, needles, or barbs. Alternatively or additionally, the docking device may be coupled to a vacuum source to enable vacuum-assisted engagement of the tip of the device to ovarian tissue. In some

embodiments, the distal end of the docking device comprises a tissue engagement element. The tissue engagement element may have a preformed shape, e.g., a predetermined curvature.

[0102] In further variations, one or more therapeutic elements and/or anchoring members are delivered via the docking device. According to some embodiments, the therapeutic elements and/or anchoring members may be slidably disposed within the docking device. Here one or more ports may be disposed on the elongate body of the docking device through which the slidable therapeutic elements and/or anchoring members can be deployed into an ovarian tissue. Additionally or alternatively, the therapeutic element and/or anchoring member may comprise a lumen for delivering a thermal fluid, such as heated water or saline, or a biologic or pharmacological agent such as beta-blockers, anti-androgens (e.g., finasteride, flutamide, nilutamide, bicalutamide, spironolactone, cyproterone), follicular stimulating hormone, luteinizing hormone, other hormones, neurotoxins or tissue toxins (e.g., botox, guanethidine, ethanol), 5-alpha-reductase inhibitors (e.g., finasteride, dutasteride, izonsteride, turosteride, and epristeride), insulin modulating agents, or aromatase inhibitors (e.g., letrozole, exemestane, anastrozole), VEGF modulating agents, agents modulating inhibin, agents modulating interleukins, anti-cancer agents, pluripotent or multipotent stem cell preparations, or cellular components. Furthermore, an agent (e.g., radiopaque material, echogenic material, etc.) may be left behind to tag the location(s) in which the therapeutic agent(s) are delivered. The one or more ports may also be disposed on the tissue engagement element. Additionally or alternatively, the one or more therapeutic elements may include an electrode, a cryoablation element, an ultrasound transducer, a laser, or a combination thereof. The therapeutic element, docking device, or separate device may also contain a lumen (or lumens) with suitable size to deliver a sufficient volume of fluid, such as saline or lactated Ringer's solution, to fill the abdominal cavity. This fluid could be used to help separate tissues (move non-ovarian tissues away from the ovary to reduce risk of injury when treating the ovary), improve ultrasonic visualization by surrounding tissues with fluid, shift tissues into new locations for improved visualization, provide cooling or other protection to the ovary or neighboring tissues while treating the ovary, or promote healing of the ovary after the procedure is completed. In some embodiments, the inner diameter of the docking device may range from 0.25 to 3.0 mm, from 0.25 to 2.5 mm, from 0.25 to 2.0 mm, from 0.25 to 1.5 mm, or from 0.25 to 1.0 mm to allow suitable flow rate while infusing or withdrawing fluid from the abdominal cavity. In other

embodiments, the inner diameter of the docking device may range from 1.0 to 1.9 mm to allow suitable flow rate while infusing or withdrawing fluid from the abdominal cavity. In other variations, the docking device, therapeutic element, or anchoring member could be used to aspirate fluid from within the ovary or retrieve sample fluid from the abdominal cavity to detect the presence of substances, such as blood, intestinal (e.g., fecal matter), or biomarkers, that provide information regarding the safety or success of the procedure.

[0103] According to some embodiments, the system may also comprise an energy generator so that energy can be delivered to ovarian tissue via the therapeutic elements. The energy generator may be configured to deliver one or more of the following: radiofrequency energy, direct heating, cryoablation, cooling, laser, microwave, unfocused ultrasound, partially-focused ultrasound, focused (HIFU) ultrasound, heated water/saline, or steam. In addition, the energy generator may be powered using a disposable battery, a re-chargeable battery, or via mains power.

[0104] Additionally or alternatively, the system may also comprise a mechanical drive system so that the therapeutic element rotates and/or translates in order to disrupt and/or remove target tissue. The mechanical drive system may incorporate a motor, a drive train, and means for operatively connecting to the therapeutic element. In some embodiments, only mechanical tissue manipulation may occur, but in others, mechanical manipulation may occur in series or in parallel with thermal energy as a means to cut and/or cauterize the tissue to minimize the risk of bleeding.

[0105] The system may further include a processor that has an algorithm operable to run a feedback control loop based on one or more measured system parameters, one or more measured tissue parameters, or a combination thereof. In any of the embodiments described herein, one or more sensors may be included in the system and may be used to measure the one or more system or tissue parameters. The sensors may be temperature sensors, impedance sensors, pressure sensors, or a combination thereof. The temperature sensor may be used to measure electrode temperature. The target electrode temperature may range from about 80°C to about 100°C. In this instance, the duration of energy delivery may be about 120 seconds or less. The target electrode temperature may be about 80°C, about 85°C, about 90°C, about 95°C, or about 100°C. Energy delivered at the target electrode temperature may be for about 120 seconds, about 115

seconds, about 110 seconds, about 100 seconds, about 95 seconds, about 90 seconds, about 85 seconds, about 80 seconds, about 75 seconds, about 70 seconds, about 65 seconds, about 60 seconds, about 55 seconds, about 50 seconds, about 45 seconds, about 40 seconds, about 35 seconds, about 30 seconds, about 25 seconds, about 20 seconds, about 15 seconds, about 10 seconds, or about 5 seconds. The impedance sensor may be used to measure tissue impedance. When implemented, the feedback control loop may be configured to modify a parameter of energy delivery based on the measured one or more system or tissue parameters. For example, the parameter of energy delivery (or energy removal in the case of cooling/cryotherapy) that may be modified is duration of energy delivery, power, voltage, current, intensity, frequency, pulse, pulse width (e.g., duty cycle), temperature, type of energy delivery, flow rate, pressure, or a combination thereof. In another example, the system may deliver power in a manner to achieve a desired or predetermined target temperature, such as 80 to 120 degrees Celsius, 65 to 80 degrees Celsius, 80 to 90 degrees Celsius, or 90 to 100 degrees Celsius. Additionally or alternatively, the system may deliver power in order to achieve a desired target temperature but limit the power to some maximum power (e.g., 30 watts or less, 20 watts or less, or 10 watts or less) in the event the target temperature cannot be achieved.

[0106] Any of the systems disclosed herein may further comprise a user interface configured to allow user defined inputs. The user-defined inputs may include duration of energy delivery, power, target temperature, target impedance, target change in impedance, mode of operation, or a combination thereof. The mode of operation may be a coagulation mode, a heating mode, a cooling mode, a cryoablation mode, an ablation mode, a desiccate/char mode, an irrigation mode, an aspiration mode, mechanical disruption mode, tissue removal mode, or a combination thereof. Any of the systems disclosed herein may further comprise an automated treatment delivery algorithm that could dynamically respond and adjust and/or terminate treatment in response to inputs such as temperature, impedance, treatment duration, treatment power and/or system status. For example, the system may terminate power if a measured temperature exceeds 100 degrees Celsius. In another example, the system may terminate power if a measured impedance exceeds some predetermined value (e.g., 800 ohms) or the if a change in impedance exceeds a predetermined rise in impedance (e.g., 200 ohms above the measured impedance at the start of energy delivery). An increase in impedance could signify changes in tissue characteristics such as collagen denaturization, dessication, or char formation.

[0107] According to embodiments described herein, which may partially or as a whole combine with other embodiments, the system and method may include a transvaginal ultrasound probe for placement in the vagina to aid with visualization of tissue and/or navigation of system components. A docking/guiding device (e.g., a docking catheter) may be coupled to the ultrasound probe and advanced through the wall of the vagina directly into the peritoneal space to engage the surface of the ovary (e.g., the medial aspect of the ovary), or be advanced into the ovary, under ultrasound guidance. Via this docking catheter, a treatment device could be delivered/deployed such that one or more radiofrequency energy treatment elements, e.g. electrodes, are delivered within the ovary through a single entry point on the surface of the ovary. Following delivery of the treatments, aspiration could be applied at the aperture created in the ovary. Aspiration could also be achieved via holes or slots in or near an electrode that are connected to a lumen in the docking catheter. In an alternative embodiment, aspiration may be applied prior to and/or during delivery the treatments.

[0108] In some embodiments, e.g., prior to or after docking on/engaging the ovary, the system may include a spacing device that includes an expandable structure, or that is configured to infuse fluid for creating space around the ovarian tissues or for separating ovarian tissues. For example, the spacing device may contain scaffolding, one or more balloons, or at least one port for delivering fluid or gas into the space adjacent to the ovary, the purpose of which would be to aid in the separation of tissues such that the desired portion of the ovary could more optimally be accessed and such that therapeutic elements could be delivered in a way to minimize disruption of non-ovarian tissues. Referring to FIG. 2, in one embodiment the spacing device (20) may include scaffolding having an expanded configuration (22) and a collapsed configuration (not shown). Here the expanded configuration (22) is effected by movement of an outer shaft (24) relative to an inner shaft (26). Upon motion of the outer shaft (24) relative to the inner shaft (26), the scaffolding is able to transition from its collapsed configuration to its expanded configuration (22). Other expandable scaffolds may be constructed from self-expanding materials that are constrained for delivery then expanded via removing the constraint. The scaffold may be made from a polymer, metal, metal alloy, or combinations thereof. The scaffold may also comprise one or more wires, braid, a laser cut tube, or a slotted tube.

[0109] In the embodiment shown in FIG. 3, the spacing device (30) comprises a balloon (32) that is concentrically disposed about a shaft (34). The balloon (32) is inflated via fluid (e.g., a liquid or a gas) flowing through an infusion port (36) in the shaft (34).

[0110] In another embodiment, as shown in FIG. 4, the spacing device (40) includes a plurality of infusion ports (42) that may be located at the distal end/or in one or more locations along the length of the shaft (44) for the delivery of infusate (I) to create space around target ovarian tissues or to separate ovarian tissues. In some variations, the spacing devices may be used to displace non-target tissues (e.g., bowel) during advancement of system components, e.g., docking devices, from the vagina to the ovary.

[0111] Furthermore, FIG. 5 shows an embodiment of an atraumatic or flexible sheath-like device (50) that may be delivered and potentially guided via a blunt dissection element (52) and guidewire (54) or steering mechanism (not shown) through the vaginal wall and proximate to the ovary. Once positioned, the optional blunt dissection element (52) and/or guidewire (54) may be removed and the guiding/docking device and/or therapeutic element(s) may be delivered through the lumen of the outer sheath (56). The outer sheath (56) may serve as the guiding/docking device with optional aspiration used to engage the ovary or infusion to create additional space as described in association with FIG. 4. In some instances, the guidewire (54) may be sharpened and used to penetrate the ovary once the dissection element (52) is positioned proximate the ovary. In this configuration, the guidewire (54) may be positioned at a target location within the ovary. Once positioned, the dissection element (52) may be removed and replaced with therapeutic element(s) in an over-the-wire approach. The guidewire (54) may optionally be removed prior to applying therapy.

[0112] As previously stated, the guiding/docking device may be one component of the systems described herein, and could be utilized to facilitate access to the ovaries from the selected approach. The guiding/docking device may have a preset shape that facilitates navigation to the ovary and it could be torqueable. Additionally or alternatively, it could have a steerable tip that could be actuated by the handle. The guiding/docking device and the therapeutic device could also be combined into a single device, e.g., an ovarian tissue apparatus. The docking device generally comprises an elongate body (e.g., a needle, trocar or catheter) having a proximal end, a

distal end, a lumen extending from the proximal end through or until the distal end, and a distal tip. This lumen may be used to deliver fluid and/or to aspirate.

[0113] Docking to the ovary can be accomplished using various techniques. Referring to FIG. 6, docking to the ovary (60) can be accomplished by a docking device (62) that applies vacuum (64) through a lumen of the docking device (62). Alternatively, as shown in FIG. 7, docking to the outside of the ovary (70) may be accomplished by a docking device (72) via a concave surface or surface that was mildly abrasive on the docking device (not shown), or via one or more hooks (74) at the distal end (76) of the docking device (72) that are configured to secure to a desired section of the ovary (70). Instead of docking to the outside surface of the ovary, docking within the tissue of the ovary (80) can also be performed, as shown in FIG. 8. Here docking may be accomplished using a docking device (82) having one or more anchoring members (e.g., needles or wires) (84) that are deployable through or near the distal end (86) of the docking device (82), and which are configured to anchor within the tissue of the ovary (80). The needles, wires, or hooks may also be configured to deliver therapy (e.g., they may be wire electrodes or may further incorporate electrodes for delivering energy and/or may have mechanical motion applied to mechanically disrupt tissue). Alternatively, the docking device (62) may be configured to deliver therapy (e.g., one or more electrodes may be disposed at or near the distal end of the docking device). In some instances, it may be useful to secure the ovary in a manner that allows for repositioning for further treatments. Anchoring either the docking device and/or the therapeutic element in the target tissue may help the user to move the ovary relative to surrounding non-ovary tissues to improve and/or confirm visualization. Moving the ovary may also allow the user to more easily reposition the device for subsequent treatments.

[0114] Docking could further be accomplished using a docking device having a preset shape that is configured to fit the shape of the ovary at a specific location. In this variation, the docking device could be configured to engage ovaries having a size ranging from about 3 to 7 cm in length, about 1 to 4 cm in width, and about 0.5 to 4 cm in thickness. For example, as shown in FIG. 10, docking device (102) has a shaped portion (104) at its distal end that is shaped to fit the junction of the ovary (106) and the broad ligament (108) (e.g., near the mesovarium), and which could allow therapeutic elements (110) disposed therein to be advanced/delivered into

the ovary adjacent to the mesovarium (112). The multiple therapeutic elements (110) may be curved, but their structure is not so limited, and any suitable configuration may be employed. In one exemplary embodiment, the docking device may comprise a cup configured to engage at least a portion of the outer surface of an ovary. Here the cup may comprise a proximal end configured for communication with a vacuum source and a distal end for securing the ovary. The distal end of the cup can have an arcuate or annular surface configured to match the contours of the outer surface of the ovary. The distal end can also be sized to match the dimensions of a human ovary, wherein the distal end has a diameter of about 0.5 to 7.0 cm, about 0.5 to 6.0 cm, about 0.5 to 5.0 cm, about 0.5 to 4.0 cm, about 0.5 to 3.0 cm, about 0.5 to 2.0 cm, or about 0.5 to 1.0 cm. Additionally, the cup may comprise a conical geometry for accommodating a variety of ovary sizes.

[0115] Further embodiments of the docking mechanism may include securing the ovary at more than one point with a docking device. With such a device (90) as shown in FIG. 9, docking could occur at opposite sides of the ovary (92), which could facilitate delivery of therapy across the entire ovary or between multiple points on and/or within the ovary in a way that either mechanically penetrates or does not mechanically penetrate the outer surface of the ovary. A docking/guiding device (90) that grasps at two or more places on the ovary (92) may have the ability to be actuated or adjusted to widen or narrow the amount of ovarian tissue captured between its contact points. Alternatively, therapeutic elements may be delivered through the docking devices (90) and into the ovary (92), facilitating independent control of positioning the therapeutic elements.

[0116] FIGS. 11A and 11B depict yet further variations where the docking/guiding device (200) could be used to target and/or capture the mesovarium (202) (e.g., by looping around the mesovarium as shown in FIG. 11B) to deliver therapy to the mesovarium (202) and/or the suspensory ligament (206) or ovarian ligaments. In this configuration, therapy may be delivered via electrodes incorporated into the docking/guiding device (200), or via a separate element.

[0117] The therapeutic elements may have any suitable configuration, e.g., they may have any suitable length, diameter, flexibility, geometry, shape memory, etc. suitable for the ovarian tissue procedures described herein. In some variations, the therapeutic elements include one or more curved structures that comprise one or more electrodes. A therapeutic element such as those

depicted in FIG. 12A-12F comprising one or more curved structures with electrodes may be useful for a variety of reasons. The curved structure may aid in anchoring the device in the target tissue, limiting the risk of the device moving during treatment due to patient movement or user error. The curved structure may also be configured to match the contour of the ovary, allowing for improved positioning within a variety of sized or shaped ovaries. Additionally or alternatively, the curved structure may allow for longer or additional electrodes to be delivered and used simultaneously, allowing for larger ablation volumes per energy application. This feature may limit pain experienced by the patient and reduce procedure time. The curved structures may have a straightened length and an unconstrained radius of curvature. The straightened length may range from about 5.0 to about 40 mm, from about 5.0 to about 35 mm, from about 5.0 to about 30 mm, from about 5.0 to about 25 mm, from about 5.0 to about 20 mm, from about 5.0 to about 15 mm, or from about 5.0 to about 10 mm. The unconstrained radius of curvature may range from about 3.0 to about 10 mm, from about 3.0 to about 9.0 mm, from about 3.0 mm to about 8.0 mm, from about 3.0 mm to about 7.0 mm, from about 3.0 mm to about 6.0 mm, from about 3.0 mm to about 5.0 mm, or from about 3.0 mm to about 4.0 mm. In some embodiments, the unconstrained radius of curvature ranges from about 4.0 mm to about 6.0 mm.

[0118] The therapeutic elements may be advanced into the ovary in various ways. For example, and as shown in FIGS. 12A-12E, upon advancement of the docking device (300) through the capsule (316) of the ovary (304), the therapeutic element(s) (306) are advanced from inside the ovary (304) to a target location(s) within the ovary (304). The therapeutic elements may be curved (FIG. 12A, 306) or straight (FIG. 12B, 308), or they may take a spiral or helical configuration (FIG. 12C, 310) or a random configuration (not shown) when deployed, e.g., within an ovarian cyst (312). Alternatively, and as shown in FIG. 12D, the therapeutic element (314) may be configured to track about at least a portion of the perimeter of the ovary (304) such that therapy targets tissue proximate the cortex or follicles of the ovary (304). Alternatively, the therapeutic element may be configured to track about at least a portion of the ovary at or near the junction of the stoma and cortex such that therapy may target tissue proximate to this junction. The therapeutic elements may be provided as a feature of the guiding/docking device. They may also be provided as elements that can be deployed from a lumen within the guiding/docking device or sheath-like device, as shown in FIG. 5. The therapeutic elements (306) may be shaped

such that they releasably secure the device within the tissue when deployed, as shown in FIG. 12A.

[0119] The one or more therapeutic elements (306, 308, 310, 314) may be advanced from the docking device (300) into the ovary (304) one or multiple times and deployed within the ovary proximate to or within ovarian follicles or cysts, or other target tissue. One benefit of this method may be that multiple therapies (e.g., multiple sequential therapies where a single therapeutic element is repositioned, or sequential/simultaneous deployment of multiple therapeutic elements) could be delivered through a single entry/access point (302) on the surface of the ovary, which may minimize the risk of adhesions.

[0120] FIG. 12E depicts a variation where the docking/guiding device (300) is used to penetrate into the ovary (304) and permit delivery of one or multiple therapeutic elements (318) and/or anchoring members out of the distal tip (320) or through one or more side ports (322). The docking/guiding device (300) may comprise, for example, a 14 to 18 gauge needle approximately 20 to 45 cm long, and the therapeutic element (318) may comprise, for example, one or more 0.020 cm to 0.076 cm diameter metal wire(s) or tube(s) that exit the side port (322), as shown, or the distal tip (320). However, the diameter of the metal wire may be as large as 0.140 cm. In the case of a tube, the diameter may be as large as 0.170 cm or as large as 0.211 cm. In some cases, the wire may simply be a straight wire, but in other variations, the distal portion of the therapeutic element (318) may be processed to have a pre-set shape (e.g., a curve), as shown in FIG. 12E. In the case where a curved tube or tubular-like structure is used as part of the therapeutic element, the tube geometry may be altered to increase its flexibility, e.g., laser-cut pattern to remove material from the tube. The therapeutic element may be insulated along the majority of its length to electrically isolate it from the docking device (e.g., via a polyimide sleeve, PET heat shrink), if it is constructed of metal. As such, only the distal portion of the wire(s) or tube(s) that extend beyond the distal end or side port would deliver therapeutic doses of energy to the tissue from the energy generator. When two wires or tubular-structures are employed, they may be deployed in a geometry similar to that shown in FIG. 12A with a distance between the tips of the wires ranging from approximately 3 to 20 mm apart. However, in other instances the distance between the tips of the wires may range from about 7.0 to 10 mm apart, or up to about 15 mm apart. In some cases, the cross-section of the wires or tubular-

structures could consist of a non-round geometry to reduce their profile when withdrawn into the docking device. For example, as depicted in FIG. 40, the cross-sections could have a D-shape (4020) where the flat portions (4021) are oriented towards one another when withdrawn into the docking device (4022).

[0121] The docking/guiding device may also be configured to rest on the outer surface of the ovary (i.e., the distal tip of the docking device is not inserted into the ovary). For example, as illustrated in FIG. 12F, the docking device (300) may include a wider element or shelf (324) proximal to the therapeutic element (326) to act as a backstop and prevent it from penetrating deeper into the ovary than a preset distance. For example, the shelf may have a diameter greater than or equal to about 20% larger than the diameter of the element to be inserted into the ovary.

[0122] Referring back to FIG. 10, the side holes (114) of the guiding/docking device (102) could alternatively be used to facilitate delivery of the therapeutic elements (110) in a pre-specified consistent pattern of multiple entry points of the ovary. This could be done to allow consistent targeting of a preferential portion of the ovarian tissue or to deliver a preferential pattern of therapies.

[0123] The system may also provide features that are configured to rotate the one or more therapeutic elements during application of energy to facilitate driving the therapeutic elements through the tissue (e.g., cutting, removing, or ablating a volume of tissue), resulting in a larger treatment zone.

[0124] The total affected volume of tissue within a given ovary may range from about 240 mm³ to about 3000 mm³, with a single ablation volume ranging from about 30 mm³ to about 3000 mm³. In some instances, about 3% to about 20% of the ovarian volume is affected, e.g., by ablation. The system may be configured such that ablations do not extend beyond a certain distance from any edge of the electrode(s), e.g., 5 mm. The system may be further configured such that the ablations are non-spherical in shape, e.g., the in-plane longest dimension is greater than 2 times the perpendicular depth. The system may be further configured such that ablations can be delivered within the ovary in a way that spares tissue within 2 mm of the outer surface (capsule) of the ovary.

[0125] Referring to the exemplary stepwise illustration in FIGS. 13A to 13D, a guiding/docking device (400) is advanced into the ovary (402) and curvilinear therapeutic elements (404) deployed from a location inside the ovary to a target area(s) (FIGS. 13A and 13B). The curvilinear therapeutic elements (404) are then rotated in the direction of the arrow shown in FIG. 13C to affect, e.g., ablate, a volume of tissue (FIG. 13D, 406). A variety of the therapeutic elements described herein may be rotated and/or translated during the application of energy to reduce force required to traverse through tissue, cut, coagulate, desiccate/char, reduce treatment time and/or create a larger treatment zone. These techniques may be employed with other therapeutic elements as described herein and are not limited to those shown in FIGS. 13A to 13C. The system may also provide features that are configured to move the therapeutic elements within a single 2-dimensional plane through the tissue during application of energy to facilitate driving the therapeutic elements through the tissue (e.g., cutting), resulting in a larger treatment zone, which is depicted in the stepwise illustration of FIGS. 14A to 14E. Referring to FIGS. 14A to 14E, a guiding/docking device (500) is advanced into the ovary (502) and curvilinear therapeutic elements (504) deployed from a location inside the ovary to a target area(s) (FIGS. 14A and 14B). The curvilinear therapeutic elements (504) are then actuated in the direction of the arrows to change from an open configuration (FIG. 14C) to a closed configuration (FIG. 14D) to affect, e.g., ablate, a volume of tissue (FIG. 14E, 506). Although curved therapeutic elements are depicted, therapeutic elements comprising any suitable geometry, e.g., straight therapeutic elements, may be employed. Further, it is understood that any suitable therapeutic element described herein may be translated in a 2-dimensional plane of tissue during the application of energy to reduce force required to traverse through tissue, cut, coagulate, desiccate/char, reduce treatment time and/or create a larger treatment zone.

[0126] According to embodiments described herein, which may partially or as a whole combine with other embodiments, the therapeutic element may also comprise an expandable balloon that may be used to anchor the device within the tissue, mechanically disrupt tissue and/or deliver thermal energy (e.g., RF, microwave, ultrasound, direct heat) or cooling (e.g., cold saline, or cryotherapy). In one variation, as shown in FIG. 15A, a balloon (600) is mounted on the guiding/docking device (602). In another variation, as provided in FIG. 15B, the balloon (600) is delivered through the guiding/docking device (600) by pushing it out. In a further variation, the guiding/docking device may be advanced through the ovarian tissue to create a

channel into which the balloon is delivered as the guiding/docking device is subsequently retracted. One or more electrodes, antennae, or ultrasound transducers may be positioned within the balloon or on the balloon surface to induce heating of tissue directly and/or indirectly. Alternatively, a cold or cryogenic material may be delivered and removed/outgassed via lumen(s) within the guiding/docking device to induce cooling or freezing of tissue.

[0127] FIG. 31A depicts another embodiment of a docking/guiding device having a single therapeutic element deployed from the lumen within it. Here the docking/guiding device (301) may comprise, for example, a 14 to 18 gauge needle approximately 20 to 45 cm long, and the therapeutic element (305) may comprise, for example, a curved shaft having a diameter of about 0.05 cm to about 0.13 cm, or having a diameter of about 0.10 cm to about 0.18 cm, and two electrodes disposed thereon, as shown. The shaft may have a pre-set shape (e.g., a curve with radius 0.38 cm to 1.6 cm, or other shape that deploys away from the centerline of the docking/guiding device). The pre-set shape may serve multiple purposes such as anchoring the device within the ovary (to limit the risk of the device moving due to patient movement or user error), orienting the therapeutic element to be more normal to the ultrasound transducer in order to increase echogenicity, and increasing the total length of the therapeutic element that can be located within the ovary. The pre-set shape may also enable the therapeutic element to more readily reach different locations within the ovary, as compared to a straighter element, and thereby reduce the amount of manipulation by the docking/guiding device and/or reduce the number of punctures to the ovary. FIG. 41 depicts one example where the docking/guiding device (1803) has punctured the ovary (1801) along the shorter axis (1807) of the ovary (e.g., the axis of the docking/guiding device (1803) and axis of the ultrasound probe (1809) are more parallel to a shorter axis (1807) of the ovary than a longer axis (1808) of the ovary). Due to the geometry of many ovaries, particularly polycystic ovaries, and the route of access using transvaginal ultrasound guidance, the tip of the ultrasound probe (1802) may be more readily located proximate to the ovary (1801) along its shorter axis (1807). If the ultrasound probe (1802) were to be located more parallel to a longer axis (1808), then the ovary (1801) may be more likely to move away from the tip of the ultrasound probe (1802). In the example depicted by FIG. 41, the docking/guiding device (1803) has punctured the ovary along the shorter axis (1807). In some cases, it may be desirable to affect the ovarian cortex (1804), the junction between the ovarian cortex (1804) and ovarian stroma (1805), and/or ovarian stroma (1805).

More or all of a therapeutic element (1806) with a shape that deploys away from the centerline of the docking/guiding device (1803) is able to be located within the cortex (1804) and/or within the junction. On the other hand, a straighter therapeutic element would have less area in contact within the cortex (1804) or junction between cortex (1804) and stroma (1805), in this example. The therapeutic element may be insulated along the majority of its length to electrically isolate it from the docking device (e.g., via a polyimide sleeve, PET heat shrink, Parylene, nylon, Pebax), if it is constructed of metal. As such, the uninsulated portions would be electrically connected to the energy generator. In another variation, therapeutic element may be comprised of a non-electrically conductive shaft with one or more electrically conductive elements, e.g., electrodes. As previously described, the electrodes may wrap around the entire circumference of the shaft or may only cover a portion of the shaft circumference, in which case the electrodes may or may not be angularly offset from one another. The electrodes could be electrically isolated from each other and deliver energy in a monopolar or bipolar fashion. In a bipolar configuration, one electrode would serve as the active electrode and the other electrode would serve as the return electrode. In another variation, both electrodes could delivery energy and the energy would return to a neutral electrode located elsewhere, such as on the skin of the patient, on the docking/guiding device, or on the ultrasound probe. The electrodes could also be electrically connected to each other and deliver energy where the return or neutral electrode (not shown) is located elsewhere, such as on the skin of the patient, on the docking/guiding device, or on the ultrasound probe. The electrodes may have a length of about 0.10 cm to about 2.5 cm; a diameter of about 0.05 to about 0.4 cm, about 0.05 to about 0.3 cm, about 0.05 to about 0.2 cm, about 0.05 to about 0.1 cm, about 0.2 to 0.4 cm, about 0.1 to 0.15 cm, or about 0.076 cm to 0.14 cm; and spacing of 0.050 cm to 0.64 cm.

[0128] Increased echogenicity may also be employed on the therapeutic element, so that the physician knows the position of the therapeutic element during positioning and treatment. This may be achieved by methods previously described herein, including a surface feature and/or echogenic material, such as a roughened surface covered by a polymer sheath or surface indentations covered by a polymer sheath, which traps gas between the grooves of the roughened/indented surface and the polymer sheath. The trapped gas enhances the echogenicity beyond using merely a roughened/indented surface. Additionally or alternatively, the therapeutic element could contain a beveled needle tip that is angled and oriented in front of the

ultrasonic transducer such that the tip maximizes its echogenicity. In another embodiment, the portion of the therapeutic element located just proximal of the beveled needle tip could be designed to allow more sound waves from the ultrasound system to pass by and therefore reduce the echogenicity of that region. The difference in echogenicity between the tip and the portion just proximal of the tip would further differentiate the tip and provide the user enhanced feedback of the tip location within the ovary.

