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Extraction Basket

Abstract

An extraction device includes a plurality of extension legs, each extension leg of the plurality of extension legs including a distal end biased radially outward. The extraction device can include a plurality of flexible grasper legs, each flexible grasper leg of the plurality of flexible grasper legs having a proximal end mounted to the distal end of a respective extension leg and a free distal end, the plurality of flexible grasper legs defining at least a portion of a basket. The extraction device can further include a handle coupled to a shaft and a closure line coupled to a closure actuator disposed on the handle. The closure line can extend distally through the shaft to connect the free distal ends of the plurality of flexible grasper legs to define a basket opening. The closure actuator is operative to transition the basket from an open configuration to a closed configuration.

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Background/Summary

PRIORITY [0001] This application is a division of U.S. patent application Ser. No. 17/414,272, filed Jun. 15, 2021, now U.S. Pat. No. 12,290,273, as a U.S. national stage of International Application No. PCT/US2019/068620, filed Dec. 26, 2019, which claims the benefit of priority to U.S. Provisional Application No. 62/785,279, filed Dec. 27, 2018, each of which is incorporated by reference in its entirety into this application.

BACKGROUND

[0002] The present disclosure is directed to medical devices and instruments and, more particularly, to extraction devices that may be used to extract objects from within bodily canals and/or bodily reservoirs, for example.

[0003] The present disclosure contemplates that small stones in the distal ureter may be reliably and definitively extracted with ureteroscopic stone basketing. Presently, a wide range of ureteroscopic baskets are commercially available. Many of these ureteroscopic baskets include wires slidably mounted in a tubular sleeve forming a canula. The distal ends of the wires may have free ends or may be secured to one another and may be capable of expanding when extended outwardly by virtue of the resiliency of the material comprising the wires. For those wires that are connected to one another, a distal plug may be present at the far distal tip of the basket. Those skilled in the art have theorized that the presence of a distal tip of a basket may be disadvantageous because the tip may create distance from the end to the functional engaging portion of the basket, thus making stone entrapment more difficult. Also, those skilled in the art have lamented that certain baskets having distal tips can pierce the renal calyceal urothelial lining, thereby causing bleeding that obscures visualization and can lead to premature termination of stone extraction procedures. Similar drawbacks have been noted in the art with respect to baskets with ends that are free, an example of which is disclosed in U.S. Pat. No. 6,416,519.

[0004] The present disclosure contemplates that as a means to address the perceived drawbacks of a basket having a distal tip or with free distal ends, certain “open ended” baskets have been developed. Among these “open ended” baskets are the embodiments disclosed in U.S. Pat. No. 5,906,622. But the embodiments of U.S. Pat. No. 5,906,622 have one very pronounced disadvantage—the inability to affirmatively grab the intended object to be removed. Rather than grabbing the intended object by extending beyond and cinching around the object, the embodiments of the '622 patent operate to pinch the object from the object's sides. This pinching operation may be unsatisfactory because circumferential pressure on the baskets (which can be the result of drawing the baskets through a relatively small diameter renal conduit) of the embodiments of '622 patent may cause the object to spurt out of the distal end of the basket. In other words, the embodiments of the '622 patent may not be able to avoid distal motion of the object with respect to the basket when circumferential or proximal pressure is applied to the basket.

[0005] It is a first aspect of the present disclosure to provide an extraction device including a generally tubular shaft including a distal end configured to be inserted into a patient and a proximal end configured to be retained exteriorly of the patient; a basket extending from the distal end of the shaft, the basket including a plurality of flexible, distally extending legs, the legs including respective distal ends that are biased generally radially outward to at least partially define a basket distal opening; a handle disposed at the proximal end of the shaft; an actuator disposed on the handle; and/or a closure line operatively coupled to the actuator, the closure line extending distally through the shaft, through a closure line guide disposed on the distal end of the shaft, and generally

circumferentially about the basket distal opening, the closure line being slidably coupled to each leg near its respective leg distal end. The actuator may be operative between an open position and a closed position to extend and withdraw the closure line, thereby moving the basket between an open configuration and a closed configuration, respectively.

[0006] In a more detailed embodiment of the first aspect, the extraction device may include at least one generally circumferential wall disposed on at least one of the legs. The wall may include at least one of a wire mesh and an elastomeric film. At least two of the legs may be substantially identical to each other and/or may be disposed substantially symmetrically on the shaft. The closure line guide may be generally tubular, may slidably receive the closure line therein, and/or may extend substantially from the distal end of the shaft to the distal end of one of the grasper legs. At least one of the legs may include a distally extending, lobe-shaped loop. The extraction device may include a lock on the handle, the lock being operatively coupled to the actuator to lock the actuator in at least one of an open position and a closed position. The closure line may be slidably coupled to each leg near its respective leg distal end in a draw-string fashion. The closure line guide may be flexible so that the closure line guide is bent radially inward when the basket is in the closed configuration.

[0007] It is a second aspect of the present disclosure to provide a method of operating an extraction device, the method including advancing an extraction device into a patient's body until a basket of the extraction device reaches a targeted area containing an object, the basket comprising a plurality of flexible, distally extending legs, the legs including respective distal ends that are biased generally radially outward to at least partially define a basket distal opening; manipulating the extraction device to position the object at least partially within the basket; and capturing the object by at least partially closing the basket distal opening of the basket by withdrawing proximally a closure line, the closure line extending through a closure line guide and generally circumferentially about the basket distal opening, the closure line being slidably coupled to each leg near its respective leg distal end. The closure line may draw together the leg distal ends in a draw-string fashion.

[0008] In a more detailed embodiment of the second aspect, the method may include, after capturing the object, removing the extraction device and the object from the patient's body. The method may include, prior to manipulating the extraction device to position the object at least partially within the basket, placing the basket into an open configuration by moving the closure line distally. The extraction device may include a generally tubular shaft including a distal end configured to be inserted into the patient's body and a proximal end configured to be retained exteriorly to the patient's body and/or a handle disposed at the proximal end of the shaft. The basket may extend from the distal end of the shaft. The closure line guide may be disposed on the distal end of the shaft. Withdrawing proximally the closure line may include withdrawing the closure line proximally through the closure line guide and the shaft by operating an actuator disposed on the handle. The advancing operation may include advancing the extraction device through a working channel in a ureteroscope. The extraction device may include at least one generally circumferential wall disposed on at least one of the legs. Capturing the object may include capturing the object using the at least one wall. At least partially closing the basket distal opening may include bending the closure line guide radially inward.

[0009] It is a third aspect of the present disclosure to provide an extraction device including a generally tubular shaft including a distal end configured to be inserted into a patient and a proximal end configured to be retained exteriorly of the patient; a basket extending from the distal end of the shaft, the basket including a plurality of flexible, distally extending extension legs, the extension legs including respective distal ends that are biased generally radially outward, and/or a plurality of flexible, distally extending grasper legs, each grasper leg mounted to the distal end of a respective extension leg, respective distal ends of the grasper legs at least partially defining a basket distal opening; a handle disposed at the proximal end of the shaft; a closure actuator disposed on the

handle; a closure line operatively coupled to the closure actuator, the closure line extending distally through the shaft, through a closure line guide disposed on the distal end of the shaft, and generally circumferentially about the basket distal opening, the closure line being slidably coupled to each grasper leg near its respective leg distal end; and/or a retraction actuator disposed on the handle and operatively coupled to the extension legs to at least partially extend the extension legs distally from the distal end of the shaft and to retract the extension legs proximally at least partially into the shaft. The closure actuator may be operative between an open position and a closed position to extend and withdraw the closure line, thereby moving the basket between an open configuration and a closed configuration, respectively.

[0010] In a more detailed embodiment of the third aspect, the basket may include at least one generally circumferential grasper leg wall disposed on at least one of the grasper legs. The grasper leg wall may include at least one of a wire mesh and an elastomeric film. The basket may include at least one generally circumferential extension leg wall disposed on at least one of the extension legs. The extension leg wall may include at least one of a wire mesh and an elastomeric film. The closure line guide may be generally tubular, may slidably receive the closure line therein, and/or may extend substantially from the distal end of the shaft to the distal end of one of the grasper legs. The closure line may be slidably coupled to each grasper leg near its respective leg distal end in a draw-string fashion. The closure line guide may be flexible so that the closure line guide is bend radially inward when the basket is in the closed configuration.

[0011] It is a fourth aspect of the present disclosure to provide a method of operating an extraction device, the method including advancing an extraction device into a patient's body until a basket of the extraction device reaches a targeted area containing an object, the extraction device including a generally tubular shaft including a distal end configured to be inserted into the patient's body and a proximal end configured to be retained exteriorly of the patient's body, the basket extending from the distal end of the shaft, the basket comprising a plurality of flexible, distally extending extension legs, the extension legs including respective distal ends that are biased generally radially outward, and a plurality of flexible, distally extending grasper legs, each grasper leg mounted to the distal end of a respective extension leg, respective distal ends of the grasper legs at least partially defining a basket distal opening; manipulating the extraction device to position the object at least partially within the basket; capturing the object by at least partially closing the basket distal opening of the basket by withdrawing proximally a closure line, the closure line extending distally through the shaft, through a closure line guide disposed on the distal end of the shaft, and generally circumferentially about the basket distal opening, the closure line being slidably coupled to each grasper leg near its respective grasper leg distal end, the closure line drawing together the grasper leg distal ends in a draw-string fashion; and/or retracting the extension legs proximally at least partially into the shaft.

[0012] In a more detailed embodiment of the fourth aspect, the method may include, after retracting the extension legs, removing the extraction device and the object from the patient's body. The method may include, prior to manipulating the extraction device to position the object at least partially within the basket, placing the basket into an open configuration by moving the closure line distally. The extraction device may include a handle disposed at the proximal end of the shaft. Withdrawing proximally the closure line may include withdrawing the closure line proximally through the closure line guide and the shaft by operating a closure actuator disposed on the handle. Retracting the extension legs may include operating a retraction actuator disposed on the handle. The advancing operation may include advancing the extraction device through a working channel in a ureteroscope. The basket may include at least one generally circumferential grasper leg wall disposed on at least one of the grasper legs. The basket may include at least one generally circumferential extension leg wall disposed on at least one of the extension legs. Capturing the object may include capturing the object using at least one of the at least one grasper leg wall and the at least one extension leg wall. At least partially closing the basket distal opening may include

bending the closure line guide radially inward.

[0013] It is a fifth aspect of the present disclosure to provide an extraction device including a generally tubular shaft including a distal end configured to be inserted into a patient and a proximal end configured to be retained exteriorly of the patient, the distal end of the shaft comprising a distal end opening; a petal grasper extending from the distal end of the shaft, the petal grasper including a plurality of distally extending petals, the petals including respective distal ends that are biased generally radially outward, the distal ends of the petals at least partially defining a grasper distal opening when the petal grasper is in an open configuration; a handle disposed at the proximal end of the shaft; an actuator disposed on the handle; and/or an actuator line operatively coupled to the actuator and the plurality of petals to move the petal grasper between the open configuration and a closed configuration in which the plurality of petals is withdrawn at least partially within the shaft at the distal end opening. In the closed configuration, the petals may substantially completely enclose an object contained therein.

[0014] In a more detailed embodiment of the fifth aspect, the petal grasper may include at least one generally circumferential wall disposed on at least one of the petals. The wall may include at least one of a wire mesh and an elastomeric film. In the closed configuration, the distal ends of the petals may substantially come into contact with one another.

[0015] It is a sixth aspect of the present disclosure to provide a method of operating an extraction device, the method including advancing an extraction device into a patient's body until a petal grasper of the extraction device reaches a targeted area containing an object, the petal grasper including a plurality of distally extending petals, the petals including respective distal ends that are biased generally radially outward, the distal ends of the petals at least partially defining a grasper distal opening when the petal grasper is in an open configuration; manipulating the extraction device to position the object at least partially within the petal grasper; and/or capturing the object by at least partially closing the distal opening of the petal grasper by withdrawing proximally an actuator line, the actuator line being operatively coupled to the plurality of petals to move the petal grasper between the open configuration and a closed configuration.