[0129] FIG. 31B depicts another embodiment of a docking/guiding device incorporating a therapeutic element (305) and an anchoring member (315). Here, the docking/guiding device (301) may comprise, for example, a 14 to 18 gauge needle approximately 20 to 45 cm long, with the therapeutic element (305) located near the distal end (307) and a deployable anchoring member (315) exiting the distal end (307) of the needle in its deployed state. In this case, the therapeutic element may be comprised of two electrodes (309) disposed on the needle shaft with insulation (e.g., via a polyimide sleeve, PET heat shrink, Parylene, nylon, Pebax) provided between the shaft and the inside surface of the electrodes (309) to electrically isolate the electrodes from the needle. In some cases, the insulation may extend along most or all of the length of the needle to provide electrical isolation between the electrodes and other metal components of the system (e.g., outside surface of needle and/or inside surface of needle guide). The electrodes may have a length of about 0.10 cm to about 2.5 cm; a diameter of about 0.05 to about 0.4 cm, about 0.05 to about 0.3 cm, about 0.05 to about 0.2 cm, about 0.05 to about 0.1 cm, about 0.2 to 0.4 cm, about 0.1 to 0.17 cm, or about 0.076 cm to 0.14 cm; and spacing of 0.050 cm to 0.64 cm. The electrodes (309) may also be part of the docking device (301) in the event that the docking device is constructed from an electrically-conductive material such as metal; in this case, discrete portions of the docking device would be insulated (311) and the uninsulated portions could serve as electrodes, as shown in FIG. 31C. Increased echogenicity may also be employed at or just proximal to the proximal electrode, so that the physician knows the position of the therapeutic element during positioning and treatment. This may be achieved by methods previously described herein, including a surface feature and/or echogenic material, such as a roughened surface covered by a polymer sheath or surface indentations covered by a polymer sheath, which traps gas between the grooves of the roughened/indented surface and the polymer sheath. The trapped gas enhances the echogenicity beyond using merely a roughened/indented surface. Another method for enhancing echogenicity near the proximal

treatment zone is to configure the proximal electrode with an asymmetric geometry such that rotating the device would enhance the detectable motion, and thus enhance the echogenicity, of the asymmetric electrode. Mechanisms for creating the asymmetric electrode geometry include cutting a notch (1701) out of an edge of the electrode or adding a hole (1702) to the electrode (1703), as shown in FIG. 38A and FIG. 38B. Similarly, material, e.g., a thin rectangular member (1704), could be added to a portion of the circumference of the shaft near the electrode (1703), as shown in FIG. 38C, or added to the electrode itself. Another example of added material may include a band (1705) that fully or partially surrounds the circumference of the docking/guiding device and/or electrode, as shown in FIG. 38D. Adding material could also include shaping the base material, e.g., the metal shaft carrying the electrode, by indenting it outwards to cause a protrusion in the shaft surface. Rotating the device would cause the added or raised material to enhance the detectable motion under ultrasound due to the asymmetry around the axis, and thus enhance the echogenicity. The enhanced echogenicity would provide the user more confidence that position of the electrode or electrodes are in the desired target area. As previously described, the electrodes may wrap around the entire circumference of the shaft or may only cover a portion of the shaft circumference, in which case the electrodes may or may not be angularly offset from one another. The electrodes could be electrically isolated from each other and deliver energy in a monopolar or bipolar fashion. In a bipolar configuration, one electrode would serve as the active electrode and the other electrode would serve as the return electrode. In another variation, both electrodes could delivery energy and the energy would return to a neutral electrode located elsewhere, such as on the skin of the patient, on the docking/guiding device, or on the ultrasound probe. The electrodes could also be electrically connected to each other and deliver energy where the return or neutral electrode (not shown) is located elsewhere, such as on the skin of the patient, on the docking/guiding device, or on the ultrasound probe. The anchoring member (312) may comprise, for example, a curved shaft having a diameter of about 0.05 cm to about 0.13 cm or a diameter of about .03 cm to about 0.15 cm. The shaft may have a pre-set shape (e.g., a curve with radius 0.38 cm to 1.6 cm) and may be constructed from metal, polymer, or combinations thereof. A curved anchor (312) could be deployed from the distal tip of the docking element (307) as shown in FIG. 31B or proximal of the electrodes as shown in FIG. 31C. The anchor could also be more linear but deploy away from the docking device at an angle of about 45 degrees or at an angle of 15 to 60 degrees as shown in FIG. 31D. The total length of straight or non-straight anchor may range from about 1.0 to about 30 mm,

from about 2.0 to about 5.0 mm, from about 2.0 to about 10 mm, from about 5.0 to about 10 mm, from about 3.0 to about 7.0 mm, from about 10 to about 15 mm, or from about 10 to about 20 mm. The distal portion (313) of the anchoring device may be preferentially echogenic, relative to the rest of the anchoring member to provide the physician with visual confirmation of its position. The anchor could also serve as an echogenic marker for the electrode locations. By deploying away from the centerline of the docking or therapeutic element, the echogenicity of that area around the anchor is enhanced, especially when translational or rotational motion is applied to the overall device. For example, if the anchor is deployed just proximal of the electrodes as shown in FIG. 31C and FIG. 31D, then this would provide more visual confirmation to the operator of the electrode position within the ovary. In another embodiment, two or more anchors could be deployed to both stabilize the therapeutic element as well as provide echogenic markers for the distal edge of treatment zone and for the proximal edge of the treatment zone. Clear visual indicators of the treatment zone are useful since they provide the physician with more confidence that the therapeutic element is located in a desired and/or safe location. Providing these echogenic indicators, using any of the systems or methods described herein, could be accomplished by placing them on the therapeutic element, anchoring element, docking/guiding element, or combination thereof. As further described herein, it may also be advantageous to maintain planar orientation of the anchoring member with the plane of the ultrasound probe

[0130] Other systems and methods may be employed for manipulating ovulation or for treating infertility, polycystic ovary syndrome, or other diseases/disorders of the ovary as illustrated in FIGS. 16A to 16D. For example, the guide/docking device (700) may be advanced through the ovary (702) in either a straight path (FIG. 16B) or in a meandering/directed path (FIG. 16A). This could be done under imaging to ensure that the guiding/docking device (700) was placed in a desirable location throughout the delivery. The therapeutic element (706) could then be delivered through a lumen on the guiding/docking device (700) and into a follicle or cyst (708) and/or channel (710) created by the guiding/docking device as it was retracted. Aspiration could be performed by the guiding/docking device (700) as it is being delivered or retracted. Alternatively, aspiration could also be performed through the therapeutic element (706). Alternatively, no aspiration could be performed. Once fully deployed, the position of the entire therapeutic element (706) can be confirmed in real-time using 2D or 3D imaging (e.g.,

transvaginal ultrasound), allowing for all planned treated areas to be assessed/confirmed prior to application of energy. If desired, the therapeutic element may be recaptured and re-deployed to optimize position. Then, energy may be applied via the therapeutic element, which is electrically coupled to an energy generator. Optionally, the guide/docking device (700) and therapeutic element (706) can be retracted to the next desired treatment location, and energy applied. This optional step may be repeated until all desired treatments are performed, resulting in a treated section. Alternatively, and as shown in FIG. 16D, a longer portion of the therapeutic element (706) can be exposed to multiple regions of the ovary by an extended retraction of the guiding/docking device (700). The treated section may be created by a single application of energy over the length of the therapeutic element, multiple applications of energy over portions of the therapeutic element, or by continuously applying energy while simultaneously retracting the guide/docking device (700) and/or therapeutic element (706). The exemplary therapeutic element (706) used in this instance could be an expandable mesh. FIG. 17 depicts an alternative therapeutic element comprised of a flexible wire, cable, or coil (800). The expandable mesh material may enhance or maximize contact with tissue, especially within a follicle or cyst. Another example of a therapeutic element that could be used in this setting is a balloon (e.g., as shown in FIGS. 15A and 15B). Any of the other therapeutic elements disclosed herein may also be utilized to administer treatment via this method. The therapeutic element may also have an atraumatic tip.

[0131] In the case of mechanical disruption, the therapeutic element may comprise a rotating or translating element capable of mechanically manipulating (e.g., destroying, stimulating) target tissue, as illustrated in FIG. 18A to 18D. Here the tip (900) of a guiding/docking device (902) may be used to facilitate access into the ovary (904). Once positioned in a desired location within the ovary (904), a mechanical disruption element (906, 908) may be advanced in the direction of arrow (910) into the tissue. Once deployed, the mechanical disruption elements (906, 908) may be rotated in the direction of arrows (912) and/or translated in the direction of arrows (914) to disrupt tissue. Motion of the therapeutic element may be performed manually via a handle at the proximal end of the device or via a motor and/or drive train (battery or mains powered). Mechanical disruption elements may take the form of a solid screw-like component (906), an expandable wireform component (908), or other geometry that facilitates desired tissue disruption. The expandable wireform component (908) may be comprised of a self-expanding

material (e.g., spring steel, nitinol, elgiloy) that expands as tissue is morcellated. The therapeutic element may also incorporate one or more electrodes used to delivery energy to heat target tissue, ablate target tissue, cauterize blood vessels, and/or cut tissue. The morcellated tissue may be retrieved in some instances if it can be used for diagnosis, or if it contains either oocytes or cellular components that may be useful in further care. Electrodes may be either separate elements mounted on the therapeutic element or the therapeutic element itself. In some variations, it may be useful to administer a chemical cauterizing agent (e.g., silver nitrate) to control bleeding after morcellated tissue is retrieved.

[0132] The therapeutic element(s) may be constructed from a variety of materials and in a variety of geometries. In its simplest form, the therapeutic element may be comprised of round wire. Alternatively, as shown in FIG. 19, the therapeutic element (1000) may be disposed at the distal end (1002) of a guiding/docking device in a manner such that it is capable of expanding upon deployment. In some embodiments, the therapeutic element (1000) may be constructed of a metal tube or wire (e.g., nitinol, elgiloy, spring steel) with characteristics that allow for it to be shaped into an expanded configuration (1006) and a collapsed configuration (1008), and to form a sharp end (1010). The metal tube or wire may be laser cut or otherwise processed to split the tube or wire in half along a defined length (1012), which may, for example, range from about 1-3 cm. The metal tube or wire may further be cut, ground or otherwise processed to form a sharp end (1010). Once cut, the two (as shown) or more therapeutic elements may be shape set or formed into an expanded configuration (1006). When constrained by a sheath (1004), the distal end is collapsed, and an exposed portion of the sharp end (1010) used to penetrate the tissue and position the device. Once in position, the therapeutic element (1000) may be advanced out of the sheath and expanded into the tissue. Alternatively, the outer sheath (1004) may be retracted to allow the therapeutic element (1000) to become exposed. In some instances, additional manipulation and/or application of energy may be required to facilitate expansion of the therapeutic element. Energy may simultaneously or sequentially be applied to affect the target tissue. These techniques may also be employed with the variety of therapeutic elements described elsewhere herein.

[0133] FIGS. 20A to 20C depict embodiments of exemplary light-based therapeutic elements that may be used to heat or ablate target tissue. FIG. 20A shows a fiber optic approach where a

light fiber (2000) is deployed from the distal end of a guiding/docking device (2002), shown here as a needle. Once the light fiber (2000) is positioned proximate the distal end (2004) of the guiding/docking device (2002), it may be activated to generate heat within the target tissue. The light fiber (2000) may be repositioned and activated in multiple locations to complete the therapy. In some cases, it may be desirable to extend the light fiber (2000) beyond the distal end (2004) of the guiding/docking device (2002) up to about 1cm. In other cases, it may be desirable to recess the light fiber (2000) proximal to the distal end (2004) up to about 5mm.

[0134] FIG. 20B shows another variation where light (2006) from one or more light fibers (not shown) exits the side of the guiding/docking device (2002) via holes (2008). Once positioned, the individual light fibers may be activated one at a time, in pairs, in groups, or all simultaneously. Further, all fibers may activate at the same or different power levels. Depending on the configuration, the energy distribution around the circumference of the guiding/docking device (2002) may be symmetric/concentric or asymmetric/eccentric.

[0135] In some variations, the same light fiber(s) used to deliver energy may also be configured to measure temperature via operatively connecting the fiber to an IR temperature sensor. The light fiber may then switch back and forth or multiplex in order to intermittently monitor temperature during the treatment.

[0136] FIG. 20C shows an alternative light-based device where a laser diode (not shown) and prism (2010) are used to deliver energy to the target tissue. In this case, the laser diode may be located anywhere proximal to the prism (2010), which is located near the distal end of the guiding/docking device (2002), depicted as a needle in this example. Once activated, the prism (2010) may direct the energy out one or more side holes (2012) to generate the desired heat within the target tissue. If the laser wave length were extended into the infra-red range (e.g., ≥ 800 nm), then light absorbing dyes could be used to increase the range or size of affected tissue. Such dyes may be injected at the site through a lumen in the guiding/docking device (2002) just prior to activating the laser.

[0137] The therapeutic elements may also include multi-polar embodiments, as shown in FIGS. 21A to 21B. Multi-polar electrode approaches would have the effect of increased flexibility and/or control over lesion formation. Since each electrode can be controlled

independently, each may also be capable of monitoring tissue characteristics (e.g., impedance or temperature). These characteristics may be used by the controller and/or user to adjust the application of energy to optimize therapy and/or provide safety shut-offs. For example, if the temperature of two electrodes is lower than a pre-specified target and the other two electrodes are at or above said pre-specified target, the controller may increase the power level to those two electrodes to increase the tissue temperature at those two electrodes. FIG. 21A depicts a multifilar configuration where multiple (e.g., four) electrodes (3000) are spaced around the circumference of a guiding/docking device (3002) with a layer of insulation or insulative jacket (3004) (e.g., PET heat shrink) between the electrodes (3000) and the guiding/docking device (3002). Herein the guiding/docking device (3002) is constructed from metal (e.g., a 14 to 18 gauge needle). The electrodes (3000) consist of individual conductive wires that are adhered to the insulative jacket (3004) and extend along the length of the guiding/docking device (3002) and are electrically isolated from one-another via an insulative jacket (3006) (e.g., PET heat shrink) along the proximal shaft. In this configuration, the active length of each electrode may range from about 3 mm – 15 mm, and the diameter of each electrode may range from about 0.012 cm – 0.026 cm. In an alternative embodiment each conductive wire may be individually insulated along the proximal length with insulation removed along the distal portion to form the electrodes. These electrodes may be energized, for example, in a monopolar or bipolar (e.g., 90° or 180° apart in a four electrode configuration) fashion.

[0138] In yet a further variation, as shown in FIG. 21B, multiple (e.g., four) circumferential electrodes (3008) are positioned around the guiding/docking device (3002) with insulative layers similar to those described in FIG. 21A. In this configuration, the electrodes may be comprised of metallic bands, coils, or wires and may be spaced apart by about 3mm – 5mm. These electrodes may be energized, for example, in a monopolar or bipolar (e.g., adjacent or alternating pairs) fashion.

[0139] The energy delivery element may also comprise a bipolar coaxial needle device, as depicted in FIG. 22, where the outermost element is the return electrode (4000), which in this variation consists of a 16 to 18 Gauge hypodermic tube insulated on the outside with a layer of polyester shrink tubing or other non-conducting material (e.g., parylene) (4002). The insulating layer begins at a specified distance, L1, from the distal end (4010) and extends fully proximal.

Inside the outermost element is the active electrode (4006), consisting of either a solid shaft or hollow tube, with an insulating layer (4008) beginning a specified distance, L2, from the distal tip (4004) and extending fully proximal. L1 and L2 may range from approximately 2 to 8mm. In some instances, the distance between the two electrodes is fixed, but in others, it may be adjustable. If adjustable, the generator may be configured to detect changes in the distance and display recommended power settings or automatically adjust power settings based on detected distance. By way of example, should the distance increase, the power and/or time may be increased. Alternatively, there may be a mechanical indicator at or near the proximal end of the device (e.g., incorporated into the handle) that shows the distance along with the recommended power level. In this case, the operator would then manually set the power via the user interface on the generator. If the return electrode (4000) is significantly larger than the active electrode (4006), bipolar application of energy may result in substantial heating of the active electrode with minimal or no heating of the return electrode. This would allow for a single lesion to be generated proximate the active electrode without the need for a separate neutral electrode placed on the patient's skin. It would also allow for the neutral electrode to monitor tissue characteristics in contact with it, which may be used as an indicator of when to cease treatment. For example, the active electrode may heat tissue via resistive and/or conductive heating until the neutral electrode detects an increase in temperature or impedance. The system may then cease application of energy should a pre-set or user-controlled threshold be reached. If the distance between the electrodes is adjustable, it provides the advantage of user adjustability. For example, if the patient has a very large ovary, the user may choose to position the electrodes further away from each other to generate a larger lesion, thus reducing procedure time. In this instance, both electrodes may be approximately the same size, such that they both heat the tissue and potentially create a continuous lesion between them via resistive and/or conductive heating.

[0140] As previously stated, the therapeutic elements may consist of one or more of the following: a radiofrequency energy element; a direct heating element; a cryoablation element; a cooling element; a mechanical disruption element; a laser/light; a microwave antenna; an unfocused ultrasound element; a partially-focused ultrasound element; a focused (HIFU) ultrasound element; and/or means for delivering heated water/saline, steam, a chemical ablation agent, a biologic or pharmaceutical agent, a drug-eluting implant, a radioisotope seed, or a mechanical implant, which may be either passive or active via application of remote energy

(e.g., ultrasound to induce vibration). There may be mechanical methods built into the device design to prevent the therapeutic element from being advanced more deeply than a predetermined depth.

[0141] If energy is being applied via one or more electrodes or elements, it may be applied in a monopolar, bipolar, or combined fashion; each element may fire simultaneously or sequentially; energy may be applied in a continuous or pulsed fashion, and the system may have a user interface (FIG. 23, 5010) that allows the user to choose which electrodes or elements are active to customize the therapy for each patient. Different combinations of electrodes could be used to deliver energy such that patterns of treatment are achieved. For example, one embodiment could contain three electrodes (A, B, C). Any or all three could deliver energy in a monopolar fashion and/or any combination of electrodes could also deliver energy in a bipolar fashion (e.g., A to B, B to C, A to C). Energy delivery could alternate in pulses (mono A, followed by mono B, followed by mono C, followed by bipolar A to B, bipolar B to C, etc.). Or, different frequencies of energy could be delivered simultaneously or sequentially (e.g., mono at 465 kHz and bipolar at >1 MHz). These combinations may also be used for tissue mapping prior to or during the delivery of therapy. A monopolar application of energy would have the effect of generating a treatment area adjacent to the electrode and may be used to generate larger lesions at higher power in shorter time, relative to a bipolar application. A bipolar application of energy would have the effect of generating a treatment area adjacent to each electrode with the potential to create a continuous lesion spanning the volume between the electrodes via either resistive or conductive heating. A bipolar application of energy may also allow for lower power and smaller lesions. In addition, a bipolar application of energy may also allow for tissue characteristics (e.g., impedance, temperature) to be monitored at each electrode and adjustments made either before (e.g., user or system selected based on tissue characteristics, such as impedance, or based on electrode position) or during treatment (e.g., switching which electrode is active versus the return). A combined application of both monopolar and bipolar energy would also have the effect of generating a treatment area based upon tissue characteristics monitored at each electrode or between pairs of electrodes (e.g., impedance, temperature) with the added ability to use a single electrode, if appropriate. In this instance, the return electrode may be outside the ovary or on the skin of the patient. A continuous application of energy may have the effect of generating a lesion via a combination of both resistive and conductive heating.

Application of energy in a pulsed fashion would limit the amount of conductive heating and may allow for additional measurements to be made between pulses, when energy is turned off or reduced to a lower power. These additional measurements may then be used to alter or cease the application of energy and/or to provide additional feedback to the user. The use of different frequencies may allow for reduced or increased electrical coupling between multiple conductors (e.g., wiring) or electrodes. In the case of tissue mapping, the use of different frequencies may elicit different responses from different types of tissues and/or different states of tissues (e.g., ablated tissue or unablated tissue). Furthermore, in the case of ablation creation, the use of different frequencies may create different lesion characteristics.

[0142] A generator is generally included in the systems described herein to create energy to be delivered through the therapeutic element(s). The systems may include sensing elements on either the therapeutic element and/or on the guiding/docking device to detect parameters such as temperature, impedance, or other parameters that could guide therapy delivery. A feedback control system may use detected parameters within software algorithms such that treatment is delivered automatically and could be automatically stopped when certain temperature, time, power and/or impedance thresholds have been crossed. The system could also deliver two or more different sets of energy parameters. For example, the system could be configured to deliver lower energy or temperature for a longer time (e.g., to ablate and/or otherwise affect a larger volume of tissue) and higher energy or temperature for a short time (e.g., to control bleeding and/or desiccate/char tissue to enhance visualization). The parameters of the therapeutic element or the pattern of the targeting within the ovary could be configured to preferentially target certain regions and/or tissues and spare others. The sensing elements could also be used before treatment is applied to characterize or map the target tissue; for instance, impedance measures could be used to sense if the docking/guiding device and/or therapeutic element is adjacent or within follicles or cysts, to sense if portions the docking/guiding device and/or therapeutic element are within the ovary or outside the ovary, or to sense where portions of the docking/guiding device and/or therapeutic element are relative to the vasculature or other important structures. The sensing elements could also be used during treatment to dynamically adjust treatment parameters. The sensing elements could be used to measure temperature and/or impedance. For example, a temperature-sensing element could be located on each of a plurality of electrodes. In some variations, two temperature-sensing elements could be located on a single

electrode. Power could be adjusted based on the hottest temperature-sensing element or could be adjusted based on some combination of the multiple sensing elements, such as an average or weighted average. In another example comprised of bipolar electrodes and temperature sensing elements on each electrode, the active electrode (the electrode delivering the energy) could be interchanged with the return electrode before or during energy delivery based on the measured temperatures and/or impedances.

[0143] Furthermore, the sensing elements could also be used to detect if the device moves inappropriately during the treatment delivery. For example, device movement could be inferred by sensing sudden changes in temperature, impedance, and/or power. In one variation, the sudden changes could be based on an instantaneous measurement exceeding some predetermined threshold away from an averaged measurement. In another variation, the variance of a signal, such as power, could be tracked during treatment and movement could be inferred when the variance deviates by a predetermined threshold, such as a percentage difference. If movement is inferred, then the generator could automatically terminate energy delivery and/or inform the user that the device has moved.

[0144] When radiofrequency energy is employed, the generator may deliver the energy at a power of 30 watts or less, and for a duration of 120 seconds or less. In some variations, the generator may deliver the energy at a power ranging from about 1 to about 15 watts, about 1 to about 7 watts, or about 3 to about 7 watts. In one variation, the generator delivers the energy at a power of about 7 watts. In another variation, the generator delivers the energy at a power of less than about 3 watts. The generator may deliver the energy for a duration ranging from about 10 to about 120 seconds. For example, the generator may deliver the energy for a duration of about 10 seconds, about 20 seconds, about 30 seconds, about 40 seconds, about 50 seconds, about 60 seconds, about 70 seconds, about 80 seconds, about 90 seconds, about 100 seconds, about 110 seconds, or about 120 seconds. In some variations, the generator may deliver the energy for more than 120 seconds, or less than 10 seconds. In other variations, the generator may deliver the energy at a power ranging from 0.1 to 30 watts, and for a duration ranging from 1 to 180 seconds, including all values and subranges in between. For example, the generator may be configured to supply radiofrequency energy at a power of about 30 watts for a duration of about 10 to about 20 seconds, at a power of about 20 watts for a duration of about 30 to about 60

seconds, at a power of about 15 watts for a duration of about 60 to about 120 seconds, or at a power of about 15 watts for a duration of about 10 to about 20 seconds. In further variations, the generator may be configured to supply radiofrequency energy at a power of about 30 watts or less for a duration of about 60 seconds or less, at a power of about 15 watts or less for a duration of about 180 seconds or less, or at a power of about 10 watts or less for a duration of about 120 seconds or less. The radiofrequency energy may be supplied in a pulsed or continuous fashion. In other variations, the generator may deliver the energy at a first power range (e.g., 0.1 to 30 watts or 4 to 15 watts) for a first duration (e.g., 10 to 45 seconds) followed by a second, higher power range for a second, shorter duration (e.g., less than 10 seconds or less than or equal to 30 seconds). Other exemplary energy delivery parameters are provided below in Table 1. The specific power settings may be pre-determined or may be determined based on current or previously acquired system feedback, such as temperature, impedance, power, and/or time. One example of using previously acquired system feedback is to adjust the second, higher power range based on the maximum power utilized during the first duration. Applying higher power ranges or temperatures towards the end of the energy delivery can create different lesion characteristics including, but not limited to, increased volume of tissue necrosis, cauterization of blood vessels, and enhanced echogenicity via increased tissue desiccation, tissue contraction, and/or formation of steam or microbubbles. To prevent or minimize the amount of tissue deposition on the therapeutic element due to the ablations (which could lead to sticking when retracting or deploying the therapeutic element), coatings or surface treatments may be optionally applied to the any of the therapeutic elements described herein. Examples of coatings include Parylene, PTFE, hydrogels, silicone oil, and oxidation. If the coating is not electrically conductive, then additional surface treatments such as acid etching or laser etching, could be selectively applied to the coating to allow electrical energy to pass through.

[0145] FIG. 32 depicts an exemplary Power/Temperature Curve wherein energy is delivered in a two-phased approach such that the first stage (S1) is designed to heat the tissue and a second stage (S2) is designed to char/desiccate the tissue and/or cause steam and/or microbubble formation. At the start of the energy delivery (t_1) power is linearly ramped to a pre-set power (P_1) over time, t_2 . Shortly after t_2 , temperature (A) is compared to a pre-determined target range (T_{min} - T_{max}) that may range from about 65 to about 130 degrees Celsius. For example, the pre-determined target range may be range from about 65 to about 85, from about 80 to about

90, from about 80 to about 100, from about 90 to about 110, or from about 90 to about 130 degrees Celsius). If temperature (A) is less than T_{min} , power may step or ramp up until the temperature is greater than T_{min} . This is depicted by power (P2) and temperature (B). As a safety feature, a maximum power may be set. As the tissue heats and changes its characteristics, temperature may also increase. Should the temperature (C) reach or exceed a pre-set maximum temperature (T_{max}), either the treatment could be terminated (not shown) or power could be reduced over time (P3) until the temperature (D) once again falls below T_{max} at time (t_3). At the end of first stage (S1), the algorithm then enters the second stage (S2), where power ramps (e.g., in a linear or step-wise fashion, or in a non-linear manner) to a maximum power, P_{max} and hold until time (t_5), upon which energy delivery is terminated. The period defined by (t_5-t_4) may, for example, be between about 3 to about 15 seconds. In some variations, the period defined by (t_5-t_4) is between about 3 to about 10 seconds, or between about 5 to about 15 seconds, in order to char/dessicate/coagulate the tissue or cause steam and/or microbubble formation.

[0146] Alternatively, the generator may deliver power in a manner to achieve a desired target temperature but limit the power to some maximum power (e.g., 30 watts or less, 15 watts or less, 10 watts or less, or 8 watts or less) in the event the target temperature cannot be achieved, e.g., due to reasons including but not limited to inaccurate temperature measurements, or local blood flow or other anatomical conditions resulting in atypical heat transfer or ablation patterns). FIG. 33 depicts an exemplary Power/Temperature Curve wherein energy is delivered in a two-phased approach such that the first stage (S1) is designed to heat the tissue and a second stage (S2) is designed to char/dessicate the tissue or cause steam and/or microbubble formation. At the start of the energy delivery (t_1), power is ramped until a minimum target temperature (T_{min}) or a target temperature range (e.g., 65 to 85 degrees Celsius, 80 to 100 degrees Celsius, 80 to 90 degrees Celsius, 85 to 95 degrees Celsius, 90 to 100 degrees Celsius, or 95 to 110 degrees Celsius) is reached. In FIG. 33, this event is denoted by power (P1) and temperature (A) at time (t_2) where power (P1), temperature (A), and time (t_2) may also represent ranges. Exemplary ranges are shown in the table below but may include all values and subranges in between; the exemplary ranges may also include any combination of power (P1), temperature (A), and time (t_2) shown in the table.

TABLE 1

Power (P1) – Watts	Temperature (A) – Degrees Celsius	Time (t2) – Seconds
0.1 to 30	70 to 90	0 to 5
0.1 to 20	80 to 90	0 to 10
5 to 10	80 to 100	0 to 15
5 to 15	65 to 85	5 to 10
10 to 20	70 to 80	5 to 15
1 to 12	85 to 95	10 to 15
7 to 12	90 to 100	
	95 to 110	
	95 to 115	
	70 to 100	

[0147] As a safety feature, a maximum power may be set. The generator then continually adjusts power in an effort to maintain the minimum temperature (Tmin) or temperature range without exceeding a pre-set maximum temperature (Tmax). As the tissue heats and changes characteristics, a sudden increase in temperature may occur (not shown). Should the temperature reach or exceed the maximum temperature (Tmax), the generator will adjust power down or terminate the treatment. At the end of the first stage (S1) which occurs at time (t3), the algorithm then enters the second stage (S2), where power is increased (e.g., ramped in a linear or step-wise fashion, or ramped in a non-linear manner) to a second power, P2, and holds until time (t4), upon which energy delivery is terminated. The period defined by (t3-t1) may, for example, be up to 15 seconds, up to 30 seconds, up to 45 seconds, up to 60 seconds, up to 120 seconds, or up to 180 seconds. The period defined by (t4-t3) may, for example, be between 3 to 10 seconds, or between 5 to 15 seconds, in order to char/desiccate/coagulate the tissue or cause steam and/or microbubble formation. Power termination may also occur before time t4 in the event that other conditions are met. Examples of these other conditions may include a temperature limit, an impedance limit, a change in impedance, a rate of temperature change, or a rate of impedance change. In another embodiment, the generator may deliver power in a manner to achieve a desired target temperature, as described in this paragraph and as depicted in FIG. 33, except that power delivery is limited to the first stage (S1).

[0148] An exemplary system (5000) is illustrated in FIG. 23. In this embodiment, the system is configured for monopolar energy delivery using a neutral electrode (5002), which would be affixed to the skin of the patient. Bipolar configurations would eliminate the need for an externally-placed neutral electrode. For example, the therapeutic element (5004) may be configured to have two or more electrodes of approximately the same size and spaced apart to deliver energy in a bipolar or multi-polar fashion (not shown). Alternatively, the neutral electrode (5002) may be incorporated into the docking/guiding device (5006). In a further variation, the neutral electrode may be incorporated into a cover placed over the transducer of the ultrasound probe or incorporated into the needle guide. In these cases, the neutral electrode may be larger than the electrode located on the therapeutic element such that only the electrode located on the therapeutic element heats significantly. Furthermore, the sensing elements (5008) may be used to measure parameters either intra-procedurally or post-procedurally to assess for technical success of the procedure. For instance, impedance changes could accompany desirable changes in tissue characteristics in successful treatment delivery.

[0149] Some variations of the system could be configured with bipolar electrodes to deliver therapeutic doses of energy. Here a neutral electrode (affixed to the skin of the patient, incorporated into the docking/guiding device, or incorporated elsewhere away from the distal end of the device) could be utilized to measure impedance values from one or each of the therapeutic electrodes before or during energy delivery. The impedance values between the therapeutic bipolar electrodes and/or between a therapeutic electrode and the neutral electrode could be used to determine the relative location of the therapeutic elements within the ovary. An example is shown in FIGS. 34 and 35A-35C. Therapeutic elements, such as electrodes, A and B could be configured in a bipolar manner such that energy is delivered from A and returned to B (or vice versa) to generate a therapeutic effect. Impedance could also be measured between A and B. A neutral electrode, N, could be used to measure impedance from A to N and from B to N by applying low, non-therapeutic levels of energy. Optionally or additionally, a sensing element, C, could be located at the tip of the device to measure the impedance between C and N, A and C, and/or B and C. Comparing these different impedance measurements could provide feedback for the relative locations of A, B, and C.

[0150] FIGS. 35A-35C provide examples where electrode A and electrode B are both inside the ovary. In FIG. 35B, electrode A is inside the ovary and electrode B is partially outside the ovary. In FIG. 35A, the impedances of A-to-N and B-to-N are similar since the electrical paths are similar. However, in FIG. 35B, the impedances of A-to-N and B-to-N could be measurably different depending on the composition of the non-ovarian tissue-contacting electrode B. In one variation, the non-ovarian tissue could be bowel filled with gas and result in higher impedance. Other tissues adjacent to the ovary that could result in higher impedance are fat deposits. In another variation, the non-ovarian tissue could be bowel, muscle, or a blood supply such that the impedance of B-to-N is lower than the impedance of A-to-N. Based on these impedance measurements, the generator could provide the operator with different feedback regarding the relative location of the device. Similarly, FIG. 35C depicts electrodes A and B within stromal tissue of the ovary and sensing element C within a follicle or cyst. Impedance measurements A-to-B, A-to-C, and/or B-to-C (or optionally A-to-N, B-to-N, C-to-N), could be used to impute that the sensing element at the tip of the device is within a follicle and thus closer to the outer surface of the ovary. Therefore, the generator could provide feedback to the operator to stop advancing the device in order to prevent the tip from unintentionally exiting the ovary. Additionally, if sensing element C did exit the ovary, the impedance measurements from A-to-B, A-to-C, and/or B-to-C (or optionally A-to-N, B-to-N, C-to-N) could be used to detect this condition.