[0016] In a more detailed embodiment of the sixth aspect, the method may include, after capturing the object, removing the extraction device and the object from the patient's body. The method may include, prior to manipulating the extraction device to position the object at least partially within the petal grasper, placing the petal grasper into the open configuration. The extraction device may include a generally tubular shaft including a distal end configured to be inserted into the patient's body and a proximal end configured to be retained exteriorly to the patient's body and/or a handle disposed at the proximal end of the shaft. The petal grasper may extend from the distal end of the shaft. At least partially closing the distal opening of the petal grasper may include withdrawing the plurality of petals at least partially within the shaft at the distal end of the shaft. The advancing operation may include advancing the extraction device through a working channel in a ureteroscope. The petal grasper may include at least one generally circumferential wall disposed on at least one of the petals. Capturing the object may include capturing the object using the at least one wall.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] Example embodiments are described in conjunction with the accompanying drawing figures in which:

[0018] FIG. 1 is an elevated perspective view of an example extraction device;

[0019] FIG. 2 is a detailed perspective view of an example extraction device with an example basket in an open configuration;

[0020] FIG. 3 is a detailed perspective view of an example extraction device with an example basket in a closed configuration;

[0021] FIG. 4 is an elevated perspective view of an example extraction device including an example dual-mode basket;

[0022] FIG. 5 is a detailed perspective view of an example dual-mode basket in an open configuration;

[0023] FIG. 6 is a detailed perspective view of an example dual-mode basket in a closed configuration;

[0024] FIG. 7 is a detailed perspective view of an example dual-mode basket in a retracted configuration;

[0025] FIG. 8 is a cross section view of an example shaft of a dual-mode basket extraction device;

[0026] FIG. 9 is a detailed perspective view of an alternative example basket in the form of a petal grasper in an open configuration;

[0027] FIG. 10 is a section view of an example petal grasper in an open configuration; and

[0028] FIG. 11 is a section view of an example petal grasper in a closed configuration; all in accordance with at least some aspects of the present disclosure.

DETAILED DESCRIPTION

[0029] Example embodiments according to the present disclosure are described and illustrated below to encompass devices, methods, and techniques relating to medical and surgical procedures. Of course, it will be apparent to those of ordinary skill in the art that the embodiments discussed below are examples and may be reconfigured by incorporating features across embodiments without departing from the scope and spirit of the present disclosure. To be explicitly clear, it is within the scope of the invention to combine one or more features across embodiments and the disclosure should be read with this intent. It is also to be understood that variations of the example embodiments contemplated by one of ordinary skill in the art shall concurrently comprise part of the instant disclosure. However, for clarity and precision, the example embodiments as discussed below may include optional steps, methods, and features that one of ordinary skill should recognize as not being a requisite to fall within the scope of the present disclosure.

[0030] The present disclosure includes, inter alia, medical devices and instruments and, more particularly, extraction devices that may be used to extract objects from within bodily canals and/or bodily reservoirs.

[0031] FIG. 1 is an elevated perspective view of an example extraction device **100** according to at least some aspects of the present disclosure. Extraction device **100** may include a shaft **200**, which may be in the form of an elongated, hollow, generally tubular sheath. Shaft **200** may be generally configured for its distal end **201** to be inserted into a patient and its proximal end **204** to be retained exteriorly of the patient. A reconfigurable basket **300** may be disposed at the distal end **201** of shaft **200**. A handle **400** may be disposed at the proximal end **204** of shaft **200**. An actuator **500** may be movably disposed on handle **400** and/or may be operatively coupled to basket **300**. As used herein, “distal” may refer to a direction generally toward basket **300** and “proximal” may refer to a direction generally toward handle **400**.

[0032] FIGS. 2 and 3 are detailed perspective views of an example extraction device **100** with basket **300** in open and closed configurations, respectively, according to at least some aspects of the present disclosure. In some example embodiments, basket **300** may include two or more legs **302**, **304**, **306**, **308**, **310**. Legs **302**, **304**, **306**, **308**, **310** may be mounted to shaft **200** at or near a shaft distal end opening **202**. For example, legs **302**, **304**, **306**, **308**, **310** may be generally evenly circumferentially spaced apart and/or may be mounted within shaft distal end opening **202**. Legs **302**, **304**, **306**, **308**, **310** may be flexible (compare FIGS. 2 and 3) and/or may be biased to the open configuration (FIG. 2). For example, legs **302**, **304**, **306**, **308**, **310** may be formed such that their respective distal ends **303**, **305**, **307**, **309**, **311** are biased generally radially outward (e.g., biased open) to form a basket distal opening **301**. In some example embodiments, legs **302**, **304**, **306**, **308**,

310 may be constructed at least partially from spring grade stainless steel and/or nickel titanium alloys (e.g., nitinol) in the super elastic range, for example.

[0033] Referring to FIG. 2, some example embodiments may include walls **312, 314, 316, 318, 320** disposed on respective legs **302, 304, 306, 308, 310**. For example, a leg **302, 304, 306, 308, 310** that is formed generally as a distally extending loop in a lobed shape may have a wall **312, 314, 316, 318, 320** disposed generally within the lobed shaped loop in a generally circumferential fashion. In some example embodiments, walls **312, 314, 316, 318, 320** may be constructed from a mesh (e.g., metal wire mesh) and/or an elastomeric film (e.g., which may be laser cut and/or may be porous).

[0034] Referring to FIGS. 2 and 3, in some example embodiments according to at least some aspects of the present disclosure, basket **300** may include a closure line **322**, which may extend generally circumferentially about the basket distal opening **301**, such as near distal ends **303, 305, 307, 309, 311** of some or all legs **302, 304, 306, 308, 310**. Closure line **322** may be operatively coupled to some or all of legs **302, 304, 306, 308, 310**, such as by being slidably attached to distal ends **303, 305, 307, 309, 311** in a draw-string (e.g., purse-string) fashion. For example, closure line **322** may run generally circumferentially around basket **300** near distal ends **303, 305, 307, 309, 311** of legs **302, 304, 306, 308, 310** in a generally circular path so that when closure line **322** is drawn tight, the distal ends **303, 305, 307, 309, 311** are drawn together and/or closed, thus at least partially closing basket distal end opening **301**.

[0035] In some example embodiments, closure line **322** may extend from legs **302, 304, 306, 308, 310**, through a closure line guide **324**, which may be disposed on at least one of a leg **302, 304, 306, 308, 310** and/or shaft **200**, such as near shaft distal end opening **202**. Closure line guide **324** may extend generally distally from shaft distal end opening **202** to near distal end **303** of leg **302**, for example. Closure line guide **324** may include a closure line guide distal end opening **325** through which closure line **322** may extend generally circumferentially outward about distal ends **303, 305, 307, 309, 311** of legs **302, 304, 306, 308, 310**. In some example embodiments, closure line guide **324** may be generally tubular (e.g., may have a longitudinal channel therethrough). In some example embodiments, closure line guide **324** may be generally flexible (e.g., generally as flexible as legs **302, 304, 306, 308, 310**) such that it bends radially inward in the closed configuration (FIG. 3).

[0036] In some example embodiments, closure line **322** may be operatively coupled to actuator **500** and/or may extend from handle **400**, distally through shaft **200**, distally through closure line guide **324**, and outward through closure line guide distal end opening **325**.

[0037] In some example embodiments, actuator **500** may be configured for operation by a user, such as by rotating, sliding, and/or pivoting, to extend and/or withdraw closure line **322** to open and/or close basket **300**. In some example embodiments, when basket **300** is in the open configuration (FIG. 2), operating actuator **500** from an open position (FIG. 2) towards a closed position (FIG. 3) may pull closure line **322** proximally through shaft **200**, which may draw distal ends **303, 305, 307, 309, 311** of legs **302, 304, 306, 308, 310** radially inward, generally in a draw-string (e.g., purse-string) fashion, thereby substantially reducing and/or at least partially closing basket distal end opening **301**.

[0038] Some example embodiments may include a lock **502** on handle **400**, which may be operatively coupled to actuator **500** to lock actuator **500** in an open position, in a fully closed position, and/or in between the open position and the closed position (e.g., in a partially closed position).

[0039] In some example embodiments, in a fully closed configuration, walls **312, 314, 316, 318, 320** may substantially completely enclose (e.g., encapsulate) object **600** held within basket **300**. In some example embodiments, in a fully closed configuration, walls **312, 314, 316, 318, 320** may partially enclose object **600** held within basket **300**. In some example embodiments, in a partially closed configuration, walls **312, 314, 316, 318, 320** may partially enclose object **600** held within

basket **300**.

[0040] In some example embodiments, when basket **300** is in the closed configuration (FIG. 3), operating actuator **500** from the closed configuration (FIG. 3) towards the open configuration (FIG. 2) may allow distal movement of closure line **322**, which may be tensioned distally by the opening bias of legs **302, 304, 306, 308, 310**. Movement of closure line **322** distally may allow distal ends **303, 305, 307, 309, 311** of legs **302, 304, 306, 308, 310** to move radially outward, generally circumferentially expanding and/or opening basket distal end opening **301**.

[0041] In some example embodiments, legs **302, 304, 306, 308, 310** and/or walls **312, 314, 316, 318, 320** may be substantially identical to each other and/or may be arranged generally symmetrically about shaft distal end opening **202**. In some example embodiments, one or more legs **302, 304, 306, 308, 310** and/or walls **312, 314, 316, 318, 320** may differ from the others and/or may be arranged generally asymmetrically about shaft distal end opening **202**.

[0042] Referring to FIGS. 1-3, an example method of operating an extraction device **100** including a basket **300** is described. Extraction device **100** may be utilized to extract various objects **600** from within an interior of an anatomical cavity. As an example, use of extraction device **100** will be explained in the context of a kidney stone removal procedure. Nevertheless, those skilled in the art will understand that use of the extraction device **100** is not limited to kidney stone removal procedures, but rather that this description is just one of numerous procedures for which the extraction device **100** has application.

[0043] In some example methods, a suitable path to the kidney stone in the patient's body is established, and appropriate visualization may also be established, such as by means of a ureteroscope. Thereafter, extraction device **100** is advanced until basket **300** reaches the targeted area where object **600** to be removed is located. In some example embodiments, this advance may be accomplished by manually feeding shaft **200** through a working channel in the ureteroscope.

[0044] Upon reaching object **600**, basket **300** is placed in the open configuration (FIG. 2), if it is not already in the open configuration. For example, in some circumstances it may be desirable to insert extraction device **100** with basket **300** in the closed configuration. Then, extraction device **100** may be manipulated to position object **600** (e.g., a kidney stone) at least partially within basket **300**. Then, actuator **500** may be operated to withdraw proximally closure line **322**, which may draw distal ends **303, 305, 307, 309, 311** together and/or closed, thus at least partially closing basket distal end opening **301** and/or at least partially capturing object **600** within basket **300** (FIG. 3). With object **600** retained basket **300**, extraction device **100** may be removed from the patient, thereby removing object **600** from the patient.

[0045] FIG. 4 is an elevated perspective view of an example extraction device **1100** including a dual-mode basket **1300** according to at least some aspects of the present disclosure. Extraction device **1100** may include a shaft **1200**, which may be in the form of an elongated, hollow, generally tubular sheath. Shaft **1200** may be generally configured for its distal end **1201** to be inserted into a patient and its proximal end **1204** to be retained exteriorly of the patient. A reconfigurable basket **1300** may be disposed at the distal end **1201** of shaft **1200**. A handle **1400** may be disposed at the proximal end **1204** of shaft **1200**. A closure actuator **1500** and/or a retraction actuator **1502** may be movably disposed on handle **1400** and/or may be operatively coupled to basket **1300**.