[0151] According to embodiments described herein, which may partially or as a whole combine with other embodiments, it may be useful for the systems to include features configured to maintain the orientation of the energy delivery elements (e.g., radiofrequency energy elements) and/or anchoring member(s), in a single plane, which may be desirable for visualization optimization. The features for maintaining planar orientation may include the use of ribbon and/or use of side ports on the guide/docking device to better guide deployment. In other variations, orienting a planar therapeutic element and/or anchoring member such that it is in plane with a 2-dimensional ultrasound field may be accomplished by placing visual cues or identifiers (e.g., markers comprised of an echogenic material; markers comprising echogenic bands, rings, arcs, or other geometric structures, etc.) or tactile cues (e.g., bumps, flat spots, or other features that could be felt by finger tips) or identifiers (e.g., a wing-like structure, label, arrows, or other printing) on a portion of the device, e.g., the proximal end of the device that deploys the therapeutic element and/or anchoring member into the ovary. For transvaginal

procedures, providing features for maintaining the rotational orientation between the ultrasound probe/transducer, the guiding/docking device, the therapeutic element, and/or the anchoring member(s) may also be employed. FIG. 24 shows an exemplary system (6001) for maintaining therapeutic elements and/or anchoring members (6000) in the two-dimensional plane with the ultrasound visualization field/plane. For needle-guided transvaginal procedures, a needle guide (6002) is affixed to the shaft of the probe to ensure that the tip of the needle is always within the field of view of the probe (6004). The needle guide (6002) may also ensure that the needle enters the field of view from the same location and travels along the same angle with respect to the head of the ultrasound probe/transducer (6004). However, when therapeutic elements and/or anchoring members with a curvilinear shape (6000) need to be deployed, planar orientation must be maintained in order to see them as the probe (6004) or other system elements are manipulated. In one instance, the needle guide may incorporate a unique geometry that mates with a guide on the docking device. In this instance, an offset coupler (6006) may be affixed to the needle guide (6002). The offset coupler (6006) may include a guide rod (6008), which can slide through an advancing handle (6010) by sliding an advancing mechanism (6012) forward to force the therapeutic elements (6000) into the tissue. The advancing mechanism (6012) may then be pulled back to recapture the therapeutic elements (6000) when finished.

[0152] Referring to the embodiment shown in FIG. 26, a curvilinear therapeutic element and/or anchoring member (7000) is shown within the ultrasound field of view (7002). If the docking/guiding device (7004) and/or curvilinear element (7000) are rotated a few degrees with respect to the ultrasound transducer (7006), then the curvilinear element (7000) would no longer exist within the same plane as the ultrasound visualization plane and the curvilinear element would no longer appear on the ultrasound display. Therefore, the operator would need to rotate the docking/guiding device (7004) and/or curvilinear element (7000) until the curvilinear element reappeared on the ultrasound display. This could increase procedure time and increase the risk of patient injury by requiring additional manipulation of the device. It may also be beneficial to have an alignment feature that orients or aligns the curvilinear element to the ultrasound visualization plane in a manner that ensures the curvilinear element is visible as it deploys. Visualizing the entire element as it deploys may allow the operator to more precisely position the element in the desired location. In other embodiments, it may only be necessary to see the distal tip of the curvilinear element (7000), to ensure that it is still within the target

tissue. Visualization of the distal tip of the curvilinear element (7000), optionally combined with visualization of the distal tip of the docking/guiding device (7004), may provide adequate visualization for precise positioning.

[0153] In some cases, it may be desirable to have the ability to decouple and re-couple the docking/guiding device from the needle guide *in situ*. FIG. 25 depicts an exemplary magnetic detachable needle guide (8000), which may be combined with other embodiments described herein. For example, the needle guide (8000) may incorporate a trough (8002) with embedded neodymium magnets (8004) underneath it that may be used to position and hold a metallic docking/guiding device in place, while also making it removable.

[0154] Alternative mechanisms for maintaining planar alignment are provided in FIGS. 27A to 27F. For example, an alignment adapter (9000) may be attached to a handle (9002) of a transvaginal ultrasound probe (9004). Alignment adapter (9000) may be removably attached to the ultrasound probe handle (9002) by snapping on, strapping, clamping circumferentially via a two-piece or hinged clamshell, or other suitable ways. In order to be adaptable to a variety of ultrasound probes, the mating surface (9006, shown in the cross-sectional view of FIG. 27B) may include features such as a low durometer or other suitably conformable polymer (e.g., neoprene, polyurethane, silicone, etc.). These features may be molded into alignment adapter (9000) or provided as separate insert pieces. The alignment adapter (9000) may further comprise a receiving lumen or cavity (9008) between the main body of the alignment adapter and a guide (9010) of the guiding/docking device (9012). The alignment adapter (9000) may also include an adjustable element (e.g., a mechanical guide or lock) (9014) that may be used to fix or hold steady the guiding/docking device (9012) or allow it to be moved. For example, when the adjustable element (9014) is in a locked (down) position (FIG. 27C), it aids in aligning the guiding/docking device (9012) and/or curvilinear elements (e.g., therapeutic elements and/or anchoring members) (9016) within the ultrasound visualization plane. In the unlocked (up) position (FIG. 27D), the guiding/docking device (9012) may be freely rotated (or rotation may be limited to, for example, about 90 degrees in a clockwise or counter-clockwise direction). Additionally, the alignment adapter could allow some limited rotation, such as plus or minus up to 20 degrees of rotation, even in the locked position. For example, the opening in the mechanical guide or lock (9014) could be enlarged such that the guide (9010) could rotate about

10 degrees in the locked position. The limited rotation can be useful in maintaining the curvilinear elements within the ultrasound visualization plane while allowing the operator to quickly rotate the device back and forth to enhance visualization due to the motion. Similarly, subtle motion (for the purpose of enhanced visibility) could be achieved by allowing the operator to easily shift the curvilinear elements a small distance distally and proximally, such as plus or minus up to 0.25 mm. The adjustable element may comprise a notch configured to mate with the docking device to help effect locking. The docking/guiding device (9012) may be introduced while the adjustable element (9014) is in the unlocked position (FIG. 27D) or in a partially-locked position (FIG. 27E) where the guide (9010) need not be perfectly straight and will aid in aligning the docking/guiding device (9012) as it is lowered. The geometry of the adjustable element (9014) may also be tapered such that the docking/guiding device (9012) may rest in proper alignment but still be free to rotate easily, if desired. If rotation or translation of the docking/guiding device (9012) is desired, it may further incorporate a hub (9020) to make manipulation easier. Furthermore, the alignment adapter (9014) may further comprise sliders, knobs, and/or levers, which can be used to advance/withdraw the docking/guiding device, deploy/retract therapeutic elements and/or anchoring members, engage/disengage the alignment mechanism, etc. Due to the alignment feature, the therapeutic elements and/or anchoring members can be maintained within the visualization plane of the ultrasound probe during an ovarian procedure.

[0155] For example, as illustrated in FIG. 27F, mechanical guide or lock (not shown) may be used to orient a curvilinear element in a first planar orientation (9022) followed by retraction and redeployment in a second planar orientation (9024), allowing for two treatments to be applied within the same visualization plane (9026) of the ultrasound probe.

[0156] In the embodiment shown in FIG. 28, the alignment adapter (9028) can be a lock that is removably affixed to the handle of the ultrasound probe (9030) via a temporary adhesive located at the interface between the alignment adapter (9020) and ultrasound probe (9030). The adapter could also be attached with a conformable strap or clamp. Here alignment adapter (9028) includes a receiving alignment channel (9032) with a geometry that prevents or limits rotation once engaged (e.g., square or rectangular). The proximal end of a guiding/docking device (9036) incorporates an alignment element (9034), which mates with the receiving alignment

channel (9032) to maintain the planar orientation of the therapeutic elements and/or anchoring members (9042) and the visualization plane of the ultrasound probe. As described previously, the alignment mechanism could allow some limited rotational or translational motion to enhance visualization. For example, the alignment channel (9032) could be larger than the alignment element (9034) by 0.025 cm which would allow some rotation but still maintain the therapeutic element and/or anchoring member within the ultrasound visualization plane. The guiding/docking device (9036) further comprises a handle (9040), which may be used to manipulate the device and/or may further incorporate features for deploying the therapeutic elements and/or anchoring member (9042). Such deploying features may include a slider, knob, wheel, crank, and/or levers, which can be used to deploy/retract therapeutic elements and/or anchoring member (9042).

[0157] According to embodiments described herein, which may partially or as a whole combine with other embodiments, the guiding/docking device may comprise a handle, which may be used to manipulate the device and/or may further incorporate features for deploying the therapeutic elements and/or anchoring member(s) as well as incorporating features to limit the travel of the guiding/docking device. Since the distal tip of the guiding/docking device may contain a needle (or otherwise sharp) point to pierce through the vaginal wall and capsule of the ovary, it may be desirable to prevent the needle tip from traveling too far distally and causing unintentional injury. In one embodiment, as shown in FIGS. 36A through 36C, the handle (not shown) could provide tactile and/or visual feedback to inform the operator that the needle tip (411) of the guiding/docking device (409) is located just inside the distal end of the needle guide (401). In FIG. 36A, the distal end of the needle guide (401) is indicated by the arrow and this point can be referred as the zero point (412). Maintaining the needle tip at the zero point (412) can prevent the needle tip from contacting the vaginal wall (403) while the operator manipulates the ultrasound probe (405) for visualization and/or device placement. Furthermore, the handle could contain a limiting mechanism that limits the distal travel of the guiding/docking device to prevent the needle tip from exiting most ovaries during the initial needle puncture, e.g., a travel distance of about 3 cm (or e.g., about 1.5 to about 4 cm) from the zero point where the guiding/docking device can freely travel back and forth as long as the tip does not exceed the maximum travel distance. Once the operator inserts the docking/guiding device (409) into the ovary (407) (as shown in FIG. 36B), then the operator may release the limiting mechanism on

the handle. Additionally or optionally, the handle may comprise a mechanism to allow the operator to adjust the maximum travel distance. This would allow the operator to insert the needle tip (411) more distally towards the capsule of the ovary (407) (as shown in FIG. 36C) and define a new maximum travel distance for the needle tip (411). This could prevent the operator from inadvertently advancing the needle tip beyond the ovary and could also prevent the needle tip from exiting the ovary in the event the ovary were to move due to patient respiration or other patient movement.

[0158] In other variations, the travel of the guiding/docking device may be controlled by increasing friction as it is advanced but can be retracted with less friction. Another variation could include a limiting mechanism such that the guiding/docking device and handle can only be advanced about 3 cm (or e.g., about 1.5 to about 4 cm) from the zero point. Then another mechanism in the handle, such as a wheel, lever, or slider, could be used to advance the guiding/docking device further into the ovary. This would prevent gross motions of the handle from advancing the needle tip beyond the ovary.

[0159] As previously stated, non-invasive treatment systems may be employed. FIG. 37 depicts an exemplary non-invasive treatment system. Referring to the figure, system (501) is comprised of an imaging and/or therapeutic element (503), configured for contact with the abdomen (505) of a patient (507); a connection (509) (e.g., cable) for connecting the imaging and/or therapeutic element (503); and a console (511), comprising a user interface (513), a feedback control system (515), one or more ultrasound sources (517) configured for imaging or application of energy to affect target tissue, and a mechanism for interpreting imaging data to enable targeting of desired target tissue.

[0160] Target tissues of an ovarian procedure may include the following: follicles, follicles of a particular size range (e.g., pre-antral follicles), stroma, thecal cells, stromal cells, granulosa cells, mesovarium, or nerves. In one instance, follicles, stroma, or thecal cells could be preferentially targeted and the vasculature could be relatively avoided. In another instance, the settings of the therapeutic system could be selected such that nerves are targeted and the vasculature could be relatively spared. In another instance, the cortex of the ovary could be targeted, and the stroma of the ovary could be relatively spared. In another instance, the stroma of the ovary could be targeted, and the ovarian cortex could be relatively spared. In another

instance, the interface of the stroma and cortex could be preferentially targeted. In another instance, the mesovarium could be preferentially targeted. In another instance, the granulosa cells in antral and pre-antral cells may be preferentially targeted. In a further instance, the nerves in the pedicle of tissue connecting the ovary to surrounding tissues (i.e., mesovarium) could be targeted using treatment methods that spare the nearby vasculature (e.g., cryotherapy, selective heating/ablation, electroporation). Certain tissues (e.g., nerves) may be more susceptible to destruction at lower ablation thresholds, such that those tissues could be preferentially targeted. Some tissues may have particular acoustic or material properties (e.g., fluid-filled follicles) such that some forms of energy (e.g., ultrasound) could be used to specifically target those tissues. For example, in the case of HIFU, ultrasound imaging could be used to map the location of the follicles in the cortex of the ovary, and then energy could be directed to regions proximate to follicles clearly visible on ultrasound.

[0161] After or while delivering the therapeutic element, aspiration could be performed either through the guiding/docking device, through the therapeutic element, or through a device that contains both a docking and therapeutic element. The aspiration could be used to assist in reduction of follicle/cyst size, to assess if bleeding is controlled, to collect fluid for analysis, to remove any space created between tissues using fluid or gas, or for another purpose. The aspiration port could also be used to inject gas or other material, which might be used to change imaging characteristics of that region of the ovary; this could be used to label/mark portions of the ovary that had already been treated.

[0162] At the conclusion of the procedure, the docking element, the therapeutic element, or a combination thereof could be used to deliver materials, active agents, etc. to assist in the healing process and prevent the formation of adhesions. Some examples of these are the commercially available agents Interceed® Absorbable Adhesion Barrier (Ethicon, Somerville, NJ), Seprafilm® Adhesion Barrier (Genzyme, Bridgewater, NJ), and Adept® Adhesion Reduction Solution (Baxter, Deerfield, IL). These and other agents made of modified sugars, cellulose, fabrics, and colloids have been used in other surgical cases to minimize the frequency of surgical adhesions.

[0163] It is contemplated that in certain cases where the desired clinical effect was not achieved or where it was achieved but then subsequently the condition re-occurred, repeat

procedures could be needed. In these cases, it might be necessary to target a different portion of the ovary, different follicles/cysts, or a different portion of the mesovarium. The inventors contemplate the need for using the system to specifically re-treat the same portion of tissue as the original treatment or a distinctly different portion of tissue from the first intervention.

III. EXEMPLARY COMBINATIONS OF FEATURES

[0164] The following tables disclose various features of the methods and systems provided herein that can be combined to manipulate ovarian tissues and/or treat PCOS. The manipulation of ovarian tissues may include mechanical manipulation and/or removal, by delivery of chemical, biologic, or pharmaceutical agents, by delivery of energy, or by applying cooling/cold to the tissues. Exemplary treatment modalities may include without limitation, delivery of one or more of the following: a radiofrequency energy element; a direct heating element; a cryoablation element; a cooling element; a mechanical disruption and/or removal element; laser; a microwave antenna; an unfocused ultrasound element; a partially-focused ultrasound element; a focused (HIFU) ultrasound element; and/or an element for delivering heated water/saline, steam, a chemical ablation agent, a biologic or pharmaceutical agent, implantable pulse generator, a passive or active (e.g., electronic drug delivery unit) drug-eluting implant, a radioisotope seed, or a mechanical implant, which may be either passive or active via application of remote energy (e.g., ultrasound to induce vibration), as previously stated. Manipulation of ovarian tissues may include the delivery of energy, e.g., radiofrequency energy, to tissues, retrieval of tissues, e.g., via aspiration, or delivery of agents within an ovary.

[0165] In Table 2, exemplary combinations of features for transvaginal, laparoscopic, percutaneous, or via a natural orifice route through the vagina-uterus-fallopian tubes approaches are provided.

TABLE 2

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8
Access	Visualization	Tissue separation	Ovary docking	Landmarks	Therapeutic Mechanism	Pattern of Therapeutic Delivery	Aspiration / Compression
Transvaginal	transvaginal ultrasound	fluid	suction / aspiration / vacuum	ovarian features cysts	Tissue Heat Ablation (RF, monopolar, bipolar, multistep), HIFU, laser Heat, microwave, unfocused/partially focused ultrasound, laser, saline/water, steam	Superior	aspiration at ovary interface
Laparoscopic	transabdominal ultrasound	air	concave surface	bony	Tissue Warming (RF monopolar, bipolar, multistep), HIFU, Direct Heat, microwave, unfocused/partially focused ultrasound, laser, saline/water, steam	Near vasculature / mesovarium	aspiration within ovary
Via a natural orifice route through the vagina-uterus- fallopian tubes	CT	mechanical scaffold	hook / needle	broad ligament / ovary junction	non-thermal acoustic cavitation	away from vasculature / mesovarium	reposition to area surrounding ovary
Percutaneous	AR	mechanical balloon	abrasive surface		Cryablation (cooled element, liquid nitrogen, CO ₂ , dry-ice)	Minimize interruption of cysts	ovary external compression
	endoscopic visualization	none	laser		Tissue Coagulation (coiled element, saline/water)	preferential for cervical ovary	ovary internal compression
	OCT				Mechanical disruption	preferential for medial ovary	none
	virtual histology				Drug - implant permanent or biodegradable vs. no implant, types of drugs: beta blockers, anti-androgens, neurotrans or tissue toxins, 5-alpha- reductase inhibitors, or aromatase inhibitors	delivery to help/minimize disruption of ovarian capsule	
	ultrasound on guide or therapeutic element				mechanical irritant (permanent vs. biodegradable), could be activated externally	delivery to maximize disruption of ovarian capsule	

Notes: specific embodiments may include none of features in a column or more than one feature in a column; device harvesting may be done pre-procedure; either the guiding element or the treatment element or the combined guiding/treatment element may be alterable; optional anti-adhesion materials may be delivered to prevent adhesion formation; therapeutic element could be triggered

[0166] In Table 2 (transvaginal, laparoscopic, percutaneous, or via a natural orifice route through the vagina-uterus-fallopian tubes approaches), visualization of the procedure and/or tissues could be performed using any of the visualization techniques described in the 2nd column, tissue separation may be done via any of the techniques described in the 3rd column, the ovary could be engaged and the device could dock on the ovary via any of the techniques in the 4th column, any of the tissue landmarks that could be used in aiding the procedure are listed in the 5th column, any of the therapeutic mechanisms that may employed by the device are described in the 6th column, possible patterns of therapy delivery are listed in column 7, and the various options for aspiration or ovarian compression that may be used in any of the embodiments are listed in column 8.

[0167] Table 3 provides exemplary combinations of features that could be used for open surgical approaches.

TABLE 3

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7
Access	Visualization	Ovary docking	Landmarks	Therapeutic Mechanism	Pattern of Therapeutic Delivery	Aspiration / Compression
surgical	transvaginal ultrasound	suction / aspiration / vacuum	ovarian features cysts	Tissue Heat Ablation [RF (monopolar, bipolar, multifocal), HIFU, Direct Heat, microwave, unfocused/partially focused ultrasound, laser, saline/water, steam]	Superior	aspiration at ovary interface
	CT	concave surface	bony	Tissue Warming [RF (monopolar, bipolar, multifocal), HIFU, Direct Heat, microwave, unfocused/partially focused ultrasound, laser, saline/water, steam]	Near vasculature / mesovarium	aspiration within ovary
	MR	hook / needle	broad ligament / ovary junction	non-thermal acoustic cavitation	away from vasculature / mesovarium	aspiration to area surrounding ovary
	direct visualization	adhesive surface		Crytulation (cooled element, liquid nitrogen, CO ₂ , dry ice)	Maximize interruption of cysts	ovary external compression
	endoscopic visualization	tissue		Tissue Cooling (cooled element, saline/water)	preferential for cortical ovary	ovary internal compression
	ECT			Mechanical disruption	preferential for medullary ovary	none
	virtual histology			drug - implant permanent or biodegradable vs. no-implant, types of drugs: beta-blockers, anti-androgens, neurotoxic or tissue toxins, 3 alpha- reductase inhibitors, or aromatase inhibitors	delivery to limit/minimize disruption of ovarian capsule	
	ultrasound on guide or therapeutic element			mechanical implant (permanent vs. biodegradable), could be activated externally	delivery to maximize disruption of ovarian capsule	

Notes: specific embodiment may include some of features in a column or more than one feature in a column; ovary harvesting may be done pre-procedure; either the guiding element or the treatment element or the combined guiding/treatment element may be steerable; optional anti-adhesive materials may be delivered to prevent adhesion formation; therapeutic element could be irrigated

[0168] In Table 3 (surgical approaches), visualization of the procedure and/or tissues could be performed using any of the visualization techniques described in the 2nd column, the ovary could be engaged and the device could dock on the ovary via any of the techniques in the 3rd column, any of the tissue landmarks that could be used in aiding the procedure are listed in the 4th column, any of the therapeutic mechanisms that may employed by the device are described in the 5th column, possible patterns of therapy delivery are listed in column 6, and the various options for aspiration or ovarian compression which may be used in any of the embodiments are listed in column 7.

[0169] Other methods may include the non-invasive targeted delivery of energy to ovarian tissues. Table 4 provides exemplary combinations of elements that could be used to construct a system/device for such delivery of energy.

TABLE 4

Column 1	Column 2		Column 3	Column 4	Column 5	Column 6
Access	Visualization		Landmarks	Therapeutic Element	Pattern of Therapeutic Delivery	Aspiration / Compression
non-invasive (external)	transvaginal ultrasound		ovarian bloodless cysts	Tissue Heat Ablation [RF (monopolar, bipolar, multimodal), HIFU, Direct Heat, microwave, unfocused/partially focused ultrasound, laser, saline/water, steam]	superior	
	transabdominal ultrasound		bony	Tissue Warming [RF (monopolar, bipolar, multimodal), HIFU, Direct Heat, microwave, unfocused/partially focused ultrasound, laser, saline/water, steam]	Near vasculature / mesometrium	
	CT			non-thermal acoustic cavitation		
	MRI		ovarian ligament / ovary junction	Crycoablation [cooled element, liquid nitrogen, CO ₂ , dry-ice]	away from vasculature / mesometrium	ovary external compression
			fiducial	Tissue Cooling [cooled element, saline/water]	Maximize interruption of cysts	
				Mechanical disruption	preferential for cortical ovary	
				drug - implant permanent or biodegradable vs. no-implant, types of drugs: beta-blockers, anti-endrogens, neurotoxins or tissue toxins, 5-alpha-reductase inhibitors, or aromatase inhibitors	preferential for medullary ovary	
				mechanical implant (permanent vs. biodegradable), could be activated externally	delivery to limit/minimize disruption of ovarian capsule	
					delivery to maximize disruption of ovarian capsule	

Notes: specific embodiment may include none of features in a column or more than one feature in a column.

[0170] In one variation, non-invasive imaging may also be employed to percutaneously or via a natural orifice route through the vagina-uterus-fallopian tubes place at least one fiducial within the patient, e.g., in the proximity of the target ovarian tissue, which may be used during the delivery of therapy to target treatment locations. Fiducials may be constructed of any material chosen for biocompatibility and compatibility with the desired imaging modality used during the therapeutic procedure. The fiducial may be placed either percutaneously or via a natural orifice route through the vagina-uterus-fallopian tubes via a needle, microcatheter, or other suitable delivery system through the abdominal wall, transvaginally, laparoscopically, or surgically.

[0171] In another variation, a device could be placed within the vagina. The device may be used with integrated imaging or use of a non-integrated imaging device (e.g., transvaginal ultrasound or abdominal ultrasound) to deliver either mechanical manipulation (e.g., sound, vibration, or other mechanical manipulation) or energy (e.g., electrical current) preferentially to the ovaries or portions of the ovaries. In the case of energy delivery, this could be either an ablative or non-ablative (e.g., energy similar to that used in transcatheter electrical nerve stimulation) form of energy. This could be done repeatedly in a single session or temporally spaced as necessary.

IV. EXAMPLES

[0172] The following examples further illustrate embodiments of the systems and methods disclosed herein, and should not be construed in any way as limiting their scope.

Example 1: Ablation Volume With a Bipolar System Including a Straight Therapeutic Element and Using Max Power of 4 Watts

[0173] An ovarian tissue apparatus having a bipolar electrode configuration was created using two Platinum-Iridium (90%/10%) bands mounted on a straight polymer shaft. The electrode outer diameters were 1.27 mm and the lengths were 3.0 mm. The electrodes were spaced 3.0 mm apart from each other and a temperature sensor was mounted on the inner diameter of each electrode. To evaluate lesion (ablated tissue) sizes, raw chicken breast was placed around the electrodes and a RF generator delivered energy to one electrode while the other electrode was used as part of the return path to the generator. RF energy was delivered for 30 seconds in order to achieve a target temperature of approximately 80°C. The maximum power observed was approximately 4 watts. A cross-section of the resulting lesion (cut lengthwise) showed apparent tissue necrosis (based on visual analysis of changes in tissue color) measuring 3.8 mm wide and 10.4 mm long. Approximating the lesion volume as a cylinder (with diameter of 3.8 mm and length of 10.4 mm and volume = $\frac{1}{4} \times \pi \times D^2 \times L$), the lesion was calculated to have a volume of ablated tissue of 118 mm³. While this experiment was conducted with a straight therapeutic element, similar results would be expected using a curved therapeutic element.

Example 2: Ablation Volume With a Bipolar System Including a Straight Therapeutic Element and Using Max Power of 10 Watts

[0174] A similar experiment was conducted with the same electrode configuration described in Example 1. In this example, however, RF energy was delivered for a total of 15 seconds and targeted a maximum temperature of approximately 100°C. The maximum power utilized in this case was approximately 10 watts. A cross-section of the resulting lesion showed apparent tissue necrosis (based on visual analysis of changes in tissue color) approximating an ellipse with a major axis, D1, of 4.5 mm and minor axis, D2, of 3.9 mm. Assuming a lesion length of 10 mm, the resulting lesion volume was calculated as 138 mm³ (where volume = $\frac{1}{4} \times \pi \times D1 \times D2 \times L$).

Example 3: Ablation Volume With a Bipolar System Including a Straight Therapeutic Element

[0175] An ovarian tissue apparatus having a bipolar electrode configuration was created using two stainless steel bands mounted on a straight polymer shaft. The electrode outer diameters were 1.1 mm and the lengths were 1.8 mm. The electrodes were spaced 3.0 mm apart from each other and a temperature sensor was mounted on the inner diameter of each electrode. To evaluate lesion (ablated tissue) sizes, the electrodes were placed in a bovine ovary warmed to approximately 37 degrees °C. An RF generator delivered energy to one electrode while the other electrode was used as part of the return path to the generator. RF energy was delivered in order to achieve a target temperature of approximately 85°C for 60 seconds. The maximum power observed was approximately 5 watts. A cross-section of the resulting lesion showed apparent thermal injury (based on histologic staining) approximating an ellipse with a major axis, D1, of 5.9 mm and minor axis, D2, of 5.5 mm. Approximating a lesion length of 8.6 mm, the resulting lesion volume was calculated as 219 mm^3 (where volume = $\frac{1}{4} \times \pi \times D1 \times D2 \times L$). While this experiment was conducted with a straight therapeutic element, similar results would be expected using a curved therapeutic element.

Example 4: Ablation Volume With a Bipolar System Including a Straight Therapeutic Element

[0176] A similar experiment was conducted with the same electrode configuration described in Example 3 except that RF energy was delivered in order to achieve a target temperature of approximately 85°C for 120 seconds. The maximum power observed was approximately 5 watts. A cross-section of the resulting lesion showed apparent thermal injury (based on histologic staining) approximating an ellipse with a major axis, D1, of 6.4 mm and minor axis, D2, of 6.3 mm. Approximating a lesion length of 8.6 mm, the resulting lesion volume was calculated as 272 mm^3 (where volume = $\frac{1}{4} \times \pi \times D1 \times D2 \times L$). While this experiment was conducted with a straight therapeutic element, similar results would be expected using a curved therapeutic element.

Example 5: Ablation Volume With a Bipolar System Including a Curved Therapeutic Element

[0177] Experiments were conducted utilizing a similar bipolar electrode configuration as described in Example 1. However, the electrodes were mounted on a curved polymer shaft with an approximate radius of 7 mm. Both Platinum-Iridium (90%/10%) electrodes had outer

diameters of 1.27 mm and lengths of 3.0 mm. The electrodes were spaced 3.0 mm apart from each other and a temperature sensor was mounted on the inner diameter of each electrode. In one experiment, RF energy was delivered for 30 seconds in order to achieve a target temperature of approximately 90°C. A cross-section of the resulting lesion (cut lengthwise) showed apparent tissue necrosis (based on visual analysis of changes in tissue color) measuring 6.7 mm wide. In another experiment, RF energy was also delivered for 30 seconds in order to achieve a target temperature of approximately 90°C. A cross-section of the resulting lesion showed apparent tissue necrosis approximating an ellipse with a major axis, D1, of 6.0 mm and minor axis, D2, of 3.8 mm. Assuming a lesion length of 9 mm, the resulting lesion volume can be estimated as 161 mm³ (where volume = $\frac{1}{4} \times \pi \times D1 \times D2 \times L$).

Example 6: Method for Treating/Manipulating Ovarian Tissue

[0178] FIGS. 42A to 42F depict an example of one method for treating ovarian tissue utilizing an ovarian tissue apparatus comprising a docking device (4200) and a therapeutic element (4201), the therapeutic element (4201) being curvilinear and deployable from the lumen of the docking device (4200). In this example, the physician is positioning the docking device (4200) and therapeutic element (4201) under ultrasound guidance and has transvaginally placed the ultrasound probe (4203) proximate to the ovary (4204).

[0179] In FIG. 42A, the docking device (4200) has been inserted into the ovary (4204) via a needle guide (4205) attached to the ultrasound probe (4203). In FIG. 42B, the therapeutic element (4201) has been deployed and, in this example, is located in the junction between the ovarian cortex and ovarian stroma. The physician then, via the user interface of the system, delivers energy to the treatment zone via the therapeutic element (4201). After energy delivery is complete, the therapeutic element (4201) has been retracted into the docking device (4200) and the docking device has been retracted to a new location, as shown in FIG. 42C. In this example, the ultrasound probe (4203) remained in a similar position as it was for the first treatment. In FIG. 42D, the therapeutic element (4201) has been deployed and is located primarily in the ovarian stroma. Energy is then delivered to this second treatment zone. The process of retracting the therapeutic element (4201) is repeated (not shown) and the physician retracts the docking device (4200) such that it still remains in the ovary (process not shown).

[0180] The physician then orients the ultrasound probe (4203) and ovarian tissue apparatus, including docking device (4200), in order to access a different region of the ovary (4204). In FIG. 42E, the docking device (4200) has been advanced to this new region and the therapeutic element (4201) has been deployed in order to perform another treatment.

[0181] In this example, energy was delivered to four different areas of the ovary (4204) and all four areas were reached using a single puncture of the vaginal wall (4206) and ovarian capsule. Creating fewer punctures and minimizing the amount of device manipulation and/or ultrasound probe manipulation may have several benefits including, but not limited to, reduced pain or discomfort by the patient (during the procedure or after the procedure), ease-of-use to the physician, reduced procedure time, and/or reduced chances of complications such as bleeding.

[0182] In other examples, fewer or more treatments could be performed. Additionally or alternatively, multiple punctures could be performed in order to position the therapeutic element into the different zones for treatment.

Example 7: Treatment of Follicles or Other Fluid Filled Cysts

[0183] In some instances, there may be a need to bring target tissue proximate to a follicle or other fluid filled cyst (e.g., endometrial cyst) into proximity to a therapeutic element. The device depicted in Fig. 31C could be deployed under image guidance (e.g., ultrasound) via the transvaginal route such that the distal end of the device (307) resides within the cyst. An anchoring member (312) may be deployed to secure the distal end of the device relative to the cyst. If an anchoring member (312) were utilized, it could be configured to have a tip (313) that was optimized for visualization under certain types of imaging modalities (e.g., ultrasound); the anchoring member could also be configured to deploy in a specific orientation relative to the image modality (e.g., configured to deploy within the plane of imaging captured in a 2-dimensional ultrasound system). The fluid contents of the cyst could be aspirated via a lumen with one or more apertures near the tip (307). Following aspiration and removal of cyst contents, target tissues may have shifted to a location in closer proximity to a therapeutic element (311). With the target tissue (e.g., endometrial tissue) in closer proximity, the therapeutic element can be utilized to deliver therapy (e.g., radiofrequency energy) to the target tissue. Delivery of treatment to the target tissue may prevent recurrence of cyst formation at

that location. If an anchoring member (312) had been utilized, it could be retracted and the device could be removed from the body.

V. FURTHER EXAMPLES

[0184] Furthermore, the following examples, including any of the indicated combinations thereof, are disclosed herein and are comprised within the scope of the present disclosure.