[0046] FIGS. 5-7 are detailed perspective views of an example dual-mode basket **1300** in an open configuration, a closed configuration, and a retracted configuration, respectively, according to at least some aspects of the present disclosure. In some example embodiments, dual-mode basket **1300** may be disposed at distal end **1201** of shaft **1200**. Dual-mode basket **1300** may include two or more extension legs **1302, 1304, 1306, 1308**, which may be axially (longitudinally) slidably mounted to shaft **1200** at or near a shaft distal end opening **1202**. For example, extension legs **1302, 1304, 1306, 1308** may be generally evenly circumferentially spaced apart and/or may be partially disposed within shaft distal end opening **1202**. Extension legs **1302, 1304, 1306, 1308** may be flexible (compare FIGS. 5 and 7) and/or may be biased to the open configuration (FIG. 5).

For example, extension legs **1302, 1304, 1306, 1308** may be formed such that their respective distal ends **1303, 1305, 1307, 1309** are biased generally radially outward (e.g., biased open). In some example embodiments, extension legs **1302, 1304, 1306, 1308** may be constructed at least partially from spring grade stainless steel and/or nickel titanium alloys (e.g., nitinol) in the super elastic range, for example.

[0047] In some example embodiments, dual-mode basket **1300** may include two or more grasper legs **1310, 1312, 1314, 1316**, which may extend distally from distal ends **1303, 1305, 1307, 1309** of respective extension legs **1302, 1304, 1306, 1308**. Grasper legs **1310, 1312, 1314, 1316** may be flexible (compare FIGS. 5 and 6) and/or may be biased to the open configuration (FIG. 5). For example, grasper legs **1310, 1312, 1314, 1316** may be formed such that their respective distal ends **1311, 1313, 1315, 1317** are biased generally radially outward (e.g., biased open). Grasper legs **1310, 1312, 1314, 1316** may be formed such that their respective distal ends **1311, 1313, 1315, 1317** are biased generally radially outward (e.g., biased open) to form a basket distal opening **1301**. In some example embodiments, grasper legs **1310, 1312, 1314, 1316** may be constructed at least partially from spring grade stainless steel and/or nickel titanium alloys (e.g., nitinol) in the super elastic range, for example.

[0048] In some example embodiments, dual-mode basket **1300** may include a closure line **1322** extending generally circumferentially about the basket distal opening **1301**, such as near distal ends **1311, 1313, 1315, 1317** of some or all grasper legs **1310, 1312, 1314, 1316**. Closure line **1322** may be operatively coupled to some or all of legs grasper legs **1310, 1312, 1314, 1316**, such as by being slidably attached to distal ends **1311, 1313, 1315, 1317** in a draw-string (e.g., purse-string) fashion. For example, closure line **1322** may a run generally circumferentially around basket **1300** near distal ends **1311, 1313, 1315, 1317** of grasper legs **1310, 1312, 1314, 1316** in a generally circular path so that when closure line **1322** is drawn tight, the distal ends **1311, 1313, 1315, 1317** are drawn together and/or closed, thus at least partially closing basket distal end opening **1301** (FIGS. 6 and 7).

[0049] Referring to FIGS. 5-7, in some example embodiments, closure line **1322** may extend from grasper legs **1310, 1312, 1314, 1316**, through a closure line guide **1324**, which may be disposed on at least one of an extension leg **1302, 1304, 1306, 1308**, a grasper leg **1310, 1312, 1314, 1316**, and/or shaft **1200**, such as near shaft distal end opening **1202**. Closure line guide **1324** may extend generally distally from shaft distal end opening **1202** to near distal end **1315** of leg **1314**, for example. Closure line guide **1324** may include a closure line guide distal end opening **1325** through which closure line **1322** may extend generally circumferentially outward about distal ends **1311, 1313, 1315, 1317** of grasper legs **1310, 1312, 1314, 1316**. In some example embodiments, closure line guide **1324** may be generally tubular (e.g., may have a longitudinal channel therethrough). In some example embodiments, closure line guide **1324** may be generally flexible (e.g., generally as flexible as grasper legs **1310, 1312, 1314, 1316** and/or extension legs **1302, 1304, 1306, 1308**) such that it bends (e.g., radially inward) as required in the closed configuration (FIG. 6) and/or the retracted configuration (FIG. 7).

[0050] FIG. 8 is a cross section view of an example shaft **1200** of a dual-mode basket **1300** extraction device **1100**, according to at least some aspects of the present disclosure. Shaft **1200** may be utilized in some example extraction devices, such as extraction device **1100** including dual-mode basket **1300**. In some example embodiments, shaft **1200** may include an outer sheath **1206**, which may be generally tubular and/or may define a longitudinal cavity **1207** therein. A generally tubular conduit **1208** may be slidably disposed within cavity **1207** of outer sheath **1206**. Conduit **1208** may be generally tubular and/or may define a longitudinal cavity **1209** therein. Conduit **1208** may be axially (e.g., longitudinally) slidable relative to outer sheath **1206**, such as proximally and distally. Extension legs **1302, 1304, 1306, 1308** may be mounted to conduit **1208**, such as within cavity **1209**. Closure line guide **1324**, which may include closure line **1322** extending therethrough, may extend within cavity **1209** of conduit **1208**.

[0051] Referring to FIGS. 4-8, in some example embodiments, closure line 1322 may be operatively coupled to closure actuator 1500 and/or may extend from handle 1400, distally through shaft 1200, distally through closure line guide 1324, and outward through closure line guide distal end opening 1325. In some example embodiments, closure actuator 1500 may be configured for operation by a user, such as by rotating, sliding, and/or pivoting, to extend or withdraw closure line 1322 to open and/or close basket 1300. In some example embodiments, when basket 1300 is in the open configuration (FIG. 5), operating closure actuator 1500 from an open position towards a closed position may pull closure line 1322 proximally through shaft 1200, which may draw distal ends 1311, 1313, 1315, 1317 of grasper legs 1310, 1312, 1314, 1316 radially inward, generally in a draw-string (e.g., purse-string) fashion, generally reducing and/or at least partially closing basket distal end opening 1301 (FIG. 6).

[0052] In some example embodiments, when dual-mode basket 1300 is in the closed configuration (FIG. 6) and/or the retracted configuration (FIG. 7), operating closure actuator 1500 from the closed position towards the open position may allow distal movement of closure line 1322, which may be tensioned distally by the opening bias of grasper legs 1310, 1312, 1314, 1316 and/or extension legs 1302, 1304, 1306, 1308. Movement of closure line 1322 distally may allow distal ends 1311, 1313, 1315, 1317 of grasper legs 1310, 1312, 1314, 1316 to move radially outward, generally circumferentially expanding and/or opening basket distal end opening 1301 (FIG. 6).