[0185] 1. A system for performing an ovarian procedure comprising:

- a) an ovarian tissue apparatus, the ovarian tissue apparatus comprising a docking device and a therapeutic element, the docking device comprising an elongate body and having a proximal end, a distal end, and defining a lumen therethrough, and the therapeutic element being slidable within and deployable from the lumen of the docking device;
- b) a transvaginal probe comprising a handle and an ultrasound transducer;
- c) a mechanical guide, lock or a visual identifier on a part of the system; and
- d) a generator configured to supply energy to the therapeutic element,

wherein the mechanical guide, lock or visual identifier is configured to maintain planar orientation of the therapeutic element relative to the ultrasound transducer and during a procedure on an ovary.

[0186] 2. The system of example 1, wherein the therapeutic element comprises one or more curved structures, the curved structures comprising electrodes and having a straightened length and radius of curvature.

[0187] 3. The system of example 1 or example 2, wherein the therapeutic element comprises two curved structures.

[0188] 4. The system of example 2 or example 3, wherein the straightened length ranges between about 5.0 and about 40 mm.

[0189] 5. The system of any of examples 2-4, wherein the radius of curvature ranges between about 3.0 and about 10 mm.

[0190] 6. The system of example 1, wherein the therapeutic element comprises a curved electrode.

[0191] 7. The system of any of the preceding examples, wherein the therapeutic element comprises an elongate body having a straightened length and a radius of curvature, an active electrode, and a return electrode.

[0192] 8. The system of example 7, wherein the straightened length ranges between about 5.0 and about 40 mm.

[0193] 9. The system of example 7 or example 8, wherein the radius of curvature ranges between about 3.0 and about 10 mm.

[0194] 10. The system of any of examples 1-9, wherein the mechanical guide or lock comprises an adjustable element having a locked position and an unlocked position.

[0195] 11. The system of example 10, wherein the adjustable element comprises a notch configured to mate with the docking device when an alignment adapter is in the locked position.

[0196] 12. The system of any of examples 1-11, wherein the generator is configured to supply radiofrequency energy at a power of 30 watts or less, and for a duration of 60 seconds or less.

[0197] 13. The system of any of examples 1-11, wherein the generator is configured to supply radiofrequency energy at a power of 15 watts or less, and for a duration of 180 seconds or less.

[0198] 14. The system of any of examples 1-11, wherein the generator is configured to supply radiofrequency energy at a power of 10 watts or less, and for a duration of 120 seconds or less.

[0199] 15. The system of any of examples 1-14, wherein the generator is configured to supply radiofrequency energy to target an electrode temperature of about 80°C to about 100 °C, and for a duration of 120 seconds or less.

[0200] 16. The system of any of examples 1-15, wherein the generator is configured to supply continuous or pulsed radiofrequency energy.

[0201] 17. The system of any of examples 1-16, wherein the distal end of the docking device comprises one or more attachment elements for releasably securing an ovary.

[0202] 18. The system of example 17, wherein the one or more attachment elements comprise a hook, needle, or barb.

[0203] 19. The system of any of examples 1-18, wherein the therapeutic element comprises an echogenic material and/or surface feature.

[0204] 20. The system of any of examples 1-19, wherein a portion of the therapeutic element comprises an echogenic material and/or surface feature.

[0205] 21. The system of any of examples 1-20, wherein a portion of the docking device comprises an echogenic material and/or surface feature.

[0206] 22. The system of example 1, wherein the therapeutic element comprises an electrode, a cryoablation element, a cooling element, a laser, or a combination thereof.

[0207] 23. A method for treating polycystic ovary syndrome comprising:

a) advancing a probe comprising a handle, an ultrasound transducer, and a needle guide into the vaginal canal;

b) advancing an ovarian tissue apparatus into the needle guide, the ovarian tissue apparatus comprising a docking device and a therapeutic element;

c) advancing the docking device through a vaginal wall;

d) penetrating an ovary at a single entry point with the docking device or the therapeutic element;

e) advancing the therapeutic element from the docking device into the ovary;

f) delivering energy to affect a volume of tissue within the ovary using the therapeutic element to treat a symptom of polycystic ovary syndrome;

g) retracting the therapeutic element into the docking device; and

h) removing the ovarian tissue apparatus.

[0208] 24. The method of example 23, further comprising repositioning the therapeutic element and repeating the step of energy delivery through the single entry point.

[0209] 25. The method of example 23 or example 24, wherein the step of energy delivery comprises ablating a volume of tissue.

[0210] 26. The method of any of examples 23-25, wherein advancement of the therapeutic element occurs in the same plane as the imaging plane.

[0211] 27. The method of any of examples 23-26, wherein the affected volume of tissue ranges from about 240 mm³ to about 3000 mm³.

[0212] 28. The method of any of examples 23-26, wherein the affected volume of tissue ranges from about 30 mm³ to about 3000 mm³.

[0213] 29. The method of any of examples 23-26, wherein the affected volume of tissue ranges from about 3 to 20% of the ovary.

[0214] 30. The method of any of examples 23-29, wherein the delivered energy is radiofrequency energy.

[0215] 31. The method of example 30, wherein the radiofrequency energy is delivered for 15 to 45 seconds.

[0216] 32. The method of example 30 or example 31, wherein the power of the radiofrequency energy is 30 watts or less.

[0217] 33. The method of example 30 or example 31, wherein the power of the radiofrequency energy is 30 watts or less, and the radiofrequency energy is delivered for a duration of 60 seconds or less.

[0218] 34. The method of example 30 or example 31, wherein the power of the radiofrequency energy is 15 watts or less, and the radiofrequency energy is delivered for a duration of 180 seconds or less.

[0219] 35. The method of example 30 or example 31, wherein the power of the radiofrequency energy 10 watts or less, and the radiofrequency energy is delivered for a duration of 120 seconds or less.

[0220] 36. The method of any of examples 23-35, wherein the electrode temperature is 80°C to 100 degrees °C, and the radiofrequency energy is delivered for a duration of 120 seconds or less.

[0221] 37. The method of any of examples 23-36, wherein delivery of the radiofrequency energy is continuous or pulsed.

[0222] 38. The method of any of examples 23-37, wherein the therapeutic element comprises one or more curved structures, the curved structures comprising electrodes and having a straightened length and radius of curvature.

[0223] 39. The method of example 38, wherein the therapeutic element comprises two curved structures.

[0224] 40. The method of example 38 or example 39, wherein the straightened length ranges between about 5.0 and about 40 mm.

[0225] 41. The method of any of examples 38-40, wherein the radius of curvature ranges between about 3.0 and about 10 mm.

[0226] 42. The method of example 23, wherein the therapeutic element comprises a curved electrode.

[0227] 43. The method of any of examples 23-42, wherein the therapeutic element comprises an elongate body having a straightened length and a radius of curvature, an active electrode, and a return electrode.

[0228] 44. The method of example 43, wherein the straightened length ranges between about 5.0 and about 40 mm.

[0229] 45. The method of example 43 or example 44, wherein the radius of curvature ranges between about 3.0 and about 10 mm.

[0230] 46. The method of any of examples 23-45, wherein the symptom of polycystic ovary syndrome is infertility.

[0231] 47. The system of any of examples 1-11, wherein the generator is configured to supply radiofrequency energy at a power of about 20 watts or less, and for a duration of about 60 seconds or less.

[0232] 48. The system of any of examples 1-11, wherein the generator is configured to supply radiofrequency energy at a power of about 15 watts or less, and for a duration of about 120 seconds or less.

[0233] 49. The system of any of examples 1-11, wherein the radiofrequency energy is delivered for about 60 seconds or less.

[0234] 50. The system of any of examples 1-11, wherein the radiofrequency energy is delivered for 45 seconds or less.

[0235] 51. The system of any of examples 1-11, wherein the radiofrequency energy is delivered for 15 to 45 seconds.

[0236] 52. The system of any of examples 1-11, wherein the power of the radiofrequency energy is 30 watts or less.

[0237] 53. The system of any of examples 1-11, wherein the generator is configured to supply radiofrequency energy at a power in order to achieve a target temperature of between about 80°C and about 120°C.

[0238] 54. A system for performing an ovarian procedure comprising:

a) an ovarian tissue apparatus, the ovarian tissue apparatus comprising a docking device and a therapeutic element, the docking device comprising an elongate body and having a proximal end, a distal end, and defining a lumen therethrough, a therapeutic element disposed on or near the distal end of the docking device;

b) a transvaginal probe comprising a handle and an ultrasound transducer; and

- c) a generator configured to supply energy to the therapeutic element,

[0239] 55. The system of example 54, wherein the ovarian tissue apparatus further comprises an anchoring member and a mechanical guide, lock or a visual identifier on a part of the system.

[0240] 56. The system of example 55, wherein the mechanical guide, lock or visual identifier is configured to aid in deployment of the anchoring member and/or maintain planar orientation of the anchoring member relative to the ultrasound transducer and during a procedure on an ovary.

[0241] 57. The system of any of examples 55-56, wherein the anchoring member comprises one or more curved structures, the curved structures having a straightened length and radius of curvature.

[0242] 58. The system of example 57, wherein the anchoring member comprises two curved structures.

[0243] 59. The system of example 57 and example 58, wherein the straightened length ranges between about 5.0 and about 40 mm.

[0244] 60. The system of any of examples 57-59, wherein the radius of curvature ranges between about 3.0 and about 10 mm.

[0245] 61. The system of example 54, wherein the therapeutic element comprises a pair of electrodes disposed on the docking device.

[0246] 62. The system of any of examples 54-61, wherein the therapeutic element comprises an active electrode and a return electrode.

[0247] 63. The system of any of examples 55-62, wherein the mechanical guide or lock comprises an adjustable element having a locked position and an unlocked position.

[0248] 64. The system of example 63, wherein the adjustable element comprises a notch configured to mate with the docking device when an alignment adapter is in the locked position.

[0249] 65. The system of any of examples 54-64, wherein the generator is configured to supply radiofrequency energy at a power of 30 watts or less, and for a duration of 20 seconds or less.

[0250] 66. The system of any of examples 54-64, wherein the generator is configured to supply radiofrequency energy at a power of 20 watts or less, and for a duration of 60 seconds or less.

[0251] 67. The system of any of examples 54-64, wherein the generator is configured to supply radiofrequency energy at a power of 15 watts or less, and for a duration of 120 seconds or less.

[0252] 68. The system of any of examples 54-64, wherein the radiofrequency energy is delivered for 60 seconds or less.

[0253] 69. The system of any of examples 54-64, wherein the radiofrequency energy is delivered for 45 seconds or less.

[0254] 70. The system of any of examples 54-64, wherein the radiofrequency energy is delivered for 15 to 45 seconds.

[0255] 71. The system of any of examples 54-64, wherein the power of the radiofrequency energy is 30 watts or less.

[0256] 72. The system of any of examples 54-66, wherein the generator is configured to supply radiofrequency energy at a power in order to achieve a predetermined target temperature.

[0257] 73. The system of any of examples 54-72, wherein the generator is configured to supply radiofrequency energy at a power in order to achieve a target temperature of between about 80°C and 120°C.

[0258] 74. The system of any of examples 54-73, wherein the generator is configured to supply radiofrequency energy with a predetermined maximum power in order to achieve a target temperature and in order to achieve a predetermined maximum change in impedance.

[0259] 75. The system of any of examples 54-74, wherein the generator is configured to supply continuous or pulsed radiofrequency energy.

[0260] 76. The system of any of examples 54-75, wherein the distal end of the docking device comprises one or more attachment elements for releasably securing an ovary.

[0261] 77. The system of any of examples 54-76, wherein the one or more attachment elements comprise a hook, needle, or barb.

[0262] 78. The system of any of examples 54-77, wherein the therapeutic element comprises an echogenic material and/or surface feature.

[0263] 79. The system of any of examples 54-78, wherein a portion of the therapeutic element comprises an echogenic material and/or surface feature.

[0264] 80. The system of any of examples 54-79, wherein a portion of the docking device comprises an echogenic material and/or surface feature.

[0265] 81. The system of any of examples 55-80, wherein the anchoring member comprises an echogenic material and/or surface feature.

[0266] 82. The system of any of examples 55-81, wherein a portion of the anchoring member comprises an echogenic material and/or surface feature.

[0267] 83. The system of example 54, wherein the therapeutic element comprises an electrode, a cryoablation element, a cooling element, a laser, or a combination thereof.

[0268] 84. A method for treating polycystic ovary syndrome comprising:

- a) advancing a probe comprising a handle, an ultrasound transducer, and a needle guide into the vaginal canal;
- b) advancing an ovarian tissue apparatus into the needle guide, the ovarian tissue apparatus comprising a docking device, a therapeutic element, and an anchoring member;
- c) advancing the docking device through a vaginal wall;

- d) penetrating an ovary at a single entry point with the docking device or the therapeutic element;
- e) advancing the therapeutic element into the ovary;
- f) advancing the anchoring member from the docking device;
- g) delivering energy to affect a volume of tissue within the ovary using the therapeutic element to treat a symptom of polycystic ovary syndrome;
- h) retracting the anchoring member into the docking device; and
- i) removing the ovarian tissue apparatus.

[0269] 85. The method of example 84, further comprising repositioning the therapeutic element and repeating the step of energy delivery through the single entry point.

[0270] 86. The method of example 84 or example 85, wherein the step of energy delivery comprises ablating a volume of tissue.

[0271] 87. The method of any of examples 84-86, wherein advancement of the therapeutic element occurs in the same plane as the imaging plane.

[0272] 88. The method of any of examples 84-87, wherein advancement of the anchoring member occurs in the same plane as the imaging plane.

[0273] 89. The method of any of examples 84-88, wherein the affected volume of tissue ranges from about 240 mm³ to about 3000 mm³.

[0274] 90. The method of any of examples 84-88, wherein the affected volume of tissue ranges from about 30 mm³ to about 3000 mm³.

[0275] 91. The method of any of examples 84-88, wherein the affected volume of tissue ranges from about 3 to 20% of the ovary.

[0276] 92. The method of any of examples 84-91, wherein the delivered energy is radiofrequency energy.

[0277] 93. The method of example 92, wherein the radiofrequency energy is delivered for 15 to 45 seconds.

[0278] 94. The method of example 92, wherein the power of the radiofrequency energy is 30 watts or less.

[0279] 95. The method of example 92, wherein the radiofrequency energy is delivered at a power of 20 watts or less, and for a duration of 60 seconds or less.

[0280] 96. The method of example 92, wherein the radiofrequency energy is delivered at a power of 15 watts or less, and for a duration of 120 seconds or less.

[0281] 97. The method of example 92, wherein the radiofrequency energy is delivered for 60 seconds or less.

[0282] 98. The method of example 92, wherein the radiofrequency energy is delivered for 45 seconds or less.

[0283] 99. The method of example 92, wherein the radiofrequency energy is delivered for 15 to 45 seconds.

[0284] 100. The method of example 92, wherein the power of the radiofrequency energy is 30 watts or less.

[0285] 101. The method of any of examples 92-100, wherein the radiofrequency energy is delivered at a power in order to achieve a predetermined target temperature.

[0286] 102. The method of any of examples 92-101, wherein the radiofrequency energy is delivered at a power in order to achieve a target temperature of between about 80°C and about 120°C.

[0287] 103. The method of any of examples 92-102, wherein the radiofrequency energy is delivered with a predetermined maximum power in order to achieve a target temperature and in order to achieve a predetermined maximum change in impedance.

[0288] 104. The method of any of examples 92-103, wherein delivery of the radiofrequency energy is continuous or pulsed.

[0289] 105. The method of any of examples 84-104, wherein the anchoring member comprises one or more curved structures, the curved structures having a straightened length and radius of curvature.

[0290] 106. The method of example 105, wherein the anchoring member comprises two curved structures.

[0291] 107. The method of example 105 or example 106, wherein the straightened length ranges between about 5,0 and about 40 mm.

[0292] 108. The method of any of examples 105-107, wherein the radius of curvature ranges between about 3.0 and about 10 mm.

[0293] 109. The method of example 84, wherein the therapeutic element comprises a pair of electrodes disposed on the docking device.

[0294] 110. The method of any of examples 84-109, wherein the therapeutic element comprises an active electrode and a return electrode.

[0295] 111. The method of any of examples 84-110, wherein the symptom of polycystic ovary syndrome is infertility.

[0296] In the claims which follow and in the preceding description of the invention, except where the context requires otherwise due to express language or necessary implication, the word “comprise” or variations such as “comprises” or “comprising” is used in an inclusive sense, i.e. to specify the presence of the stated feature but not to preclude the presence or addition of further features in various embodiments of the invention.

[0297] It is to be understood that, if any prior art publication is referred to herein, such reference does not constitute an admission that the publication forms a part of the common general knowledge in the art, in Australia or any other country.

The claims defining the invention are as follows:

1. A system for performing an ovarian procedure in combination with a transvaginal probe comprising a handle, the system comprising:
 - an ovarian tissue apparatus, the ovarian tissue apparatus comprising a docking device having an elongate body, a proximal end, a distal portion having an opening and a distal end comprising one or more attachment elements for releasably securing an ovary, and defining a lumen therethrough, an anchoring member disposed for reciprocation within the lumen and having a distal region, the distal region transitioning to a curved shape when extended through the opening, and a therapeutic element disposed on the distal region of the anchoring member;
 - an alignment adapter configured to be removeably affixed to the handle of the transvaginal probe, the alignment adapter further configured to couple the docking device to the transvaginal probe; and
 - a generator configured to supply energy to the therapeutic element.
2. The system of claim 1, wherein the alignment adapter comprises a receiving alignment channel having a geometry that allows engagement with the docking device.
3. The system of claim 2, wherein the docking device comprises an alignment element configured to mate with the receiving alignment channel of the alignment adapter to maintain planar orientation of the anchoring member and a visualization plane of the transvaginal probe during a procedure on the ovary.
4. The system of claim 1, wherein the distal region of the anchoring member has a straightened length when disposed within the lumen.
5. The system of claim 4, wherein the anchoring member comprises two curved structures.
6. The system of claim 4, wherein the straightened length ranges between about 5.0 and about 40 mm.
7. The system of claim 4, wherein the curved shape of the distal region has a radius of curvature ranging between about 3 and about 16 mm.

8. The system of claim 1, wherein the therapeutic element comprises a pair of electrodes disposed on the distal region.
9. The system of claim 1, wherein the therapeutic element comprises an active electrode and a return electrode.
10. The system of claim 2, wherein engagement of the receiving alignment channel and the docking element limits rotation of the docking device relative to the transvaginal probe.
11. The system of claim 1, wherein the docking device comprises a handle having a deployment feature, the deployment feature configured to deploy the therapeutic element and the anchoring member.
12. The system of claim 1, wherein the generator is configured to supply radiofrequency energy at a power of between about 1 watts and 40 watts, and for a duration of about 10 to about 120 seconds.
13. The system of claim 1, wherein the generator is configured to supply continuous or pulsed radiofrequency energy.
14. The system of claim 1, wherein the one or more attachment elements comprise a hook, needle, or barb.
15. The system of claim 1, wherein a portion of at least one of the docking device, the anchoring member or the therapeutic element comprises an echogenic material.
16. The system of claim 1, wherein the therapeutic element comprises an electrode, a cryoablation element, a cooling element, a laser, or a combination thereof.
17. The system of claim 1 wherein the opening is disposed proximal to the distal end.

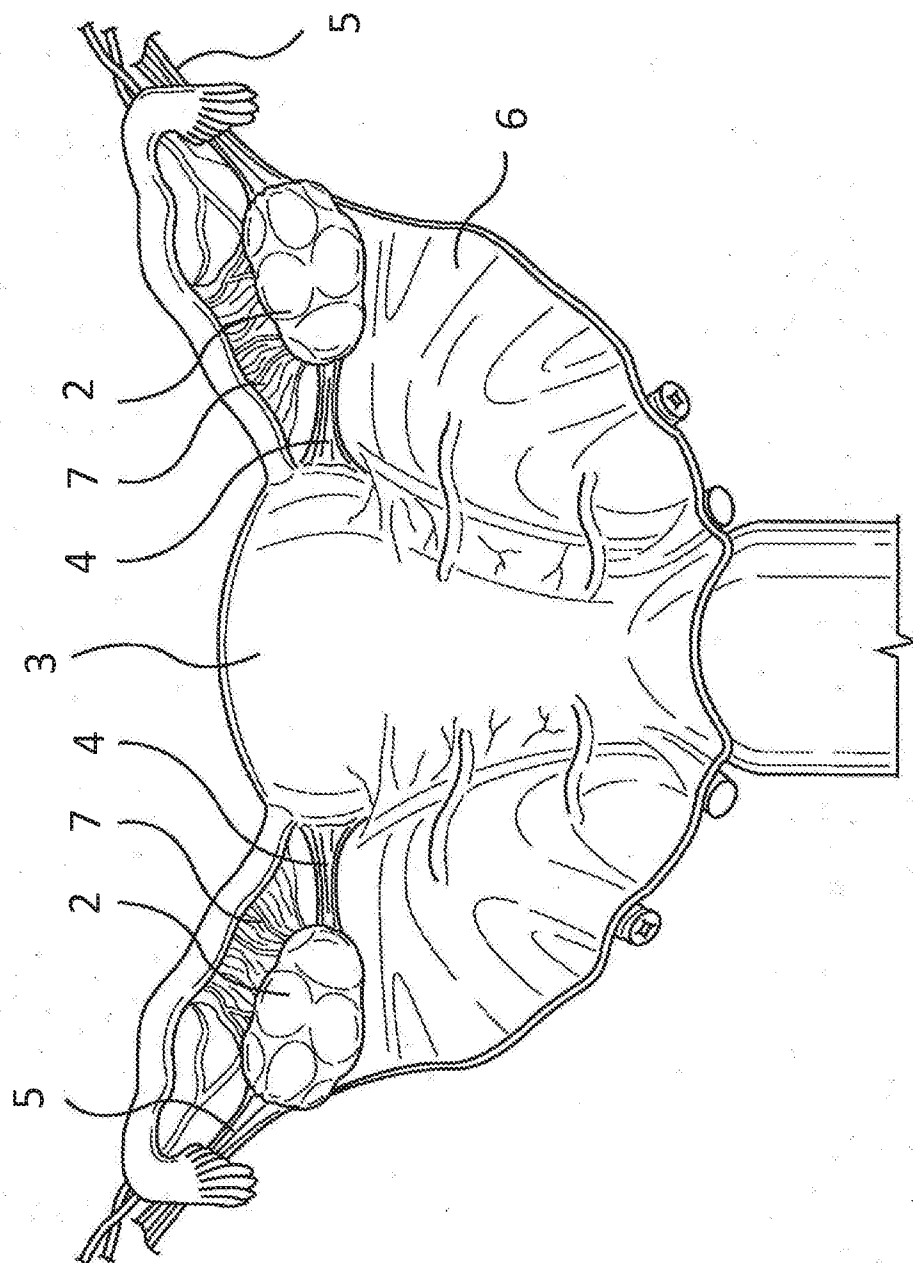
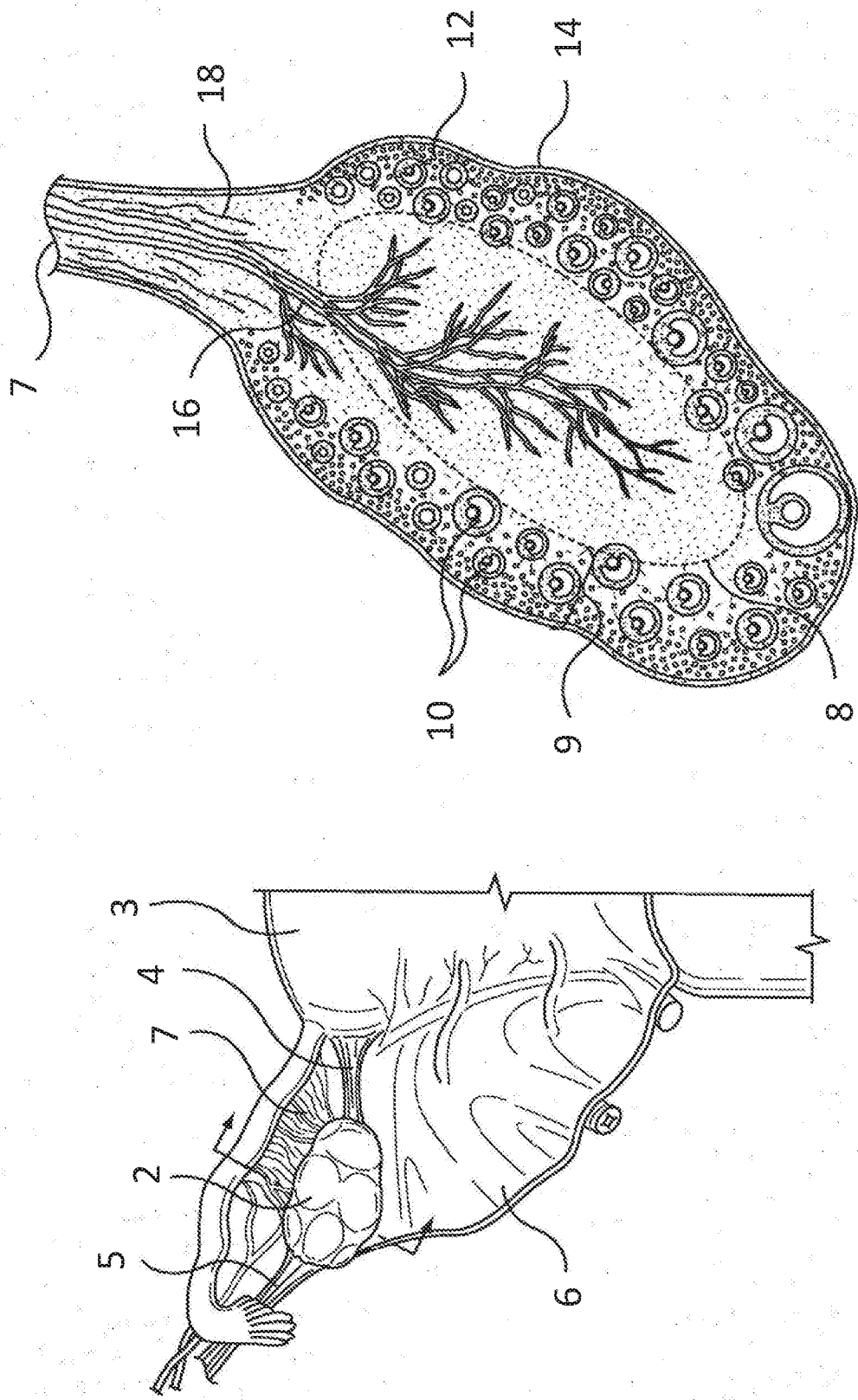