[0053] In some example embodiments, extension legs 1302, 1304, 1306, 1308 may be axially (longitudinally) slidable relative to shaft 1200. For example, extension legs 1302, 1304, 1306, 1308 may be mounted to conduit 1208, which may be slidably disposed within shaft 1200 (FIG. 8). Referring to FIG. 6, in an example extended configuration, extension legs 1302, 1304, 1306, 1308 may extend distally from shaft distal end opening 1202. Referring to FIG. 7, in an example retracted configuration, extension legs 1302, 1304, 1306, 1308 may be at least partially contained within shaft 1202. For example, extension legs 1302, 1304, 1306, 1308 may be substantially contained within shaft with only relatively short portions near distal ends 1303, 1305, 1307, 1309 of respective extension legs 1302, 1304, 1306, 1308 extending distally from shaft distal end opening 1202.

[0054] In some example embodiments, retracting extension legs 1302, 1304, 1306, 1308 at least partially into shaft 1202 may cause distal ends 1303, 1305, 1307, 1309 of extension legs 1302, 1304, 1306, 1308 to move radially closer (FIG. 7). Extending extension legs 1302, 1304, 1306, 1308 at least partially out of shaft 1202 may allow distal ends 1303, 1305, 1307, 1309 of extension legs 1302, 1304, 1306, 1308 to move radially farther apart, such as by the biased-open nature of extension legs 1302, 1304, 1306, 1308 (FIGS. 5 and 6).

[0055] In some example embodiments, retraction actuator 1502 on handle 1400 may be repositionable with respect to handle 1400 to extend (FIGS. 5 and 6) and/or retract (FIG. 7) extension legs 1302, 1304, 1306, 1308 relative to shaft 1200. Referring to FIG. 8, for example, retraction actuator 1502 may be operatively coupled to conduit 1208, to which extension legs 1302, 1304, 1306, 1308 may be mounted. Conduit 1208 may have an external maximum dimension that is smaller than the smallest internal dimension of sheath 1206, thereby allowing conduit 1208 to be longitudinally repositionable with respect to sheath 1206. In some example embodiments, closure line 1322, may be independently longitudinally repositionable with respect to conduit 1208 and/or sheath 1206, such as by the action of closure actuator 1500. Similarly, conduit 1208 may be independently longitudinally repositionable with respect to closure line 1322 and/or sheath 1206, such as by the action of retraction actuator 1502. In this fashion, motion of retraction actuator 1502 with respect to handle 1400 may be operative to transmit corresponding longitudinal motion to conduit 1208 within sheath 1206, which causes corresponding longitudinal motion (extension and/or retraction) of extension legs 1302, 1304, 1306, 1308. In some example embodiments, travel of retraction actuator 1502 may be limited so that its range of motion corresponds with the range of extending and retracting extension legs 1302, 1304, 1306, 1308. In other words, when retraction

actuator **1502** is at one end of its range of motion, extension legs **1302, 1304, 1306, 1308** may be in the retracted configuration (FIG. 7) and/or extension legs **1302, 1304, 1306, 1308** may be in the extended configuration (FIGS. 5 and 6) when retraction actuator **1502** is at the opposite end of its range of motion.

[0056] Referring to FIGS. 4-8, an example method of operating an extraction device **1100** including a dual-mode basket **1300** is described. Extraction device **1100** including dual-mode basket **1300** may be utilized to extract various objects **600** from within an interior of an anatomical cavity. As an example, use of extraction device **1100** including a dual-mode basket **1300** will be explained in the context of a kidney stone removal procedure. Nevertheless, those skilled in the art will understand that use of the extraction device **1100** including a dual-mode basket **1300** is not limited to kidney stone removal procedures, but rather that this description is just one of numerous procedures for which the extraction device **1100** including dual-mode basket **1300** has application.

[0057] In some example methods, a suitable path to the kidney stone in the patient's body is established, and appropriate visualization may also be established, such as by means of a ureteroscope. Thereafter, dual-mode basket **1300** of extraction device **1100** is advanced until dual-mode basket **1300** of extraction device **1100** reaches the targeted area where object **600** to be removed is located. In some example embodiments, this advance may be accomplished by manually feeding shaft **1200** through a working channel in the ureteroscope.

[0058] Upon reaching object **600**, dual-mode basket **1300** is placed in the open configuration (FIG. 5), if it is not already in the open configuration. For example, in some circumstances it may be desirable to insert extraction device **1100** with dual-mode basket **1300** in the closed configuration and/or the retracted configuration. Then, extraction device **1100** may be manipulated to position object **600** (e.g., a kidney stone) generally within dual-mode basket **1300** (FIG. 5). Then, closure actuator **1500** may be operated to withdraw proximally closure line **1322**, which may draw distal ends **1311, 1313, 1315, 1317** together and/or closed, thus at least partially closing basket distal end opening **1301** and/or at least partially capturing object **600** within dual-mode basket **1300** (FIG. 6). Then, retraction actuator **1502** may be operated to at least partially retract extension legs **1302, 1304, 1306, 1308** (FIG. 7). With object **600** retained within dual-mode basket **1300**, extraction device **1100** may be removed from the patient, thereby removing object **600** from the patient.

[0059] Referring to FIG. 5, some example embodiments may include one or more nets or walls disposed on one or more of extension legs **1302, 1304, 1306, 1308** and/or grasper legs **1310, 1312, 1314, 1316**. For example, FIG. 5 illustrates a net or wall **1312a** disposed on grasper legs **1312, 1314** and a net or wall **1302a** disposed on extension legs **1302, 1308**. Although the nets or walls are omitted from several of the other figures for clarity and are shown only on some extension legs and grasper legs in FIG. 5, it is within the scope of the disclosure to include nets or walls on any or all extension legs and/or on any or all grasper legs. In some example embodiments, the walls and/or the net (e.g., nets or walls **1312a, 1302a**) may be constructed from a mesh (e.g., metal wire mesh) and/or an elastomeric film (e.g., which may be laser cut and/or may be porous).