FIG. 1A

FIG. 1B



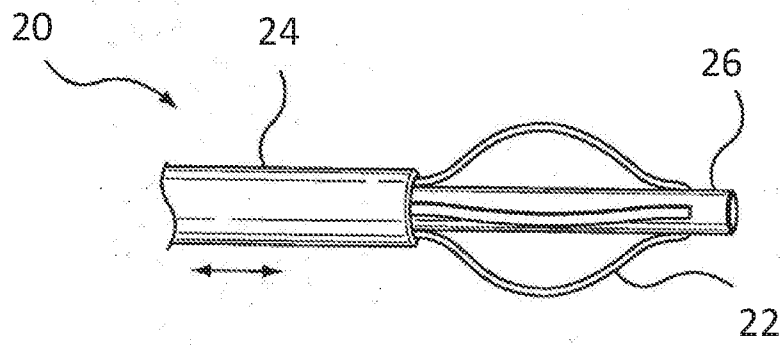


FIG. 2

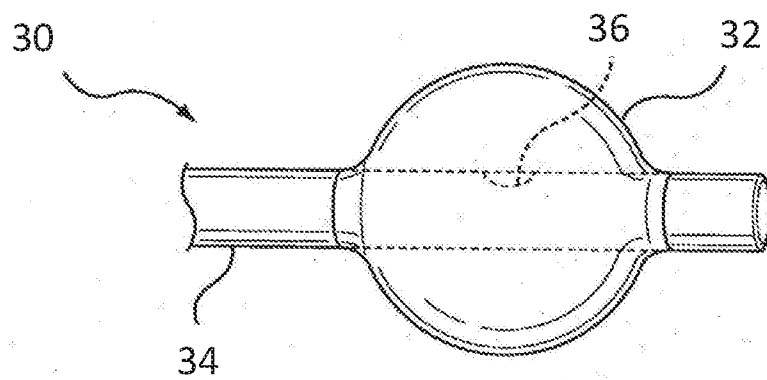


FIG. 3

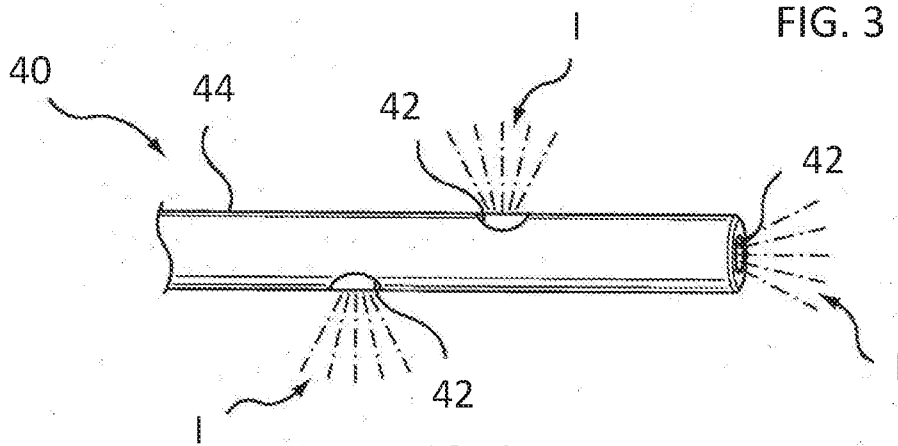


FIG. 4

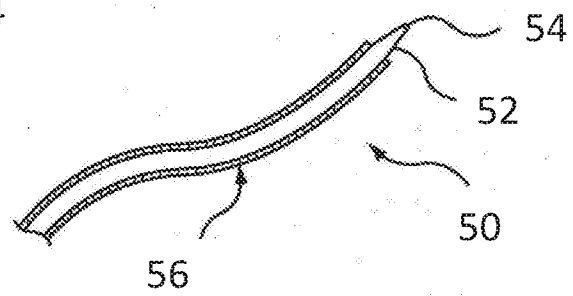


FIG. 5

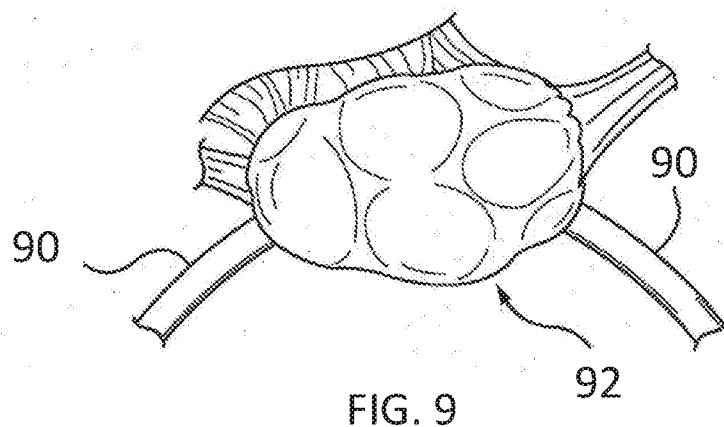
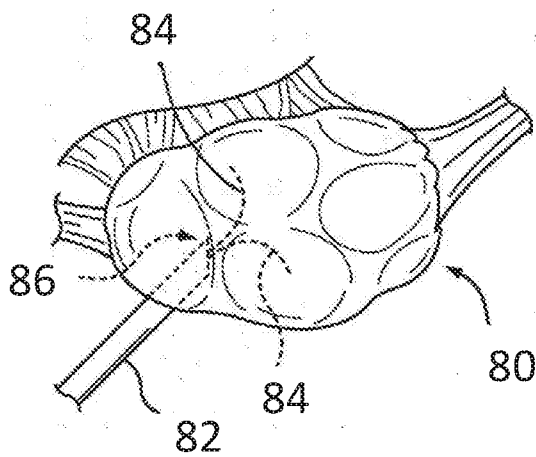
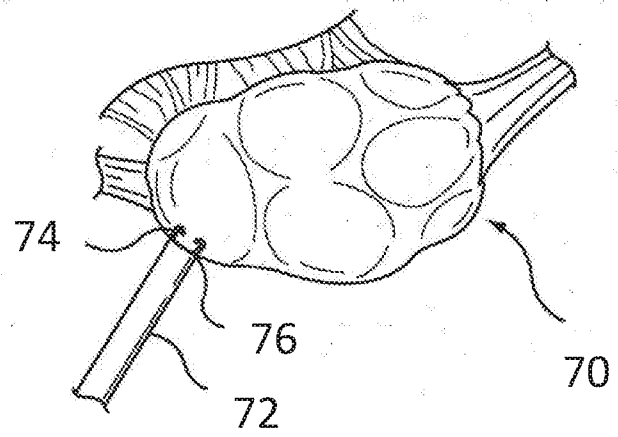
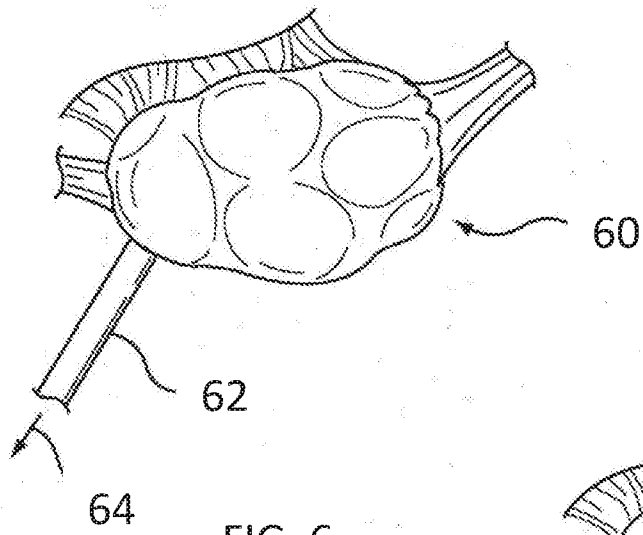
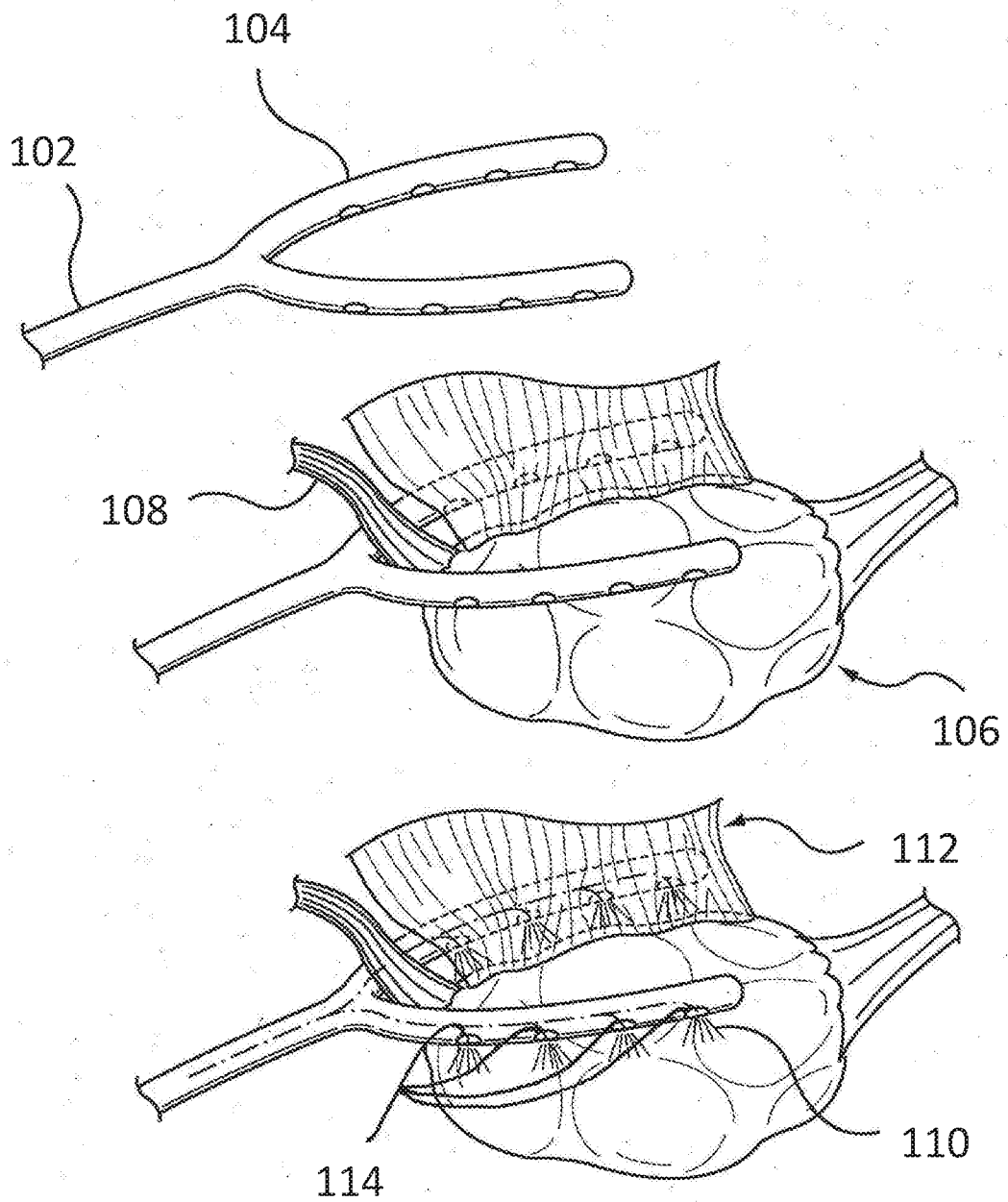


FIG. 10



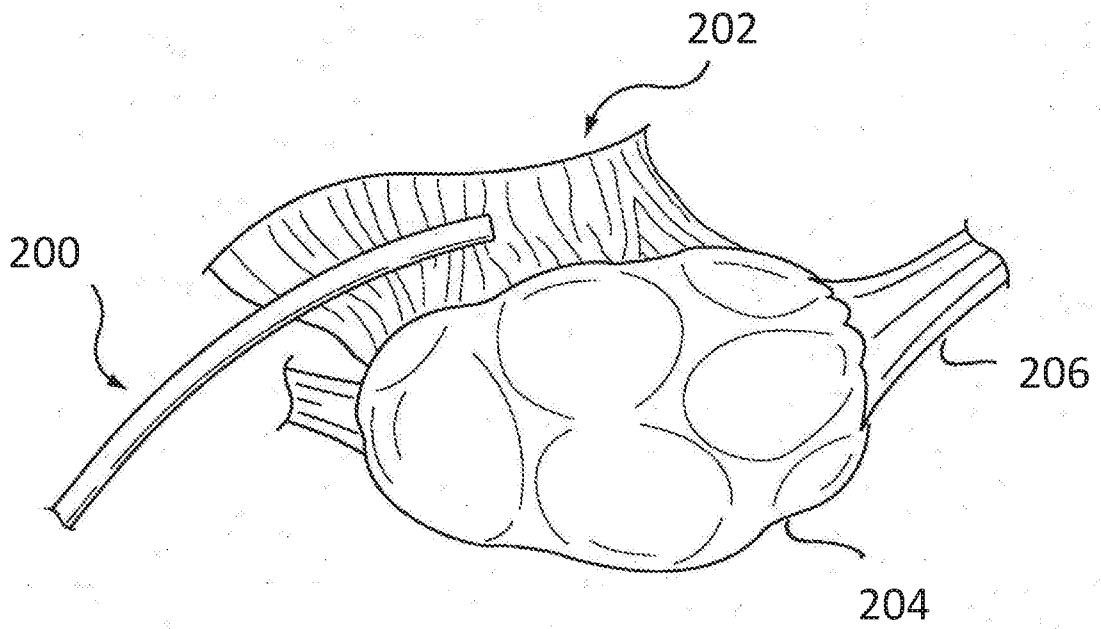


FIG. 11A

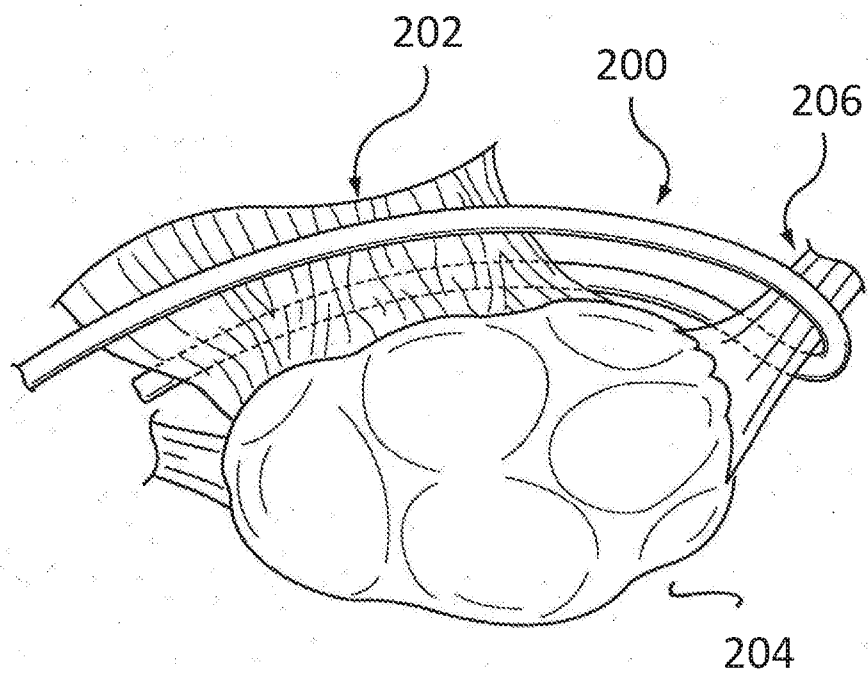
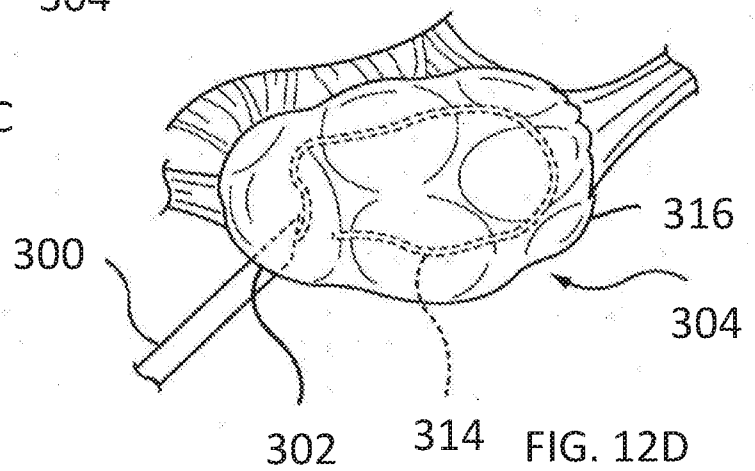
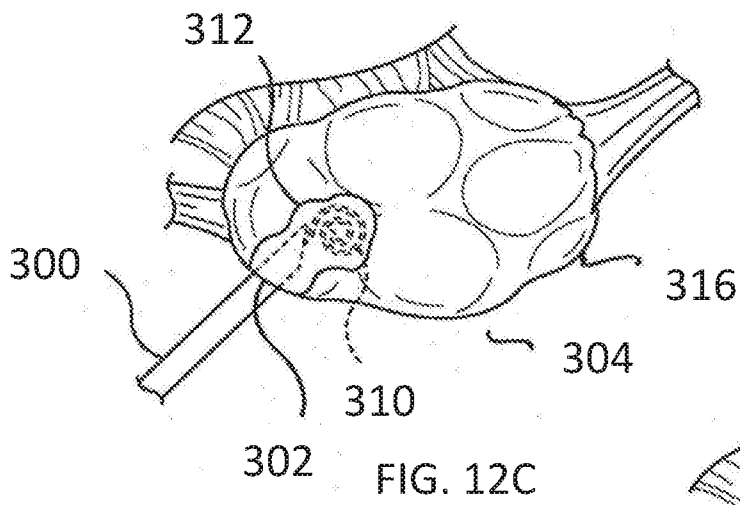
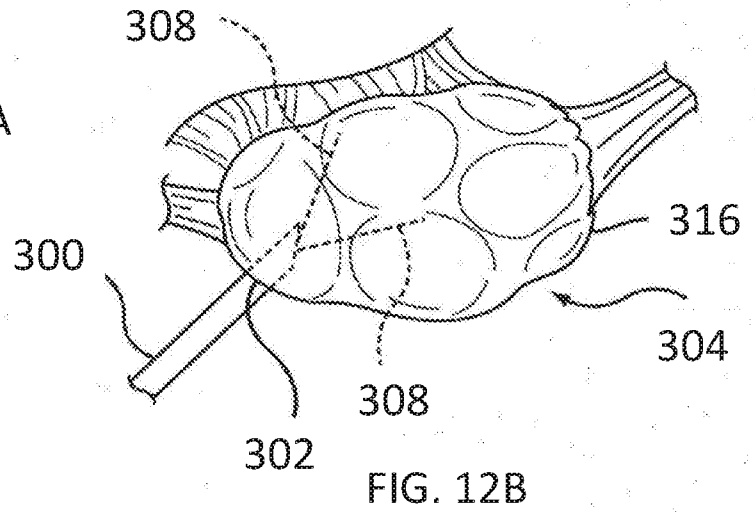
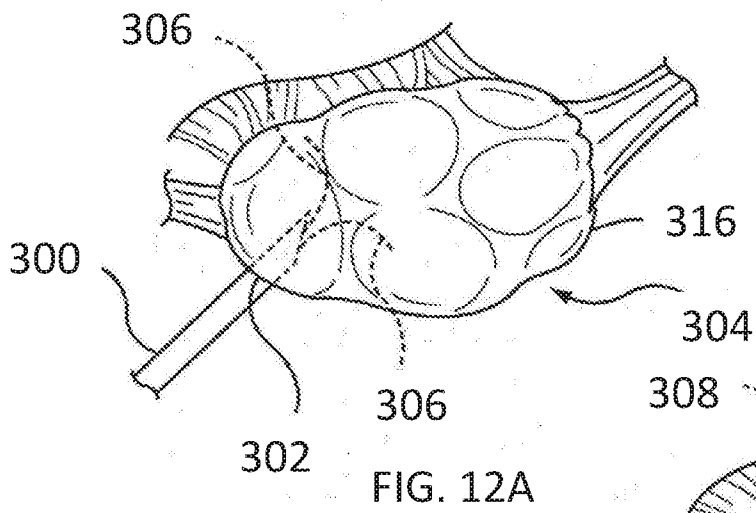
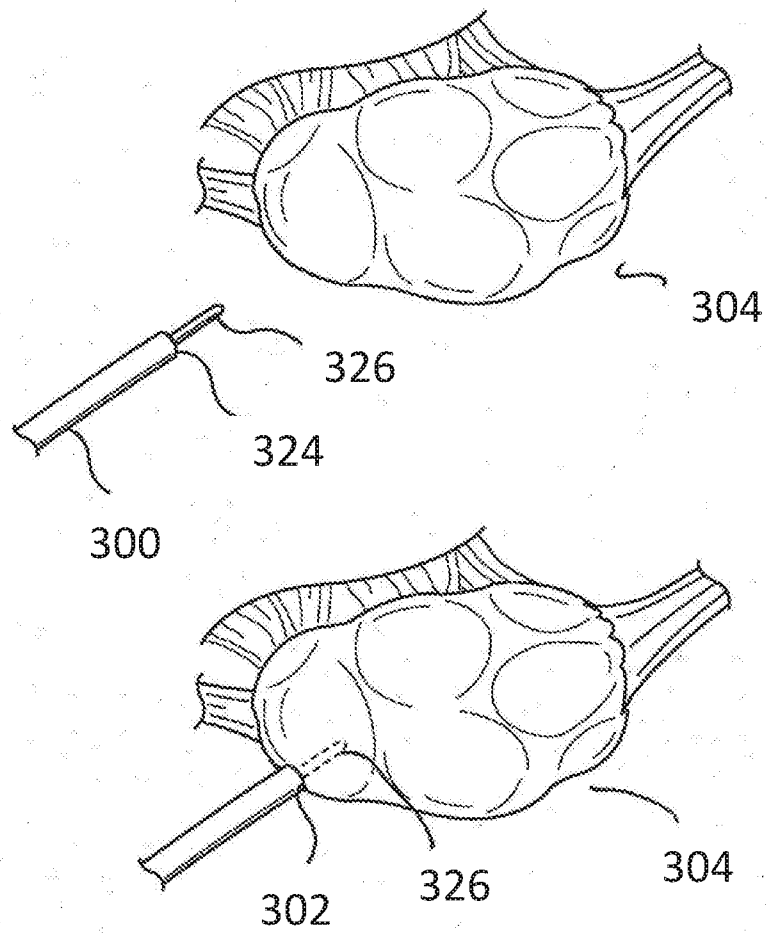
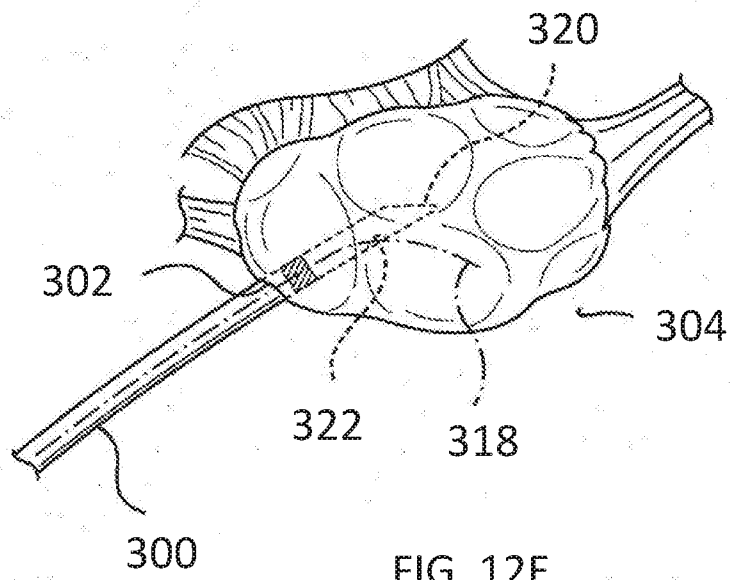


FIG. 11B





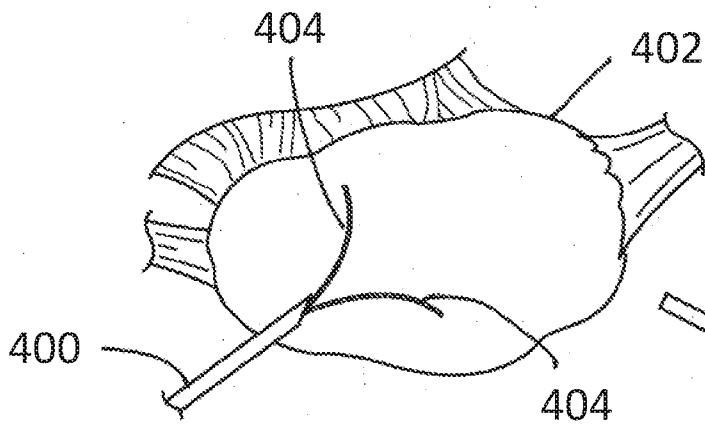


FIG. 13A

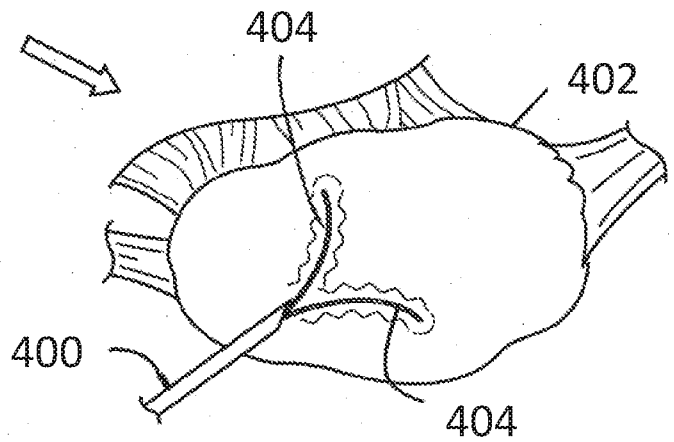


FIG. 13B

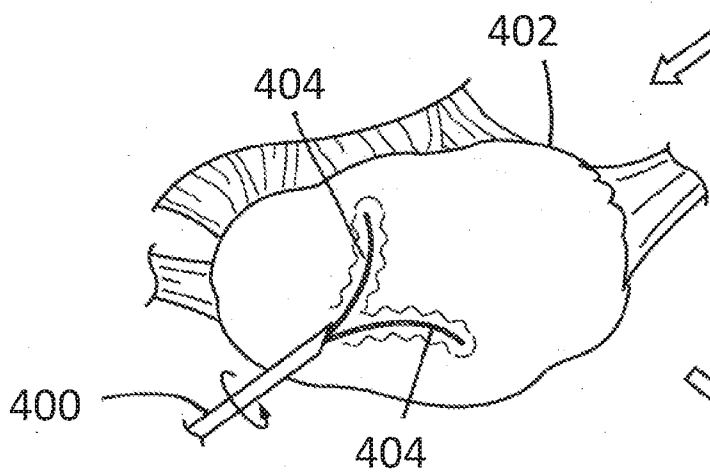


FIG. 13C

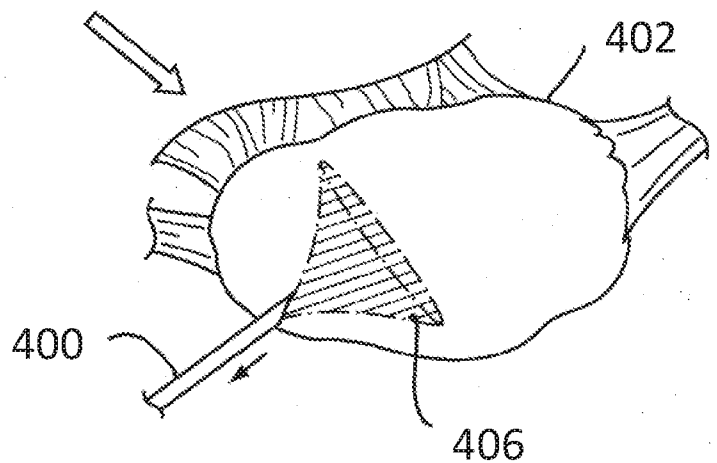
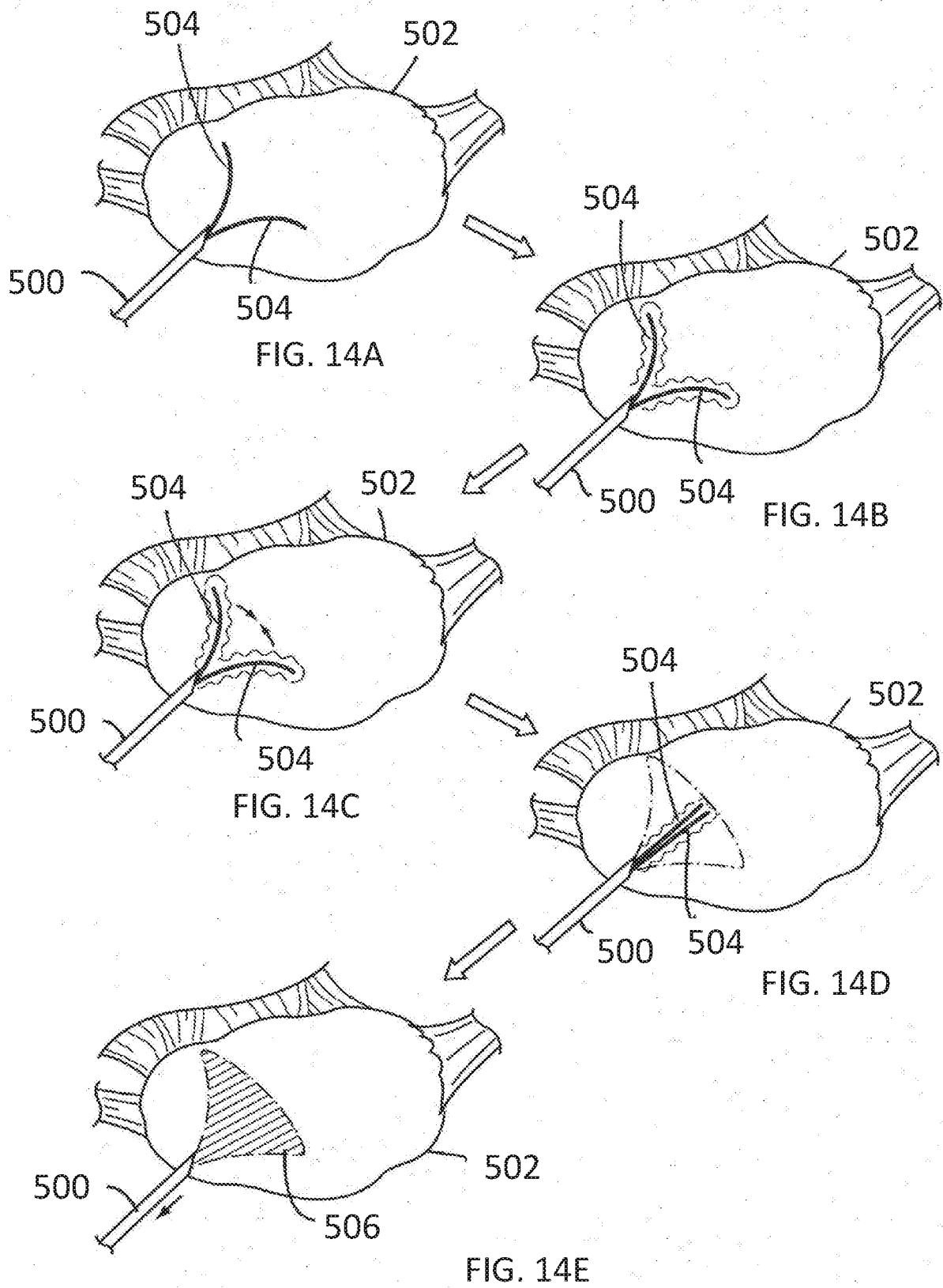


FIG. 13D



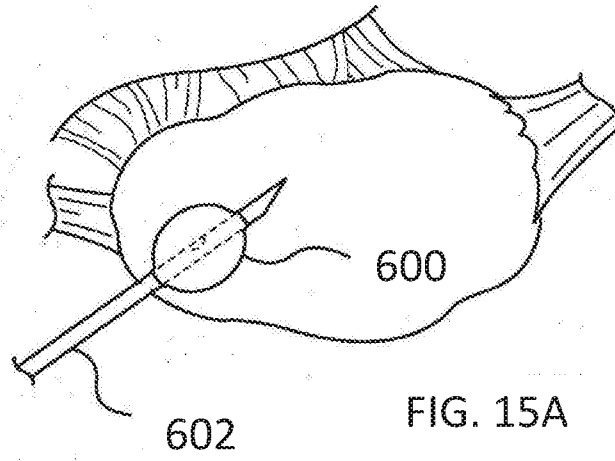


FIG. 15A

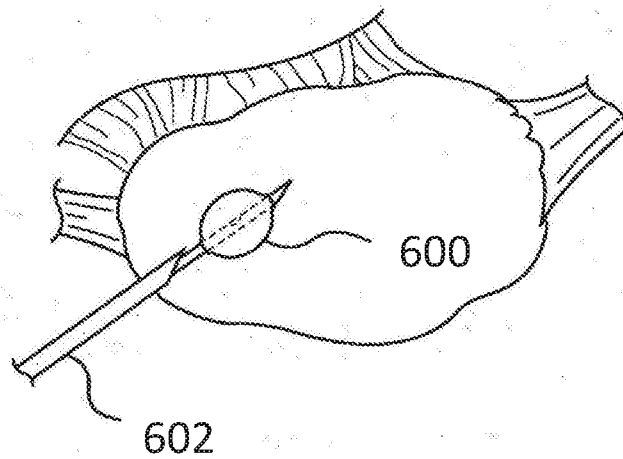
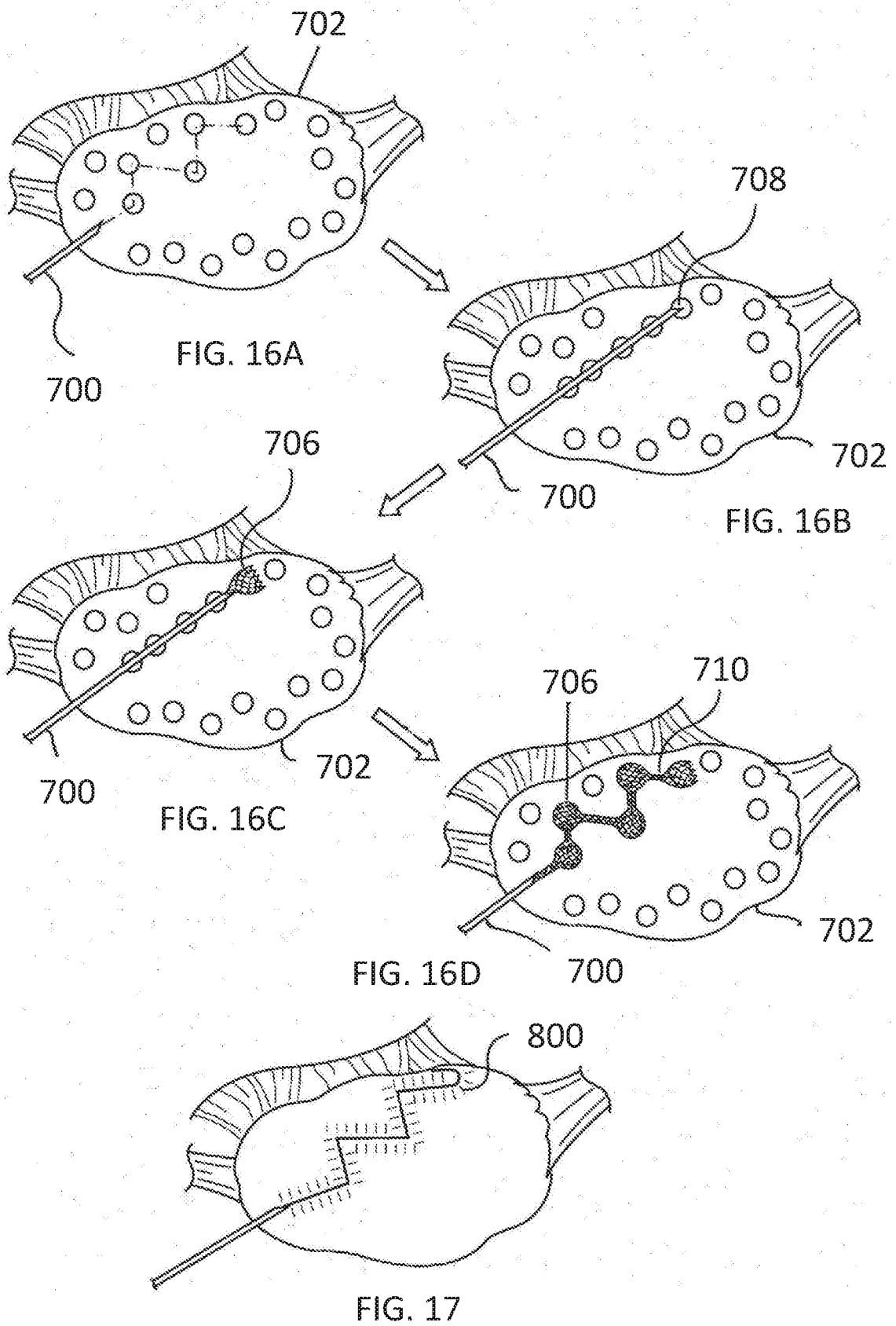
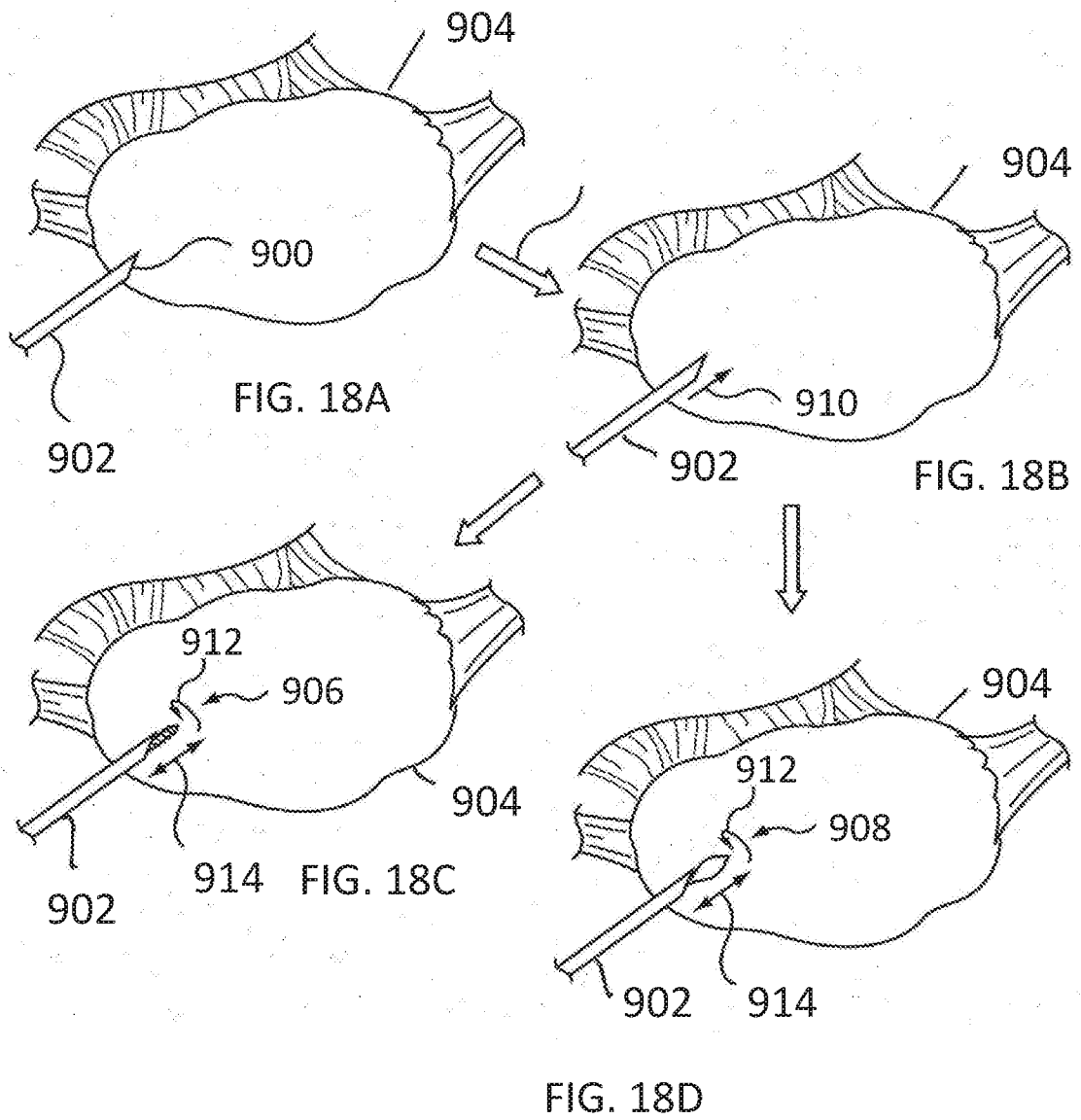