[0060] FIG. 9 is a detailed perspective view of an alternative example basket in the form of a petal grasper **2300** in an open configuration, according to at least some aspects of the present disclosure. FIGS. 10 and 11 are section views of an example petal grasper **2300** in an open configuration and a closed configuration, respectively, according to at least some aspects of the present disclosure. Generally, petal grasper **2300** may be an alternative basket structure that may be utilized in place of basket **300** in extraction device **100** (FIG. 1).

[0061] Referring to FIGS. 9-11, in some example embodiments, petal grasper **2300** may include two or more petals **2302, 2304, 2306, 2308**. Some example embodiments may include three or more petals **2302, 2304, 2306, 2308**, such as four petals **2302, 2304, 2306, 2308**. For clarity, FIGS. 10 and 11 illustrate petal **2302** and **2304**; however, one of skill in the art will recognize that any other petals (e.g., petals **2306, 2308**) may operate in substantially the same manner as petal **2302** and/or petal **2304**. Petals **2302, 2304, 2306, 2308** may be mounted to shaft **200** at or near a shaft

distal end **201**. For example, petals **2302, 2304, 2306, 2308** may be generally evenly circumferentially spaced apart at shaft distal end opening **202**. Petals **2302, 2304, 2306, 2308** may be longitudinally slidable (e.g., proximally and/or distally) relative to shaft **200**.

[0062] In some example embodiments, petals **2302, 2304, 2306, 2308** may be bendable and/or pivotable (compare FIGS. **10** and **11**) and/or may be biased to the open configuration (FIGS. **9** and **10**). For example, petals **2302, 2304, 2306, 2308** may be formed such that their respective distal tips **2303, 2305, 2307, 2309** are biased generally radially outward (e.g., biased open) to form a grasper distal end opening **2301**. In some example embodiments, petals **2302, 2304, 2306, 2308** may be constructed at least partially from nickel titanium alloys (e.g., nitinol) in the super elastic range, for example.

[0063] Referring to FIG. **9**, some example embodiments may include walls **2316, 2318** disposed on respective petals **2306, 2308**. For example, a petal **2306, 2308** that is formed generally as a distally extending loop in a lobed shape may have a wall **2316, 2318** disposed generally within the lobed shaped loop in a generally circumferential fashion. In some example embodiments, walls **2316, 2318** may be constructed from a mesh (e.g., metal wire mesh) and/or an elastomeric film (e.g., which may be laser cut and/or may be porous). Referring to FIGS. **2** and **9**, in some example embodiments according to at least some aspects of the present disclosure, walls **312, 314, 316, 318, 320, 2316, 2318** may partially cover a respective leg **302, 304, 306, 308, 310** and/or petal **2302, 2304, 2306, 2308** (see, e.g., wall **2316** in FIG. **9**) or fully cover the respective leg **302, 304, 306, 308, 310** and/or petal **2302, 2304, 2306, 2308** (see, e.g., wall **2318** in FIG. **9**). It is within the scope of the present disclosure to utilize any wall described herein with any example embodiment described herein.

[0064] Referring to FIGS. **1, 10, and 11**, in some example embodiments according to at least some aspects of the present disclosure, an actuator line **2322** may extend longitudinally through shaft **200** from actuator **500** on handle **400** to petal grasper **2300**. Actuator line **2322** may be operatively coupled to actuator **500** and/or petals **2302, 2304, 2306, 2308** such that when actuator **500** is in an open position, petals **2302, 2304, 2306, 2308** are in the open configuration (FIGS. **9** and **10**) and/or when actuator **500** is in a closed position, petals **2302, 2304, 2306, 2308** are in the closed configuration (FIG. **11**). In the closed configuration, petals **2302, 2304, 2306, 2308** may be generally drawn together and/or closed, thus at least partially closing grasper distal end opening **2301**.

[0065] In some example embodiments, in a fully closed configuration, petals **2302, 2304, 2306, 2308** may substantially completely enclose (e.g., encapsulate) object **600** held within petal grasper **2300**. For example, distal ends **2303, 2305, 2307, 2309** of petals **2302, 2304, 2306, 2308** may substantially come into contact with one another, thereby substantially closing grasper distal end opening **2301**. In some example embodiments, in the closed configuration (FIG. **11**), distal ends **2303, 2305, 2307, 2309** of petals **2302, 2304, 2306, 2308** may at least partially overlap one another, and/or may lock together.

[0066] In some example embodiments, in a fully closed configuration, petals **2302, 2304, 2306, 2308** may partially enclose object **600** held within petal grasper **2300**. In some example embodiments, in a partially closed configuration (e.g., a configuration between the open configuration and the closed configuration), petals **2302, 2304, 2306, 2308** may partially enclose object **600** held within petal grasper **2300**.

[0067] In some example embodiments, when petal grasper **2300** is in the open configuration (FIGS. **9** and **10**), operating actuator **500** from the open position towards the closed position may cause proximal movement of actuator line **2322**, which may be tensioned distally by the opening bias of petals **2302, 2304, 2306, 2308**. Movement of actuator line **2322** proximally may cause petals **2302, 2304, 2306, 2308** to withdraw at least partially within shaft distal end opening **202**, thereby contacting shaft distal end opening **202** and causing petals **2302, 2304, 2306, 2308** to rotate such that distal ends **2303, 2305, 2307, 2309** of petals **2302, 2304, 2306, 2308** to move radially

inward, generally circumferentially reducing and/or closing grasper distal end opening **2301**. In some example embodiments, in the closed configuration (FIG. **11**), petals **2302**, **2304**, **2306**, **2308** may be at least partially within shaft **200** and at least partially extending distally from shaft distal end **201**.

[0068] In some example embodiments, when petal grasper **2300** is in the closed configuration (FIG. **11**), operating actuator **500** from the closed position towards the open position may allow distal movement of actuator line **2322**, which may be tensioned distally by the opening bias of petals **2302**, **2304**, **2306**, **2308**. Movement of actuator line **2322** distally may allow distal ends **2303**, **2305**, **2307**, **2309** of petals **2302**, **2304**, **2306**, **2308** to move radially outward, generally circumferentially expanding and/or opening grasper distal end opening **2301**.

[0069] In some example embodiments, petals **2302**, **2304**, **2306**, **2308** may be substantially identical to each other and/or may be arranged generally symmetrically about shaft distal end opening **202**. In some example embodiments, one or more petals **2302**, **2304**, **2306**, **2308** may differ from the others and/or may be arranged generally asymmetrically about shaft distal end opening **202**.

[0070] Referring to FIGS. **1** and **9-11**, an example method of operating an extraction device **100** including a petal grasper **2300** is described. In some example methods, a suitable path to the kidney stone in the patient's body is established, and appropriate visualization may also be established, such as by means of a ureteroscope. Thereafter, extraction device **100** is advanced until petal grasper **2300** reaches the targeted area where object **600** to be removed is located. In some example embodiments, this advance may be accomplished by manually feeding shaft **200** through a working channel in the ureteroscope.

[0071] Upon reaching object **600**, petal grasper **2300** is placed in the open configuration (FIGS. **9** and **10**), if it is not already in the open configuration. For example, in some circumstances it may be desirable to insert extraction device **100** with petal grasper **2300** in the closed configuration. Then, extraction device **100** may be manipulated to position object **600** (e.g., a kidney stone) generally within petal grasper **2300**. Then, actuator **500** may be operated to withdraw proximally actuator line **2322**, which may cause petals **2302**, **2304**, **2306**, **2308** to withdraw at least partially within shaft distal end opening **202**, thereby contacting shaft distal end opening **202** and causing petals **2302**, **2304**, **2306**, **2308** to rotate such that distal ends **2303**, **2305**, **2307**, **2309** of petals **2302**, **2304**, **2306**, **2308** to move radially inward, generally circumferentially reducing and/or closing grasper distal end opening **2301** and/or at least partially capturing object **600** within petal grasper **2300** (FIG. **11**). With object **600** retained petal grasper **2300**, extraction device **100** may be removed from the patient, thereby removing object **600** from the patient.

[0072] In some example embodiments according to at least some aspects of the present disclosure, shafts **200**, **1200** may be fabricated to provide a generally smooth exterior periphery and a hollow interior. For example, shaft **200**, **1200** and/or outer sheath **1206** may comprise a multilayer construction, which may include an outer layer of polytetrafluoroethylene (e.g., Teflon), a polyimide layer, a stainless-steel braid layer, and/or an inner polyimide layer demarcating a hollow interior. Shafts **200**, **1200** and/or outer sheath **1206** may have a substantially constant cross-section or a cross-section that changes along its longitudinal length. Moreover, shafts **200**, **1200** and/or outer sheath **1206** may have a circular cross-section, an oblong cross-section, or any other shaped cross-section that provides a longitudinal conduit therethrough.

[0073] In some example embodiments according to at least some aspects of the present disclosure, closure lines **322**, **1322** and/or actuator line **2322** may be constructed at least partially of metal wire and/or cable. In some example embodiments, closure lines **322**, **1322** may be constructed at least partially of suture material.

[0074] Following from the above description and invention summaries, it should be apparent to those of ordinary skill in the art that, while the methods and apparatuses herein described constitute example embodiments according to the present disclosure, it is to be understood that the scope of

the disclosure contained herein is not limited to the above precise embodiments and that changes may be made without departing from the scope. Various characteristics and features described herein are designed to be combined with one another and utilized in connection with other embodiments described herein. Likewise, it is to be understood that it is not necessary to meet any or all of the identified advantages or objects disclosed herein in order to fall within the scope of the disclosure, since inherent and/or unforeseen advantages may exist even though they may not have been explicitly discussed herein.

Claims

1. An extraction device, comprising: a plurality of extension legs, each extension leg of the plurality of extension legs including a distal end biased radially outward; a plurality of flexible grasper legs, each flexible grasper leg of the plurality of flexible grasper legs having a proximal end mounted to the distal end of a respective extension leg and a free distal end, the plurality of flexible grasper legs defining at least a portion of a basket; a handle coupled to a shaft; and a closure line coupled to a closure actuator disposed on the handle, the closure line extending distally through the shaft to connect the free distal ends of the plurality of flexible grasper legs to define a basket opening, wherein the closure actuator is operative to transition the basket from an open configuration to a closed configuration.
 2. The extraction device according to claim 1, wherein the closure line is disposed in a closure line guide coupled to the shaft.
 3. The extraction device according to claim 2, wherein the closure line guide extends from a distal end of the shaft.
 4. The extraction device according to claim 3, wherein the closure line guide extends distally to the free distal ends of the plurality of flexible grasper legs.
 5. The extraction device according to claim 2, wherein the closure line guide is tubular.
 6. The extraction device according to claim 2, wherein the closure line guide is configured to bend radially inwardly when the basket is transitioned to the closed configuration.
 7. The extraction device according to claim 1, wherein the closure line is slidably coupled to each flexible grasper leg near the free distal end thereof.
 8. The extraction device according to claim 1, further comprising a retraction actuator disposed on the handle, the retraction actuator operatively coupled to the extension legs to extend and retract the extension legs relative to the shaft.
 9. The extraction device according to claim 1, wherein the basket comprises at least one grasper leg wall disposed on at least one of the plurality of grasper legs.
 10. The extraction device according to claim 9, wherein the at least one grasper leg wall comprises one or both of a wire mesh and an elastomeric film.
 11. The extraction device according to claim 9, wherein the basket further comprises at least one extension leg wall disposed on at least one of the plurality of extension legs.
 12. The extraction device according to claim 11, wherein the at least one extension leg wall comprises one or both of a wire mesh and an elastomeric film.
 13. The extraction device according to claim 1, wherein the handle comprises a lock operatively coupled to the closure actuator to lock the basket in the closed configuration.
 14. The extraction device according to claim 1, wherein at least two of the plurality of flexible grasper legs are substantially identical to each other and are positioned substantially symmetrically in the basket.
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