FIG. 15B





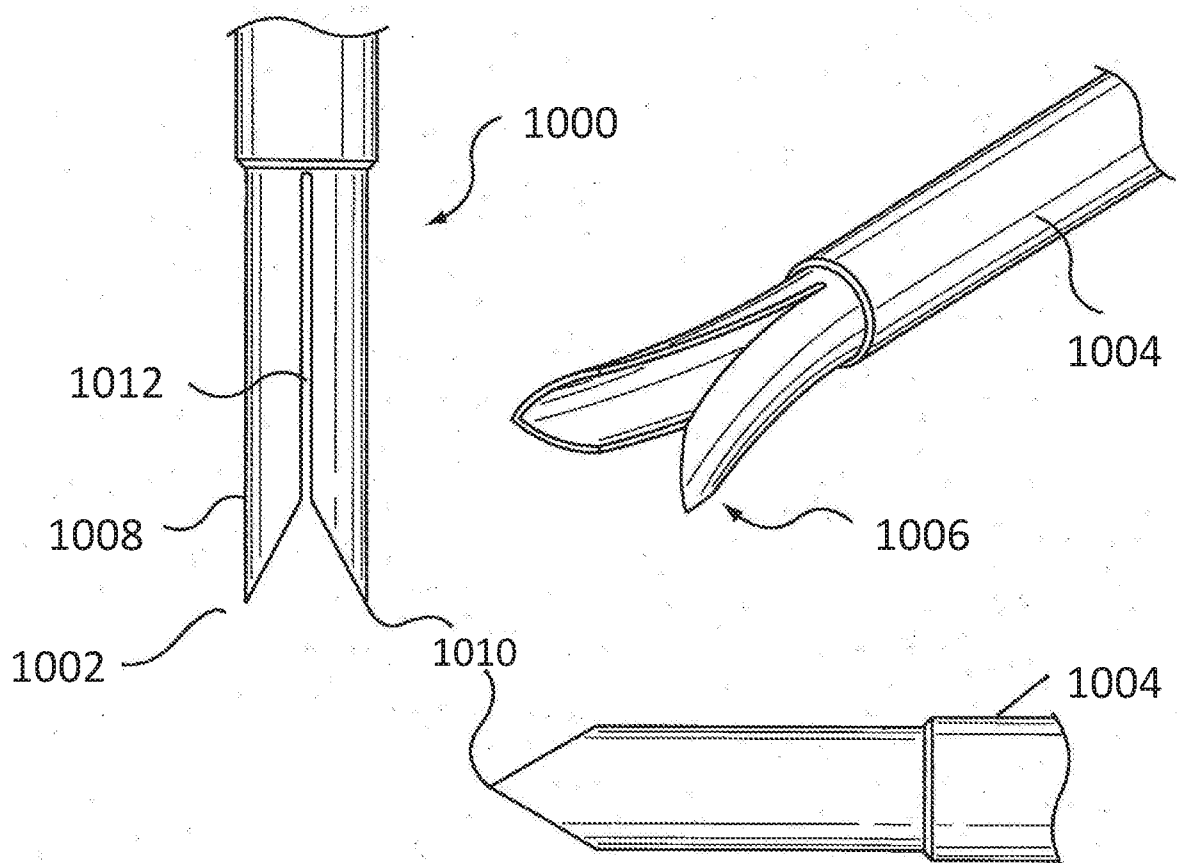
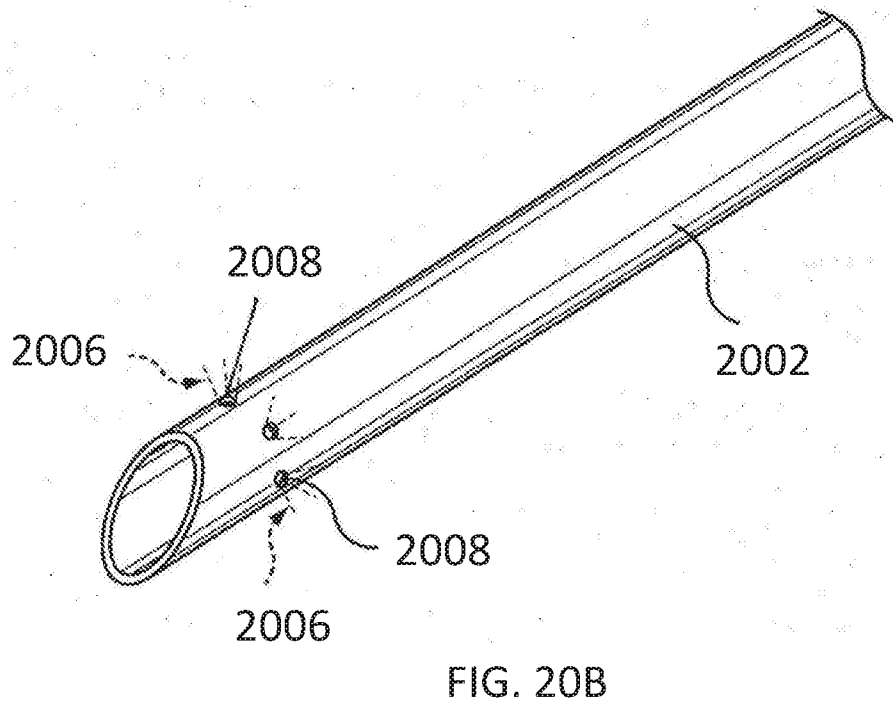
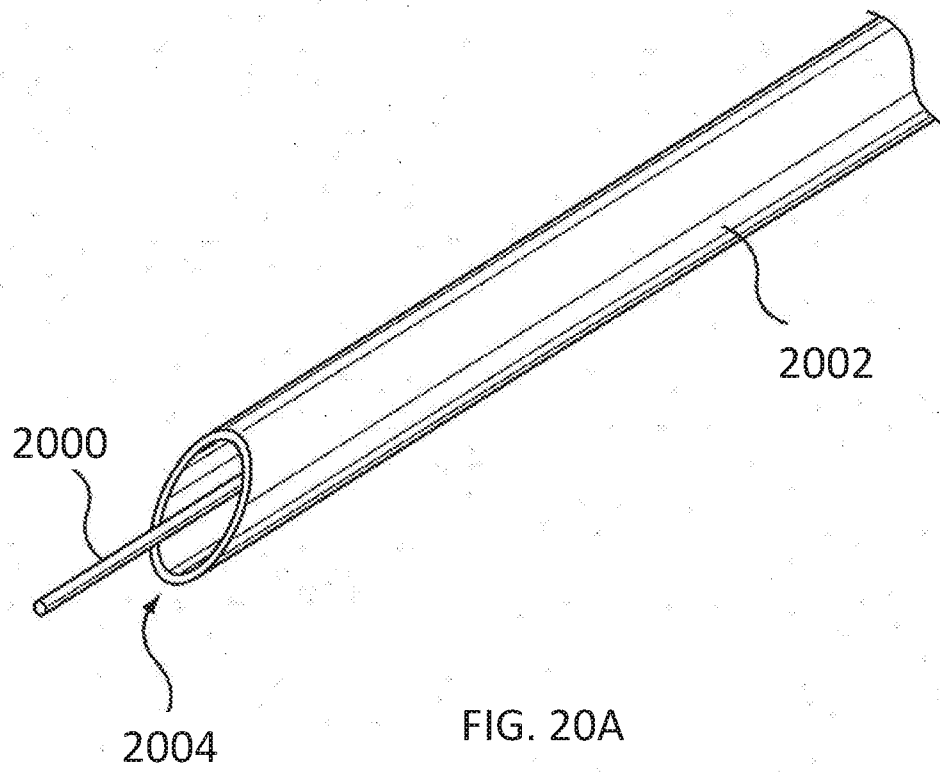


FIG. 19



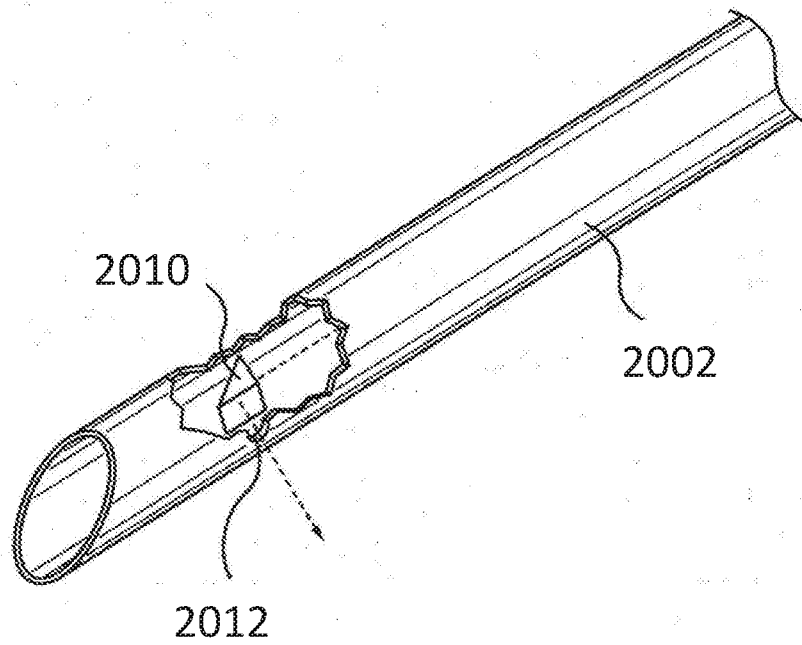


FIG. 20C

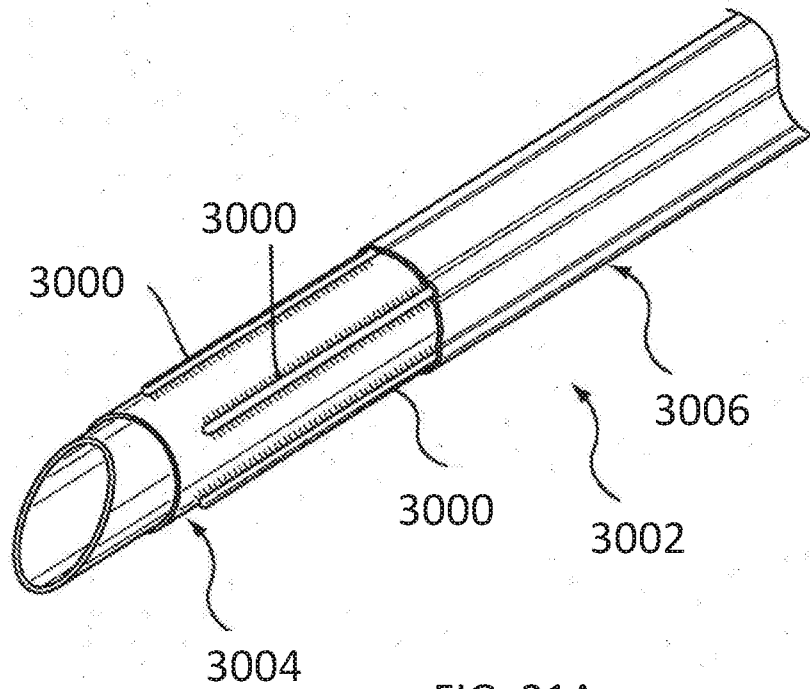


FIG. 21A

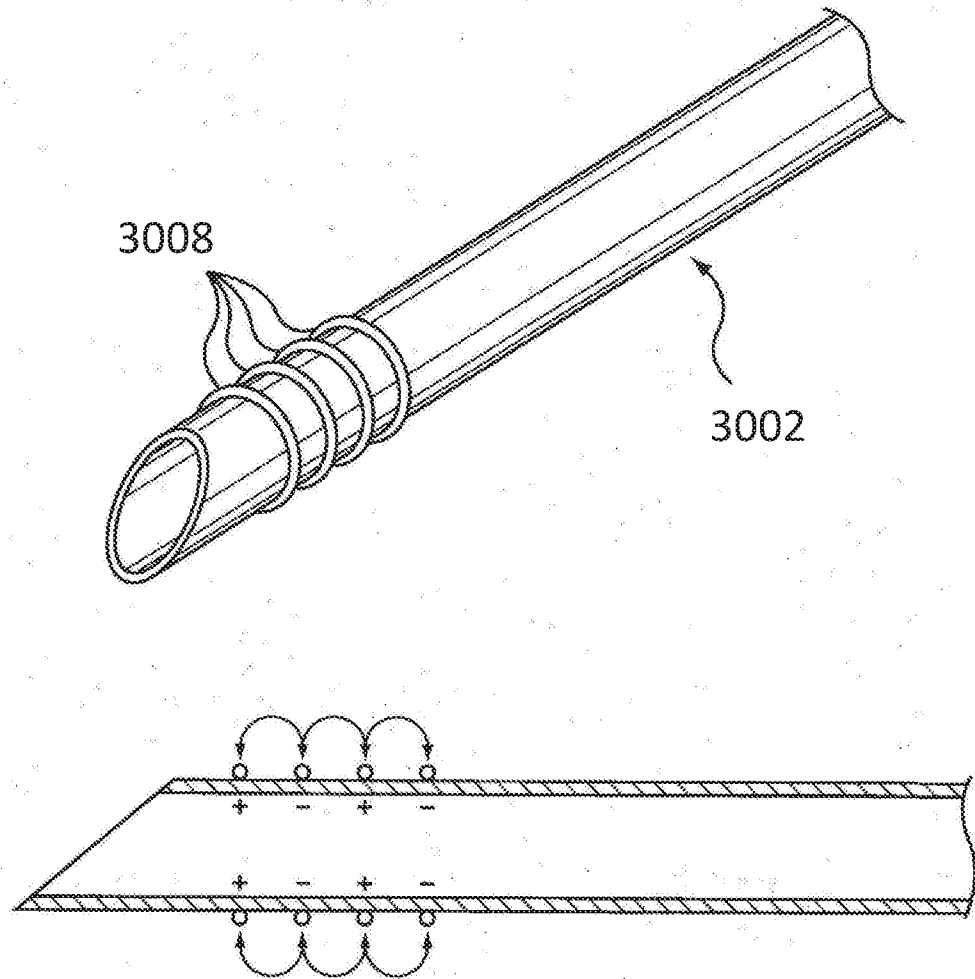


FIG. 21B

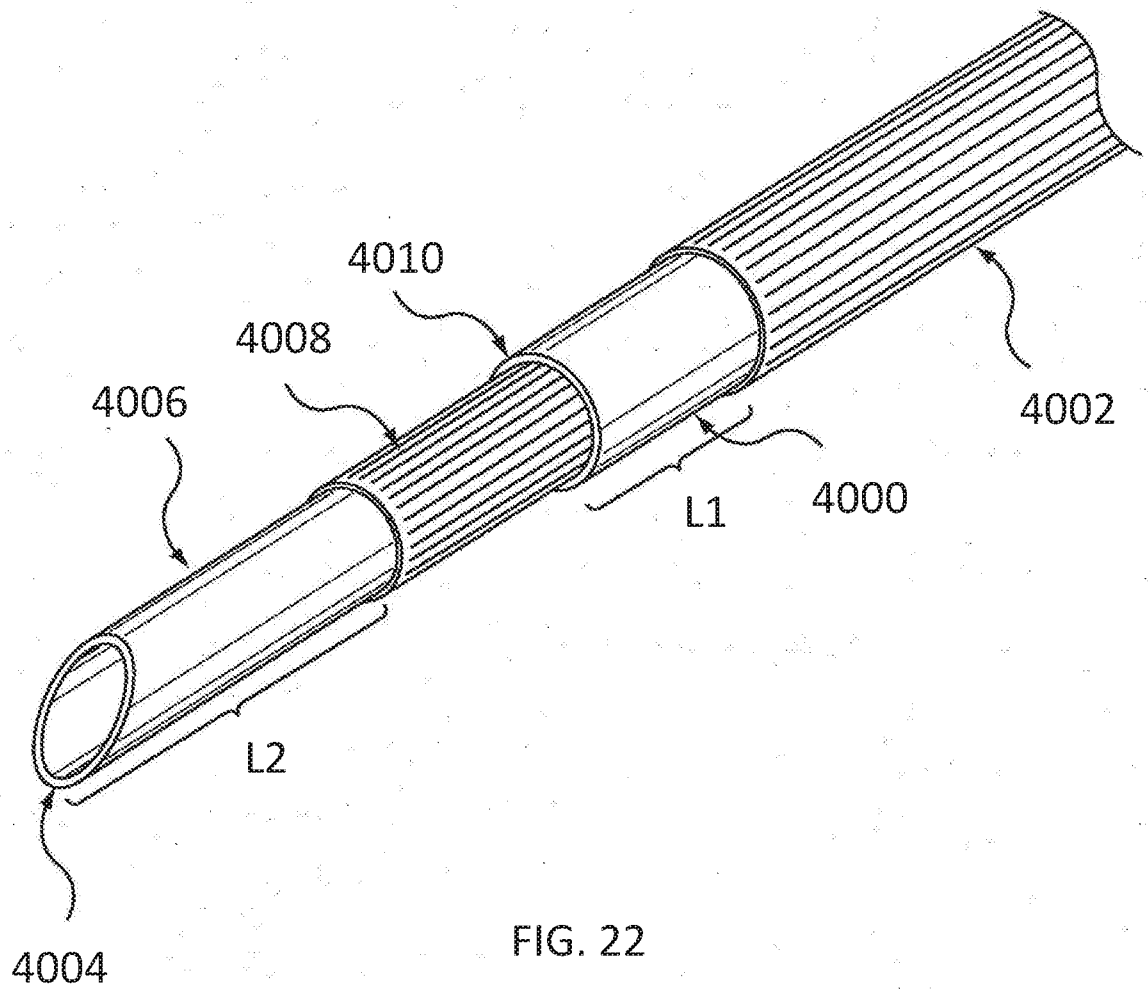
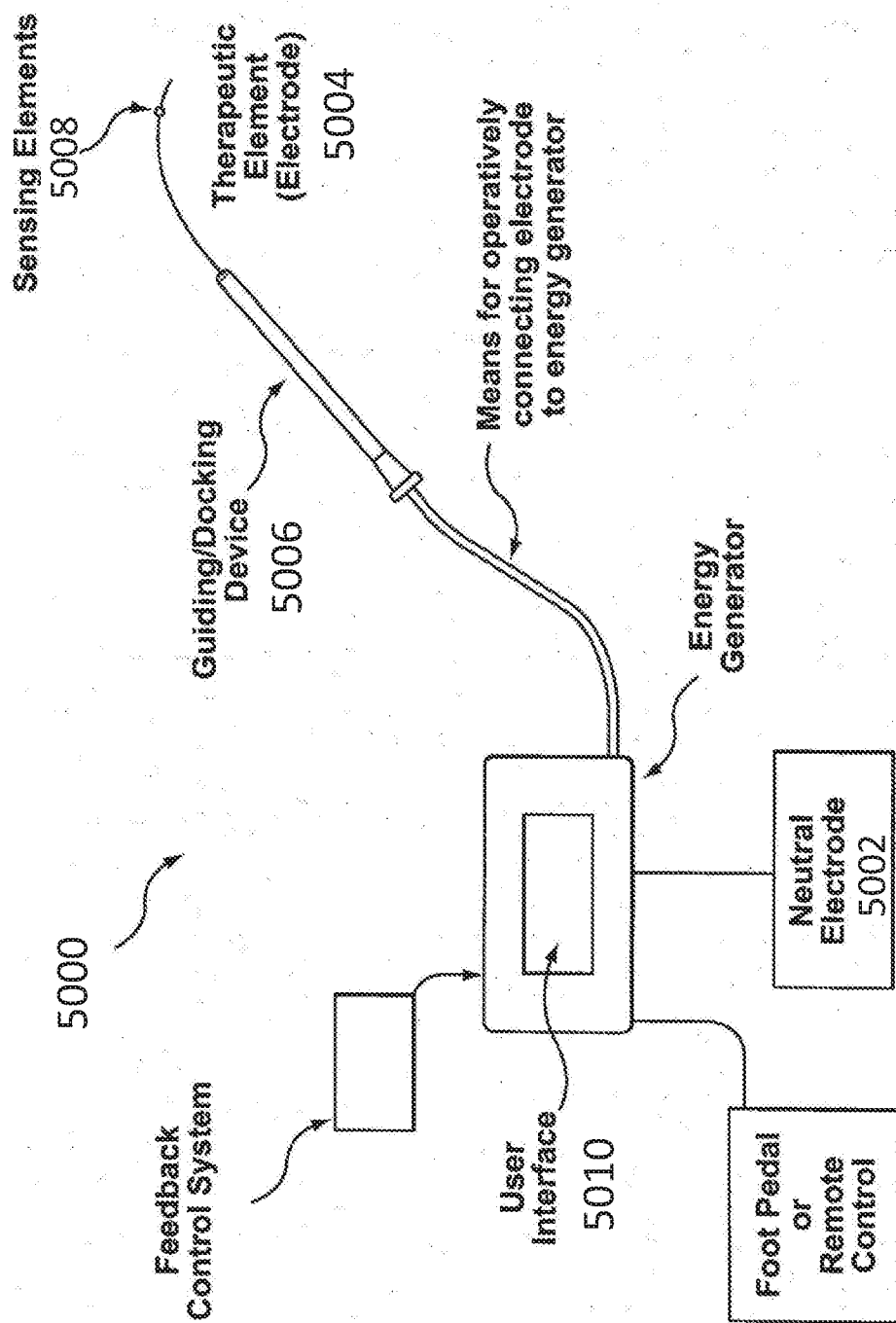


FIG. 23



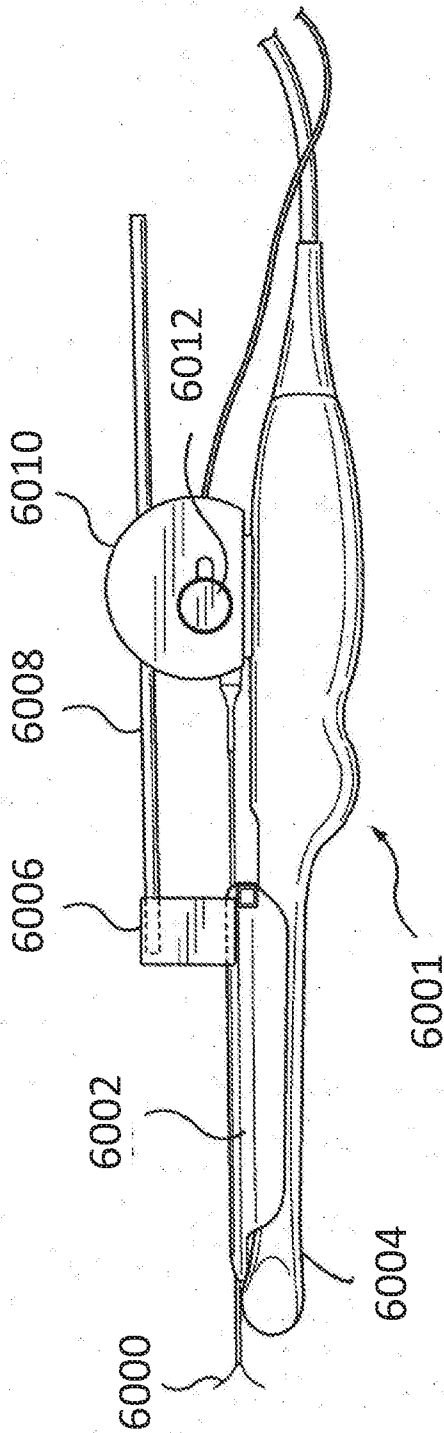


FIG. 24

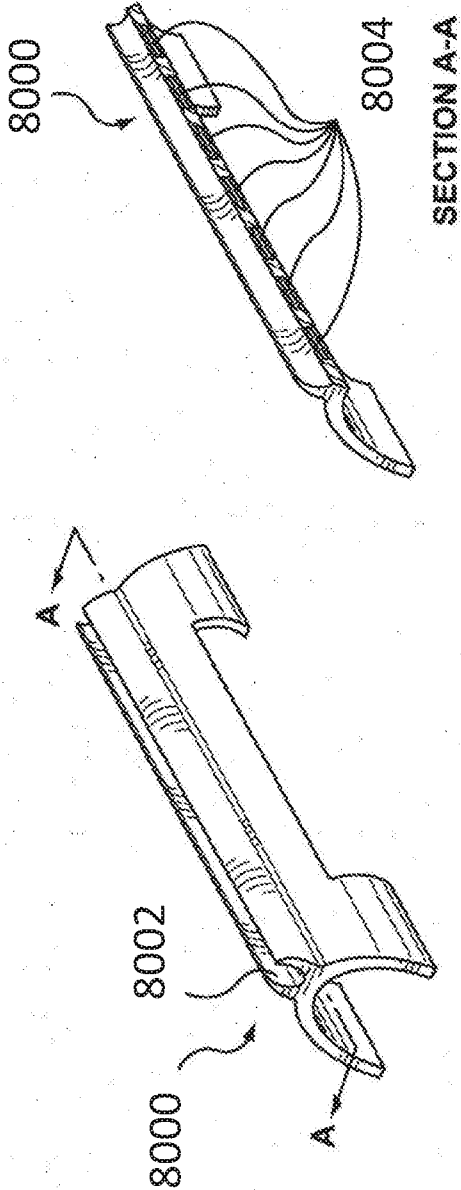


FIG. 25

SECTION A-A

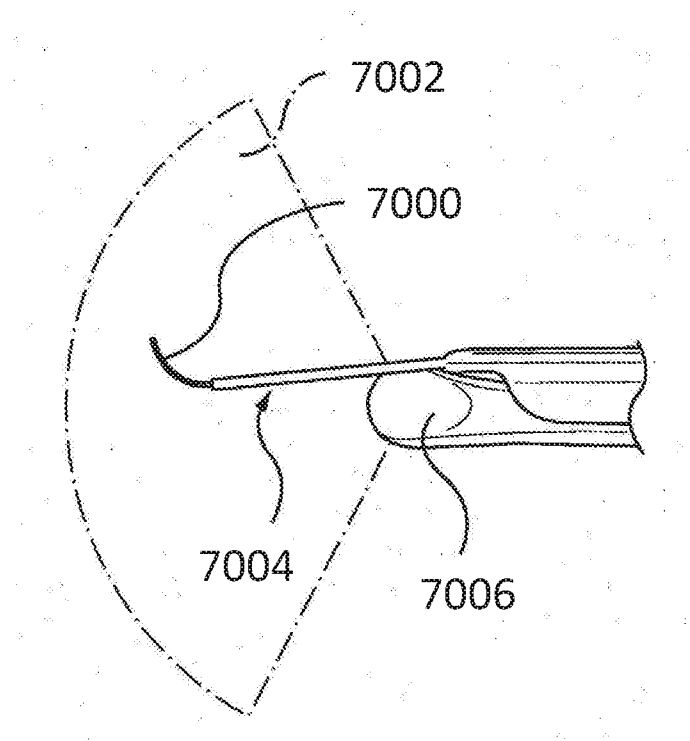
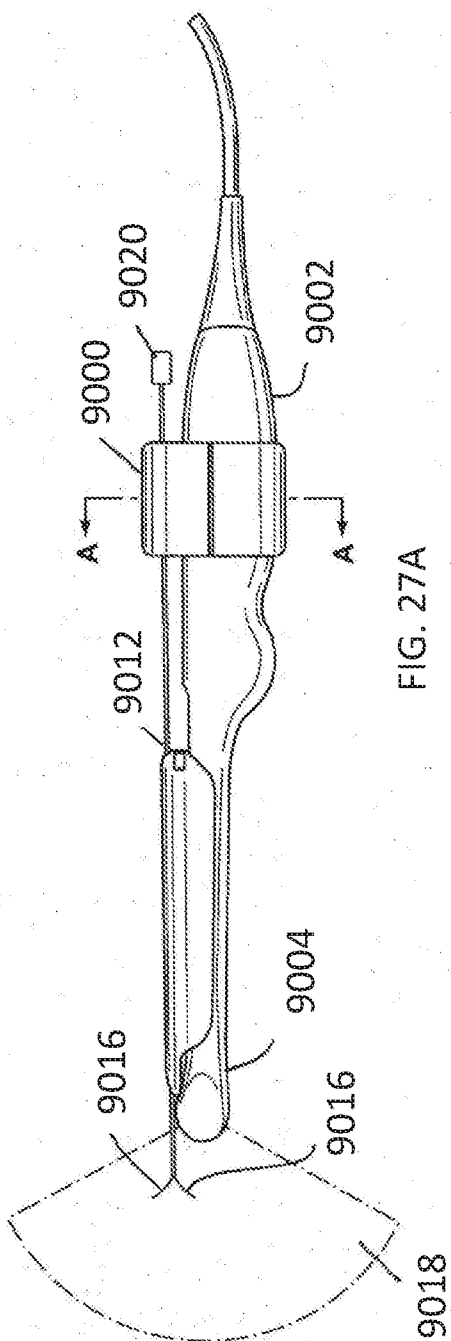
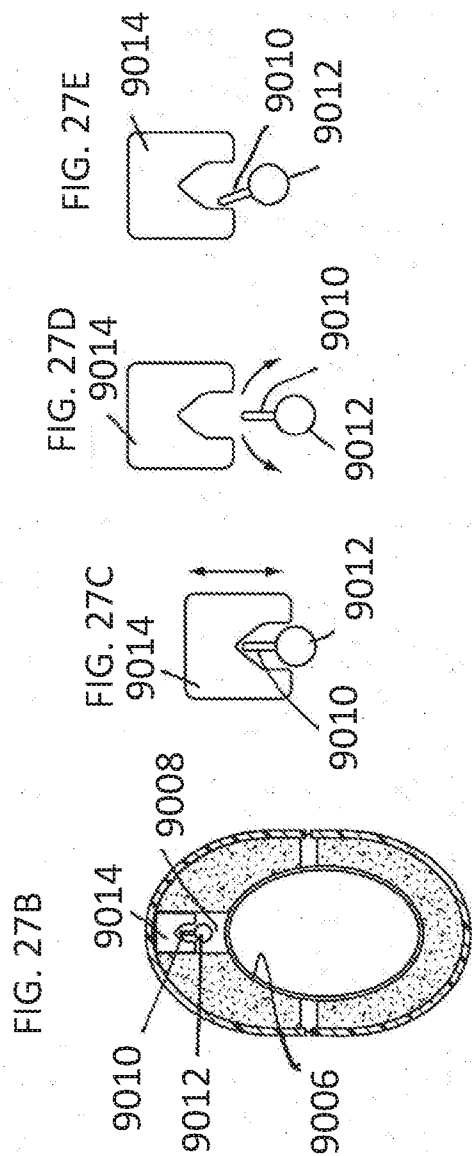


FIG. 26



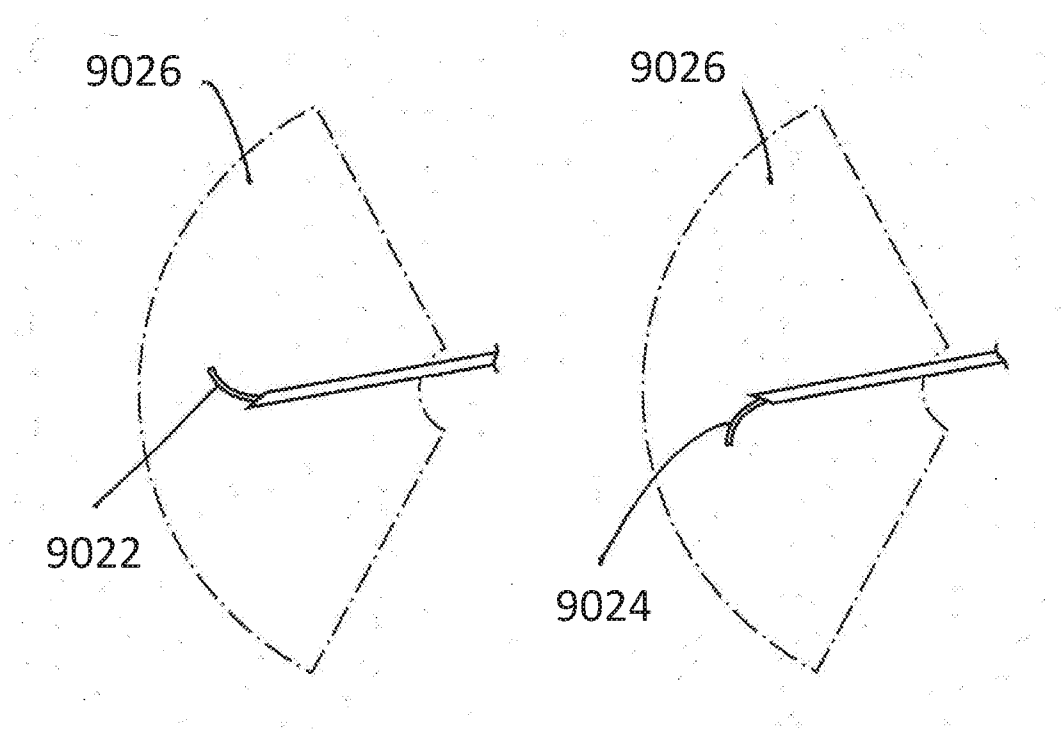
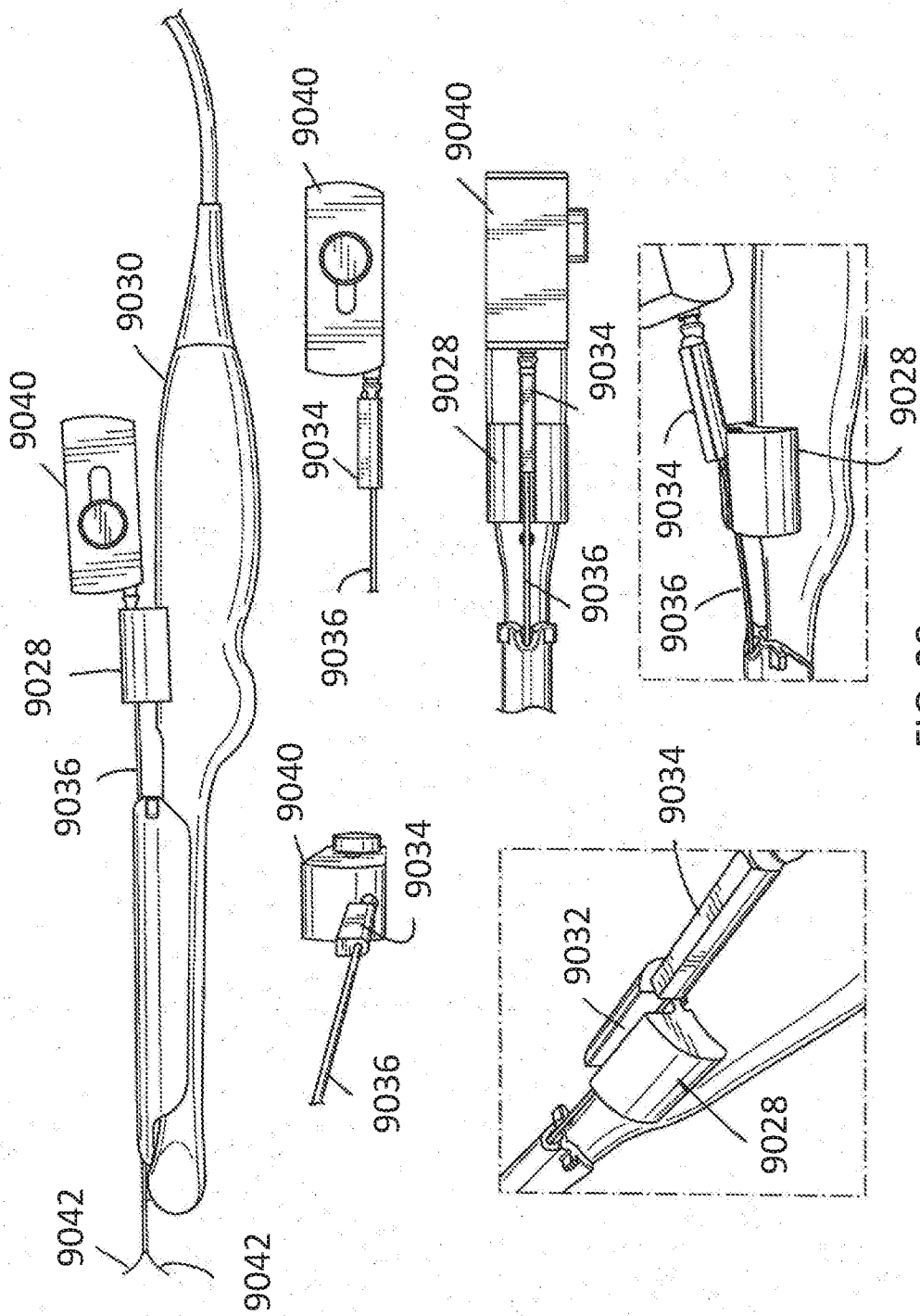


FIG. 27F



28
G.
E

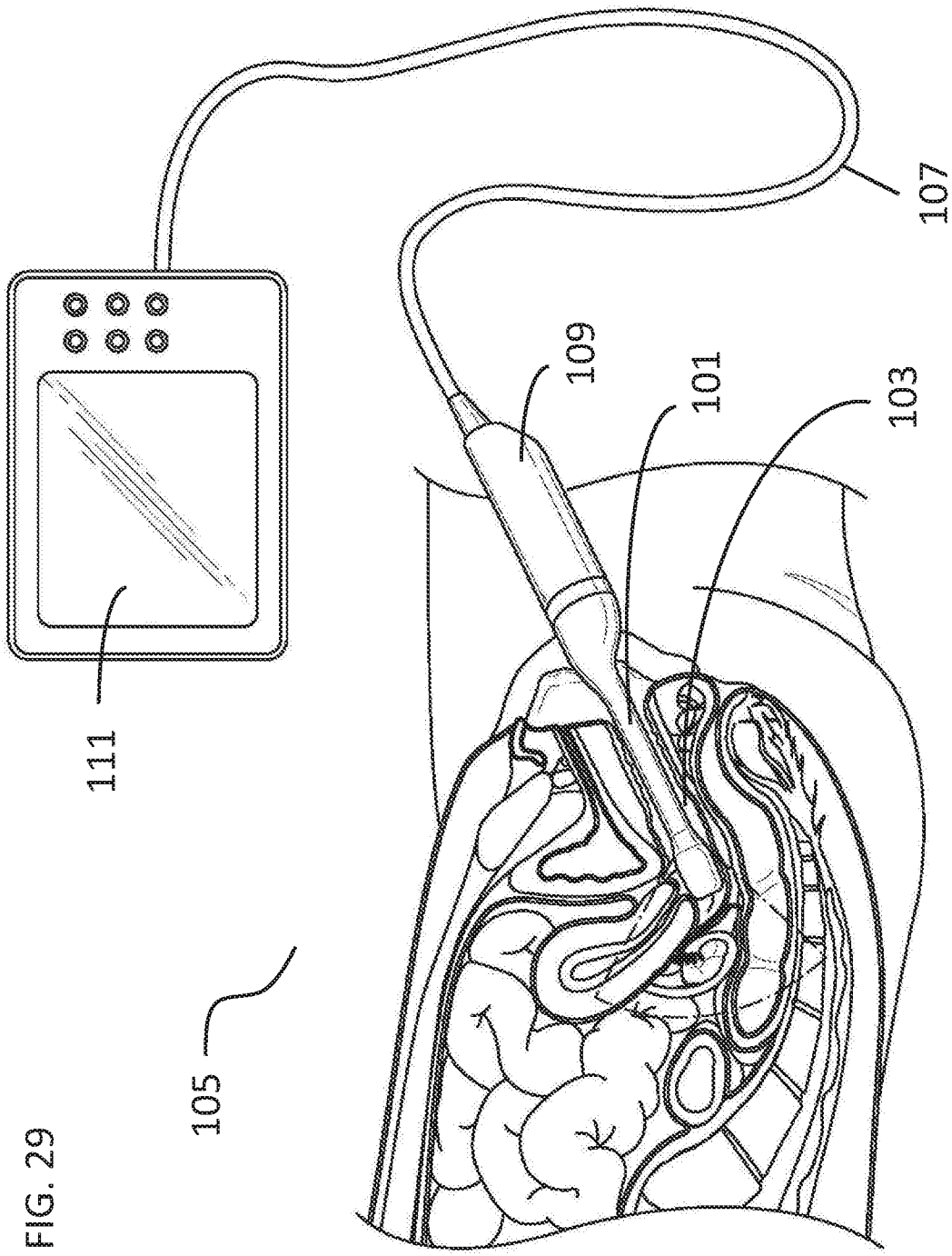


FIG. 29

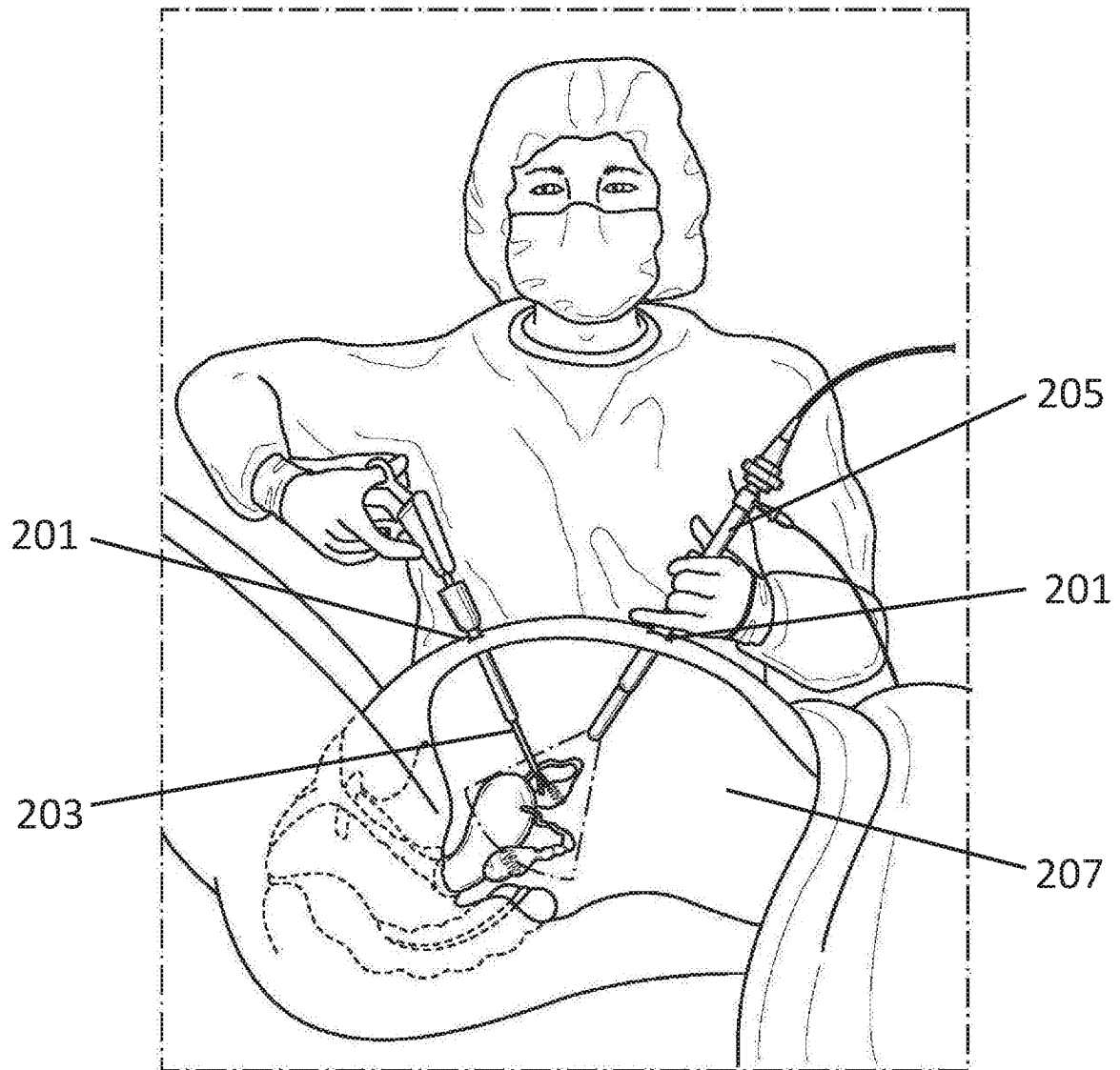


FIG. 30

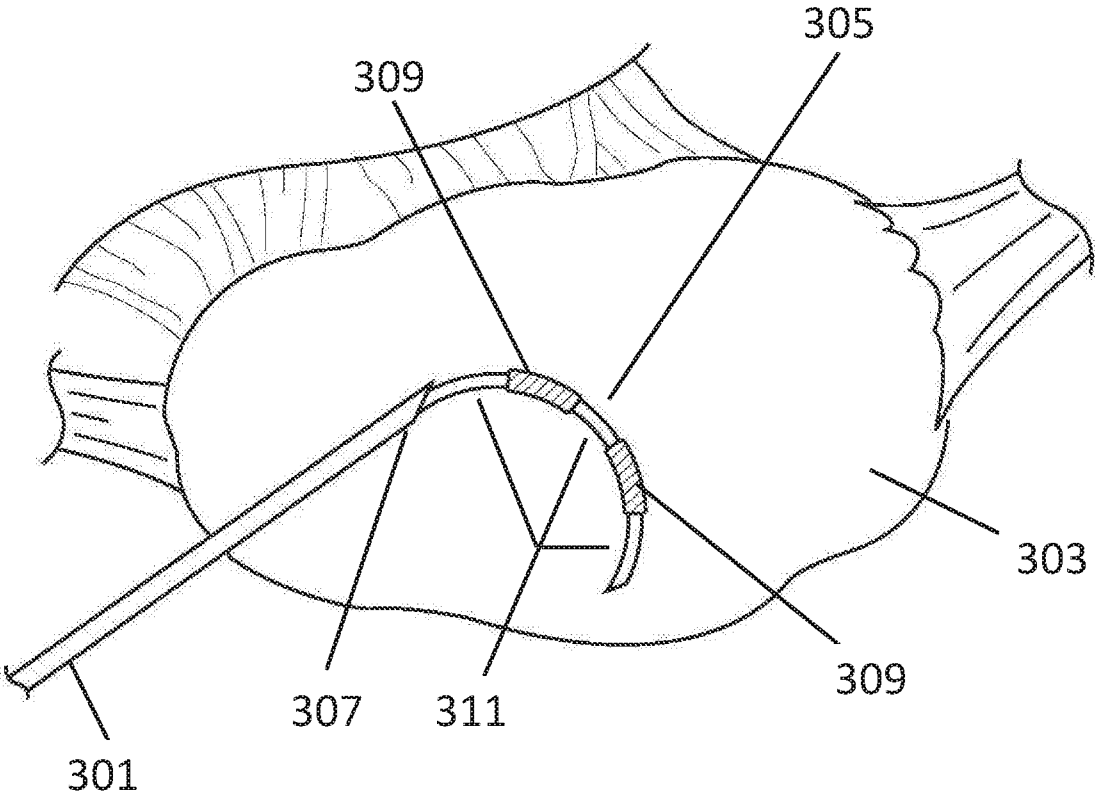


FIG. 31A

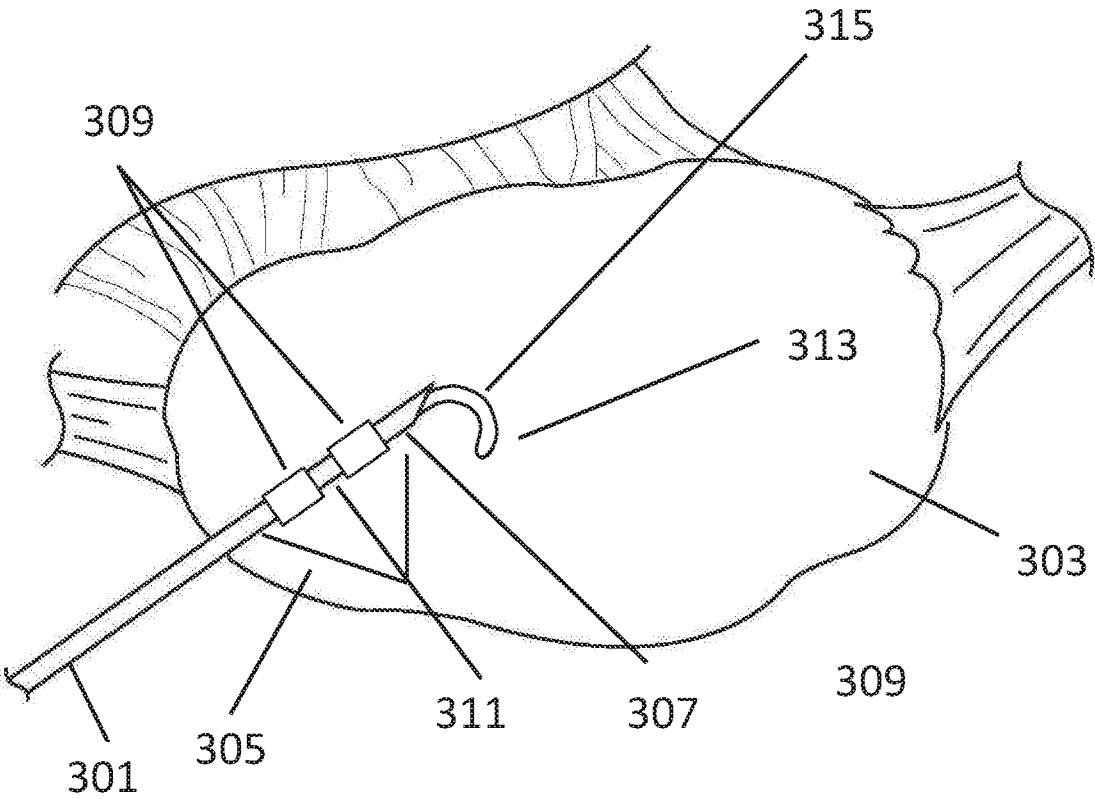


FIG. 31B

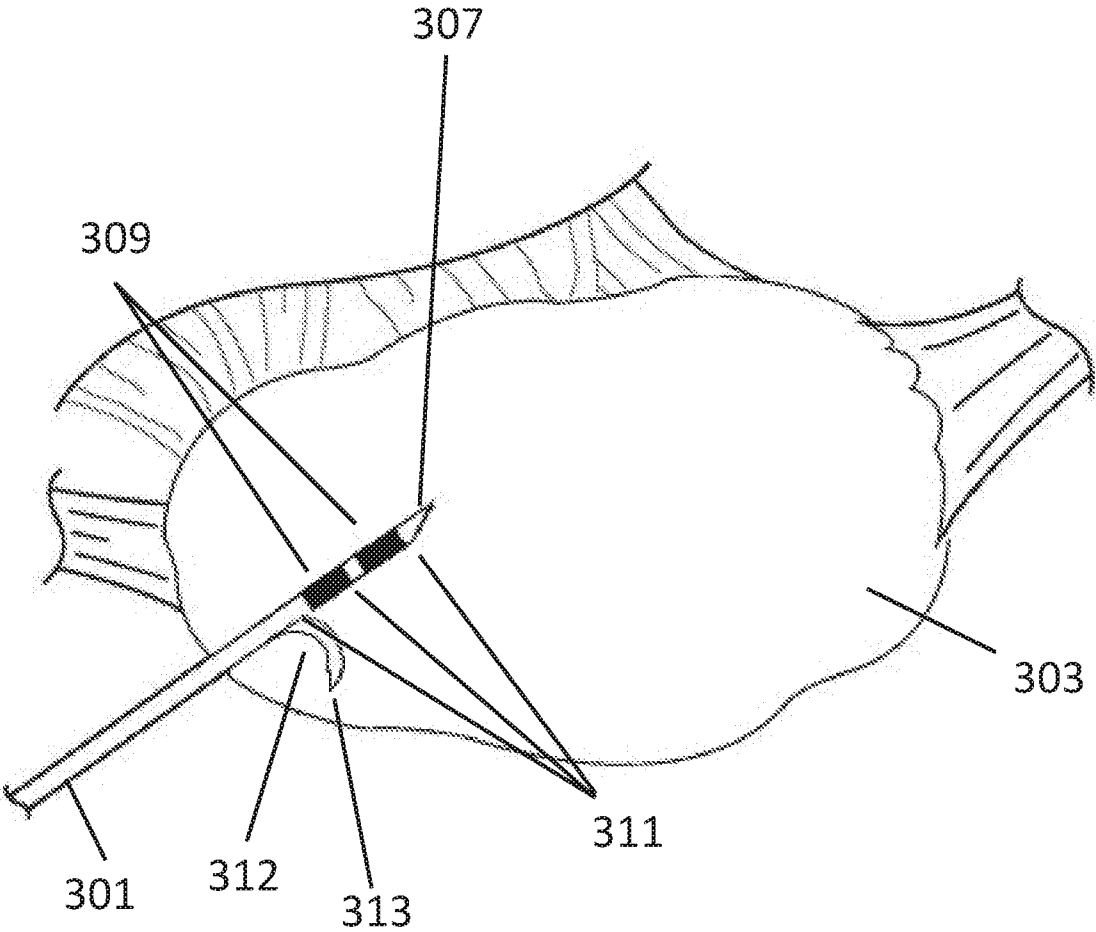


FIG. 31C

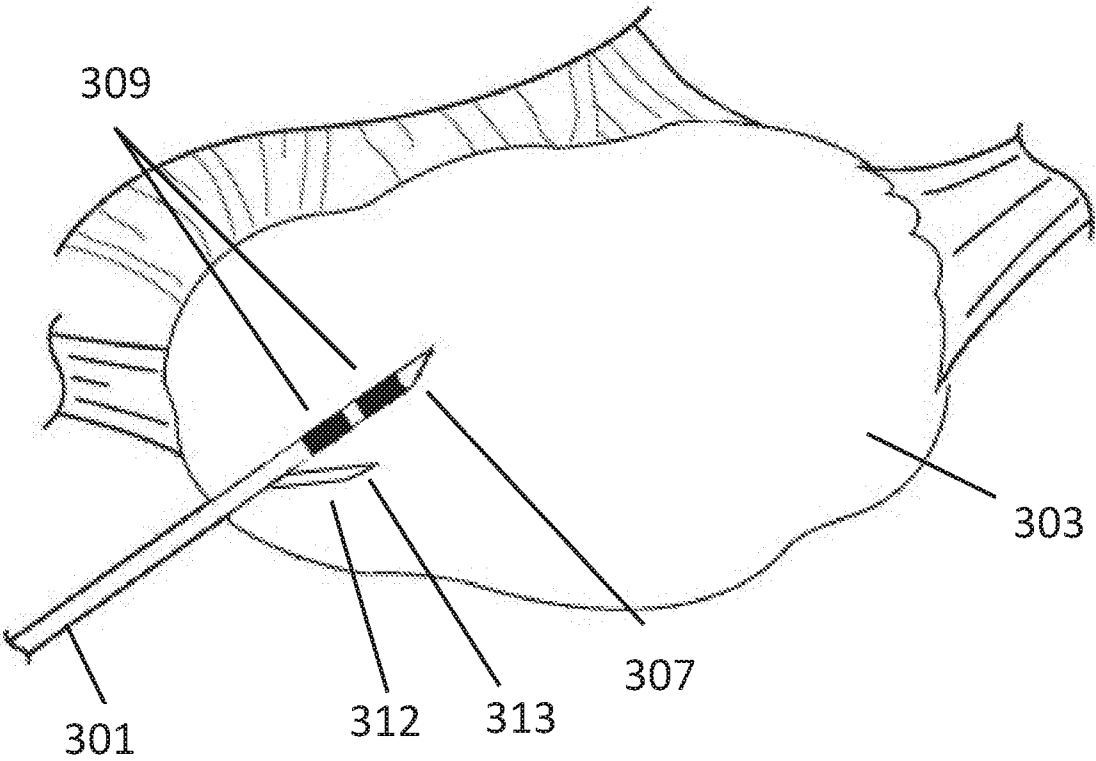


FIG. 31D

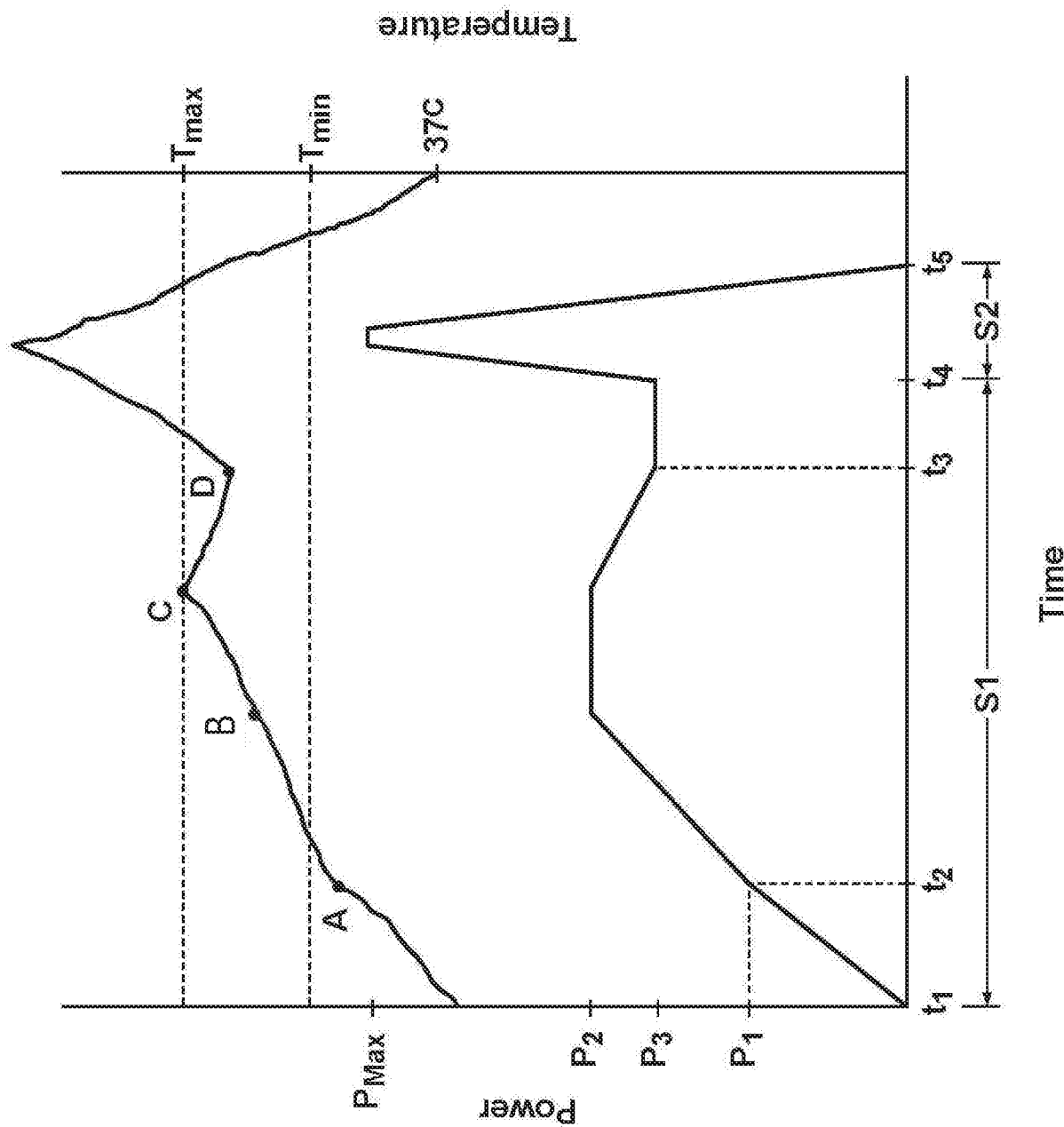
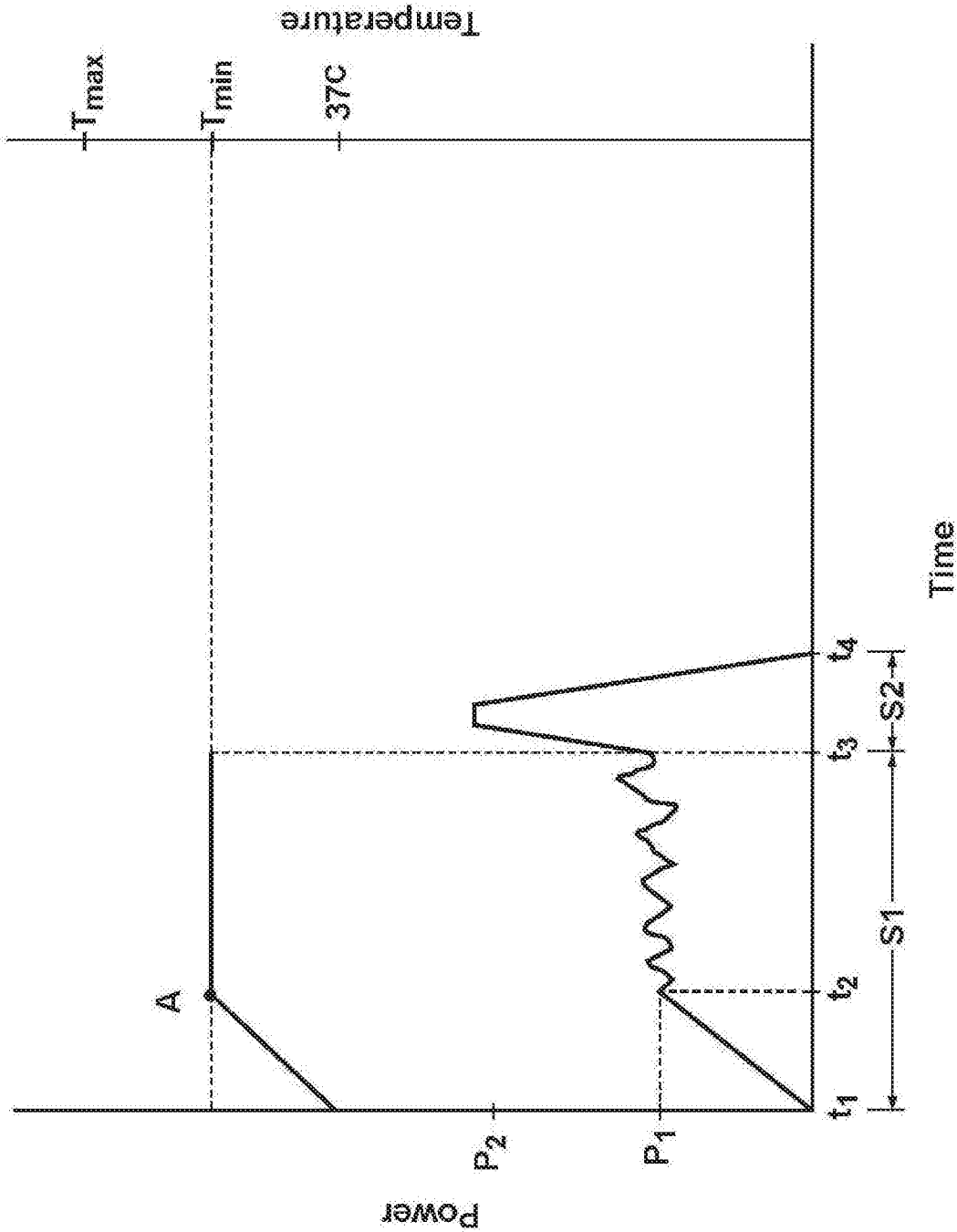


FIG. 32

FIG. 33



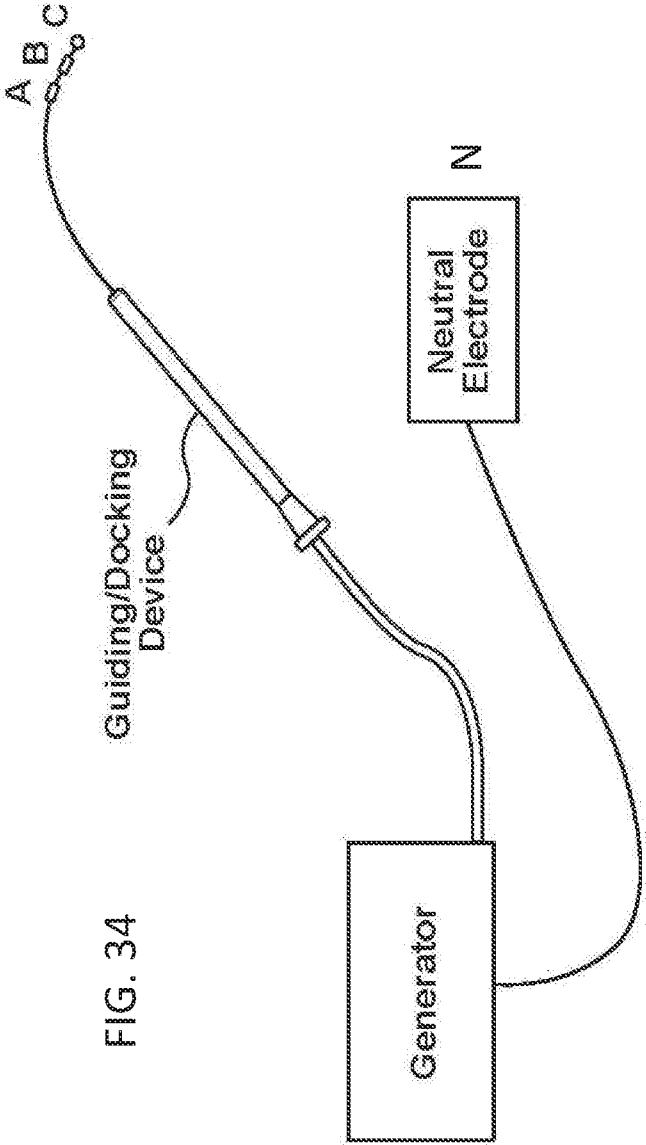


FIG. 34

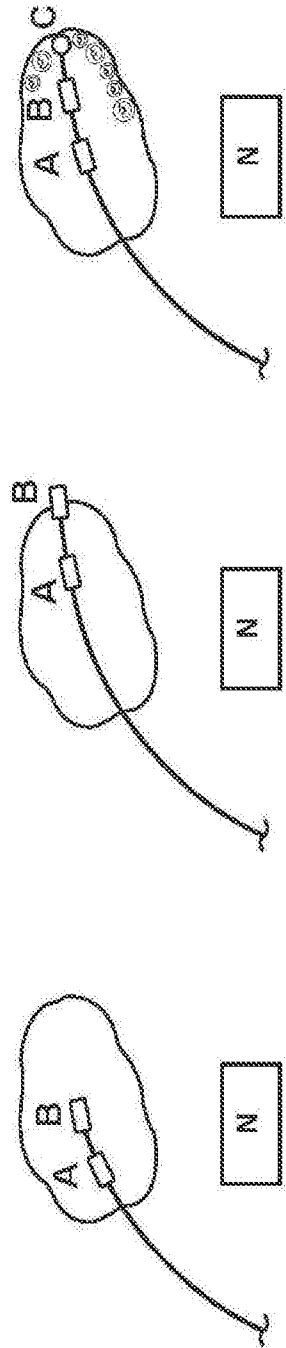


FIG. 35A

FIG. 35B

FIG. 35C

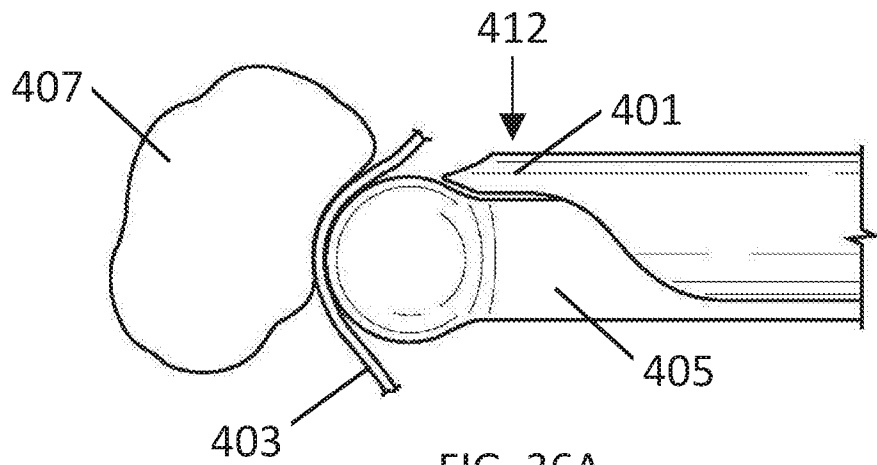


FIG. 36A

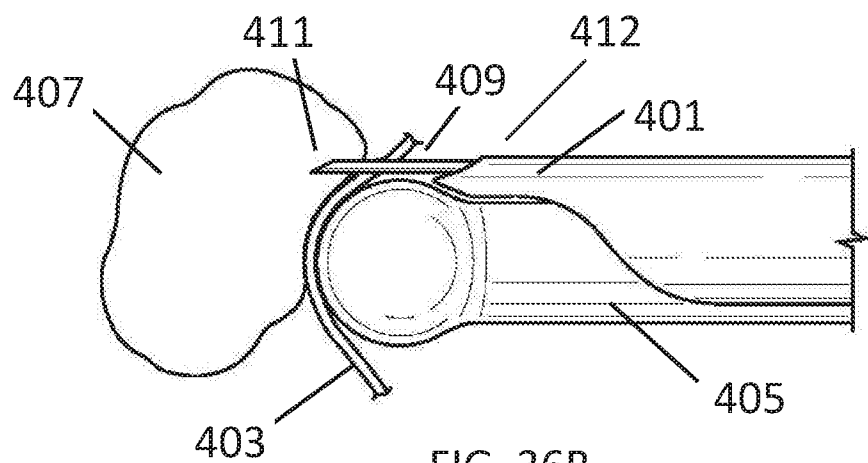


FIG. 36B

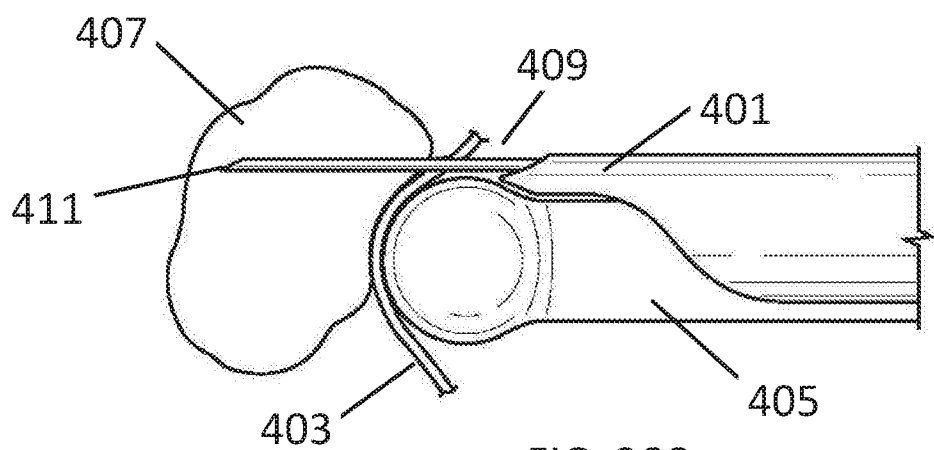
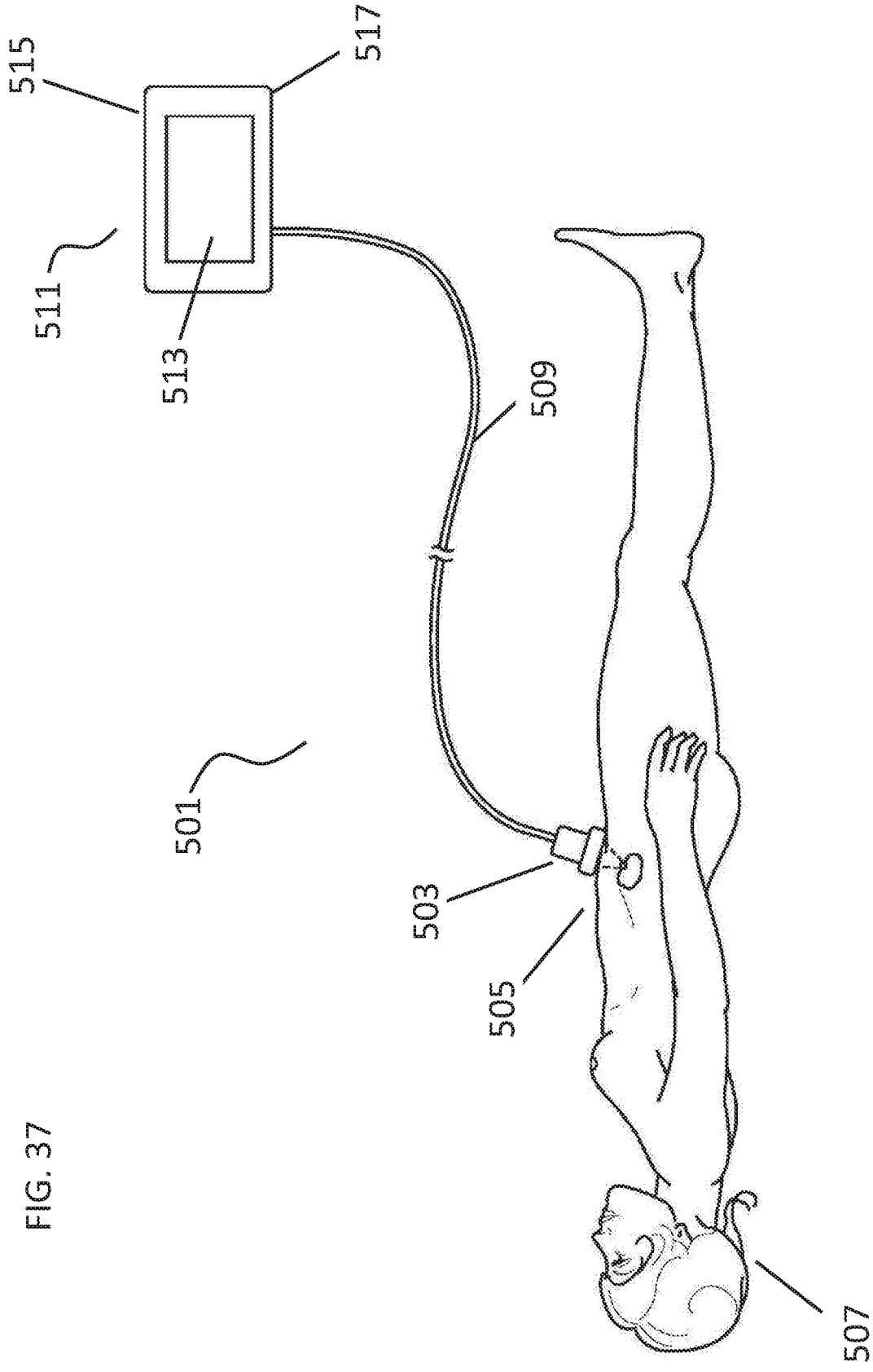
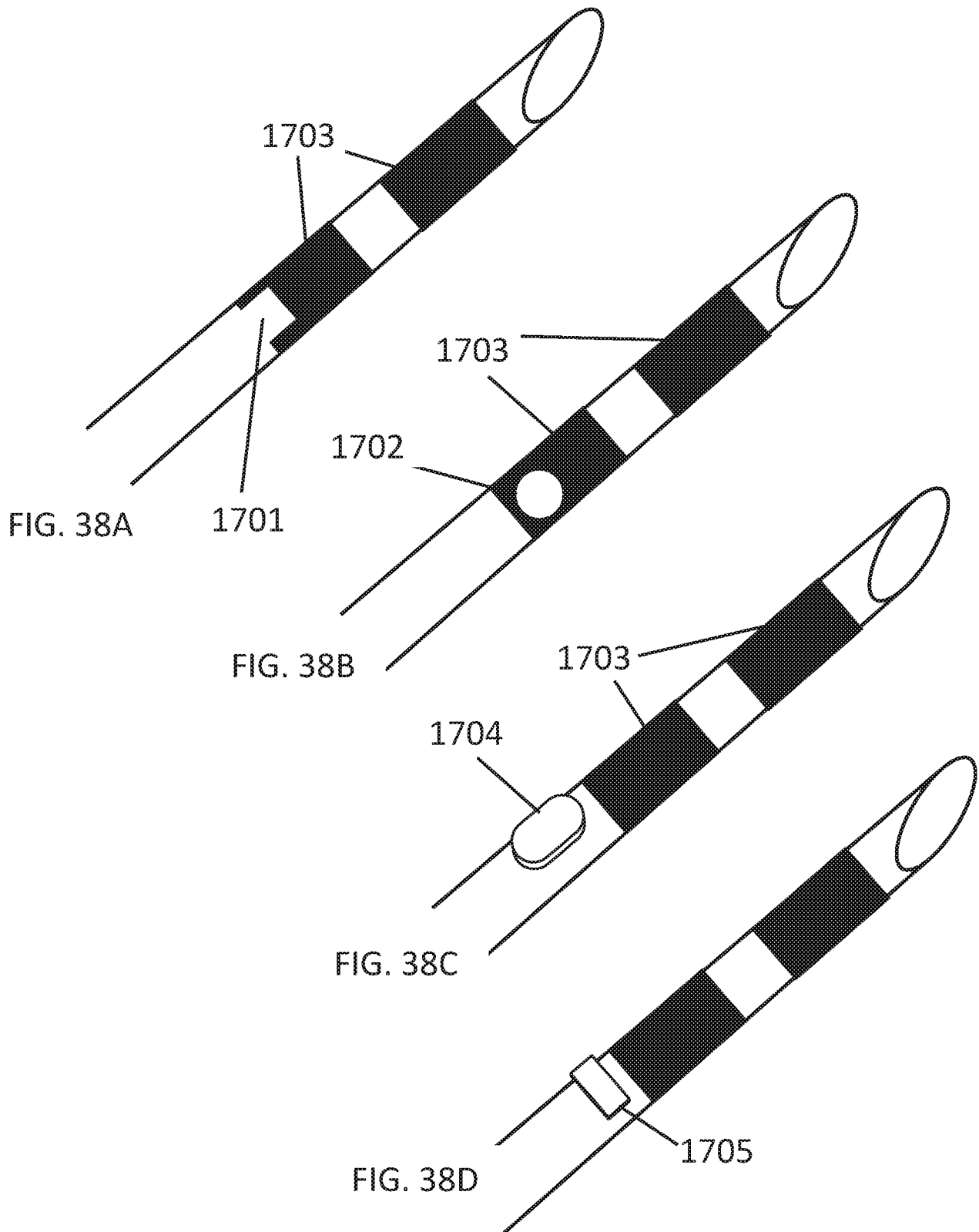


FIG. 36C





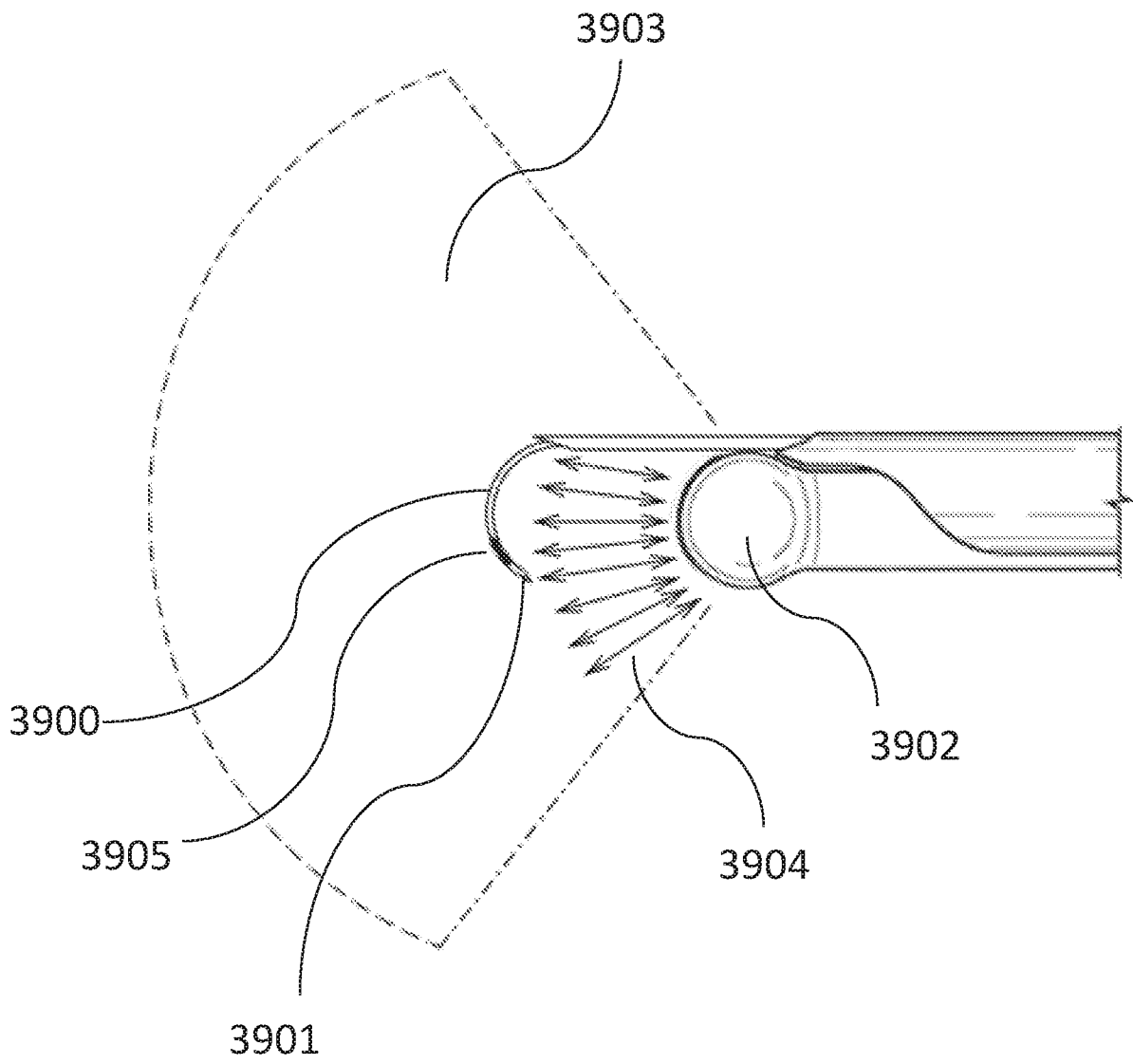


FIG. 39

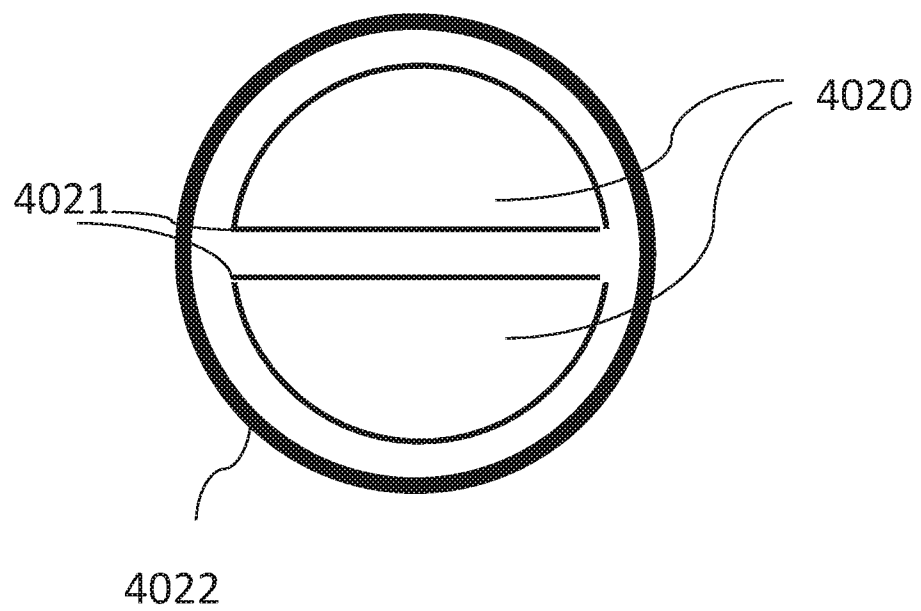


FIG. 40

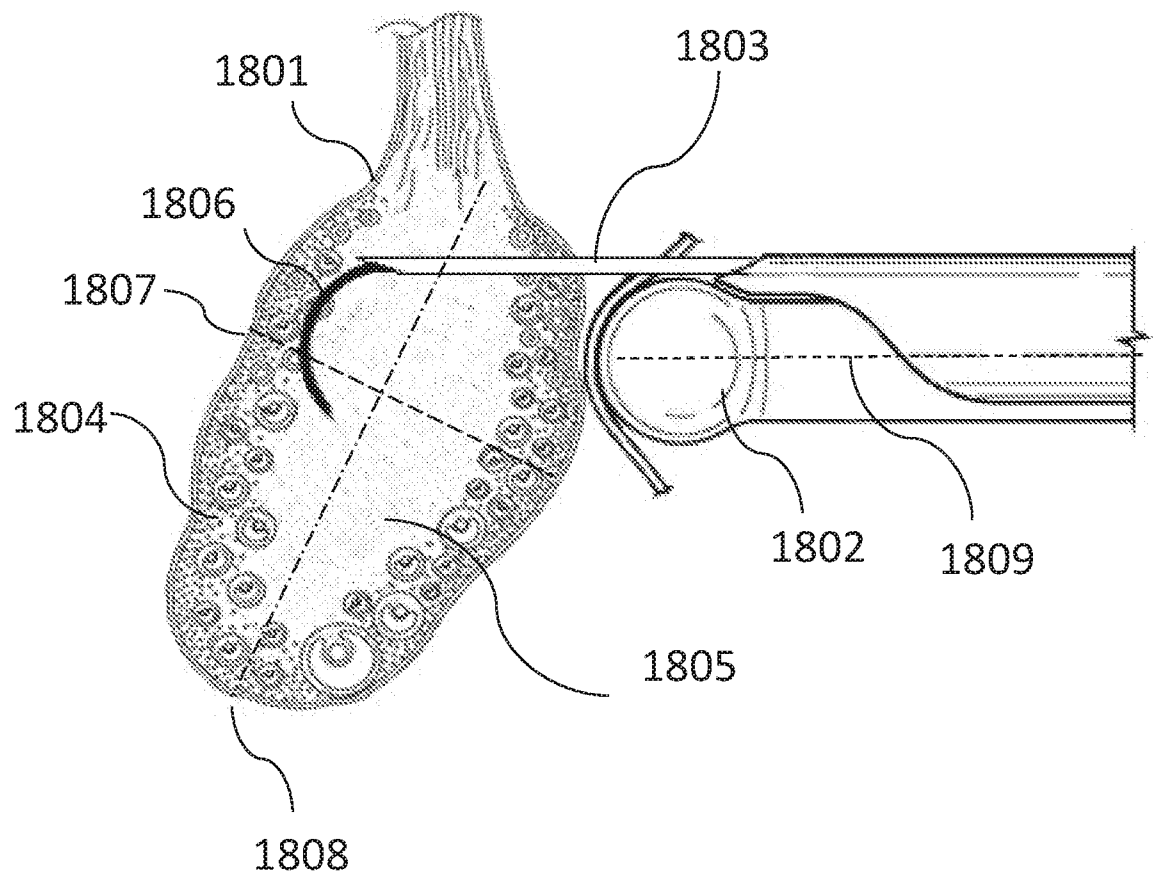


FIG. 41

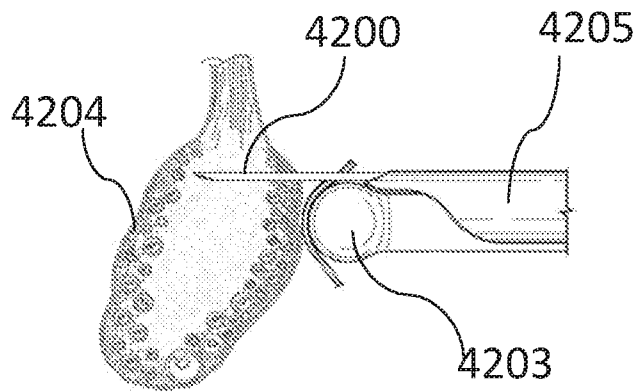


FIG. 42A

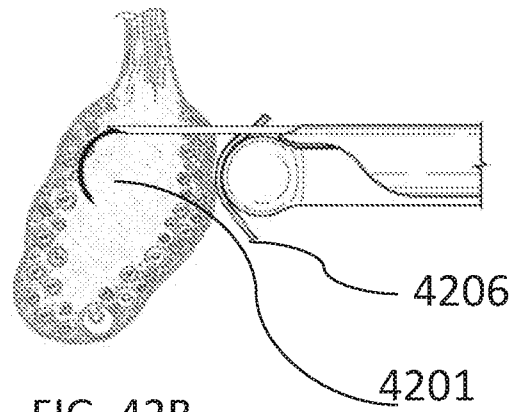


FIG. 42B

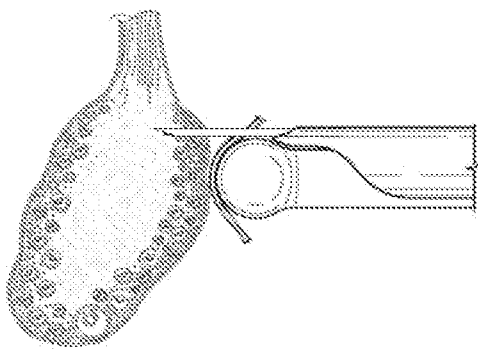


FIG. 42C

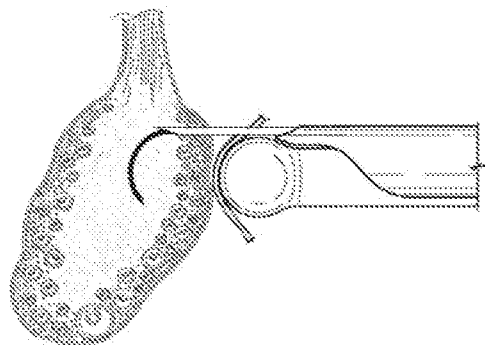


FIG. 42D

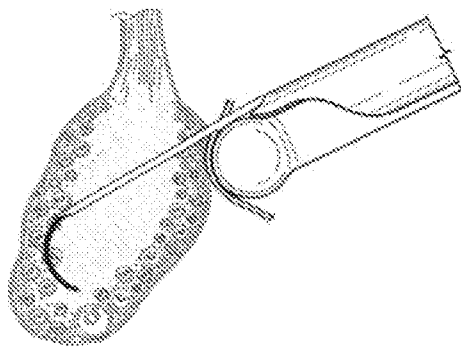


FIG. 42E

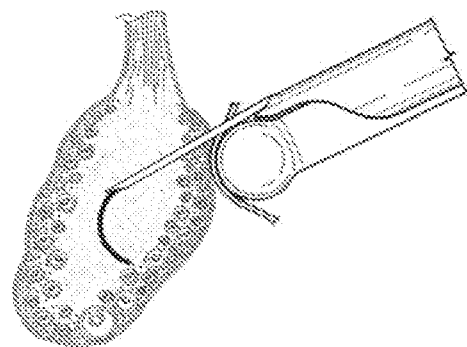


FIG. 42F