APPARATUS FOR DISINTEGRATING KIDNEY STONES

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ABSTRACT

The useful life of the wire probe in an ultrasonic kidney stone disintegration instrument is enhanced and prolonged by attaching the wire (24) of the wire probe to the tip (26) of an ultrasonic transducer (28) by means of a clamping arrangement comprising opposing set screws (60, 65), one (60) of which is adapted to accept the clamping load from the other set screw (65) without deforming the wire by machining a pair of mutually transverse grooves (64) in the inner end face (62) of the screw (60) which is adapted to accept and hold the wire probe along the central longitudinal axis (52) of the transducer tip which is adapted to impart ultrasonic energy to the wire. Additionally, damping material is applied to the wire probe (24) in the form of a damper tube (70) through which the wire probe passes in the region adjacent the transducer tip. The damper tube extends outwardly from the transducer tip a predetermined distance, terminating in a resilient soft rubber joint (72). Also, the damper tube is supported intermediate its length by a support member (82). The damper system thus provided acts to inhibit lateral vibrations of the wire in the region of the transducer tip (26) while providing little or no damping to the linear vibrations imparted to the wire (24) by the transducer (28).

18 Claims, 7 Drawing Figures
STATEMENT OF INVENTION

Accordingly, it is an object of the present invention to provide an improvement in ultrasonic instrumentation for disintegrating urinary calculi or kidney stones. Another object is to provide an improved mechanical system for prolonging the operational life of an instrument for disintegrating kidney stones.

Still another object is to provide a means for reducing the relatively high mechanical stresses encountered in an ultrasonic kidney stone disintegration instrument.

And yet another object is to provide an improved ultrasonic instrument for disintegrating kidney stones which obviates the problem of metal fatigue which would otherwise cause premature termination of a medical procedure utilized for the removal of kidney stones.

These and other objects are provided by a mechanical system for prolonging the life of an instrument for disintegrating urinary calculi or kidney stones wherein the instrument includes a wire probe connected to an ultrasonic transducer and which is fed through a catheter to the site of the kidney stone. The coupling between the transducer and the wire probe comprises clamping means at the tip of the transducer including a pair of opposing screw type members, one of which acts as an anvil for accepting the clamping load from the other member while preventing deformation of the wire probe at the point of clamping. Also included is damping means located along a predetermined length of the wire adjacent the transducer tip for inhibiting lateral vibration of the wire when driven by the transducer.

The foregoing as well as other objects, features and advantages of the invention will become apparent from the following detailed description when taken in conjunction with the appended drawings.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a side elevational view of apparatus in accordance with the prior art for fragmenting kidney stones.

FIG. 2 is a partial longitudinal sectional view of an ultrasonic transducer tip in accordance with the prior art.

FIG. 3 is a partial longitudinal sectional view of a prior art transducer tip illustrating the manner in which a wire probe is clamped therein.

FIG. 4 is a partial longitudinal sectional view of a transducer tip in accordance with the subject invention.

FIG. 5 is a partial longitudinal sectional view of the transducer tip as shown in FIG. 4 and being illustrative of the manner in which a wire probe is clamped in accordance with the subject invention.

FIG. 6 is a partial perspective view of the anvil portion of the clamping means shown in FIG. 5.

FIG. 7 is a partial side elevational view of vibrational damping means forming a part of the subject invention.

DETAILED DESCRIPTION OF THE INVENTION

Refer now to the drawings and, more particularly, to FIG. 1, where there is illustrated an ultrasonic kidney stone disintegration instrument in accordance with the prior art. The purpose of this Figure is to provide a better understanding of the invention to be described in detail when FIGS. 2 through 7 are considered. As illustrated in FIG. 1, a cystoscope 10 is shown inserted through a urethra 12 and into a bladder 14. A catheter 16 is inserted through the cystoscope 10, the bladder 14...
and into a ureter 18 until its far end 20 comes into prox-
imity to a piece of urinary calculi, hereinafter referred
to as a kidney stone 22. An ultrasonic waveguide in the
form of a wire probe 24 is inserted through one of eight
lumens in the catheter 16 until its far end 23 contacts the
stone 22. The diameter of the wire probe 24 is of a
substantially smaller diameter than the lumen diameter
of the catheter 16 so that any movement of the wire
probe is not restricted by the catheter material. The
opposite or near end 25 of the wire probe 24 is con-
ected to the tip 26 of an ultrasonic transducer assembly
28 which is mounted on a base 30. The base 30 includes
a micrometer 32 which is connected to the transducer
28 for adjusting the position of the wire probe 24 against
the stone 22 by a linear translation of the transducer
assembly 28 on the base 30. The base 30 additionally
includes an outward angular support member 34 which
includes a connector element in the form of a catheter
joint 36 for engaging and holding the near end of the
catheter 16. As shown in FIG. 1, the wire probe 24 is
clamped to the end of the transducer 26 by means of a
set screw 38 which leads now to consideration of FIGS.
2 and 3.

Referring now to FIG. 2, the transducer tip 26 which
is partially shown in section includes a central longitudi-
nal axial bore 40 which is adapted to receive the probe
wire 24 (FIG. 1), not shown. The tip 26 additionally
includes a threaded screw hole 42 which runs mutually
transverse to and through the axial bore 40, terminating
in a cone point 44 which results from the drill and/or
tap used for making the screw hole.

Referring now to FIG. 3, it can be seen that when the
wire probe 24 is inserted into the bore 40 and then
clamped by means of the set screw 38 inserted into the
threaded screw hole 42, the tip 50 of the set screw 38
causes a crimping of the end of the wire probe 24 into
the cone point 44, which causes the probe wire 24 to
become offset relative to the central longitudinal axis 52
of the transducer tip 26. As a consequence, a relatively
high mechanical stress is induced into the wire probe at
point 54. This condition has been found to be the pri-
mary source of premature breakage when subjected to
lateral vibration from the transducer 28 (FIG. 1). Addi-
tionally, the undamped motion of the vibrating wire at
the point 56 where it emerges from the transducer tip 26
does not unbalance the tuned mass of the transducer tip
while nevertheless transmitting linear vibrations im-
portant to the subject invention is a set screw
which leads now to consideration of FIGS. 2 and 3.

Referring now to FIG. 4, and 5, the transducer tip 26 is modified to
include a second threaded screw hole 58 diametrically
opposed to the threaded screw hole 42 and which ex-
tends into the longitudinal bore 40. The threaded screw
hole 58 is adapted to accept a second set screw, one
with fine threads, which is shown by reference numeral
60 in FIG. 5. Further, the set screw 60, as shown in
FIG. 6, includes a flattened end portion 62 having a
surface which includes at least one, preferably a pair of
mutually transverse shallow grooves 64 forming a +
which are adapted to accommodate and thus act as an
anvil for the end portion of the wire probe 24 when
inserted in the bore 40. The axis of the wire probe 24
can be controlled and easily centered since the anvil
face 62 is adjustable by the turning of the set screw 60
and thus the axis of the wire can be moved up or down
to coincide with the central longitudinal axis 52 (FIG.
3) of the axial bore 40. Whereas in the prior art appar-
atus the set screw 38, as shown in FIG. 3, typically in-
cludes a spherical tip, the type of set screw employed by
the subject invention is a set screw 65 with a flat tip 66,
thus removing the tendency for crimping the wire
probe 24 at the point of contact with the wire and/or
anvil face portion of the opposing set screw 60. It
should be noted that the addition of the second set
screw 60 does not unbalance the tuned mass of the
transducer assembly which includes the tip portion 26.
This is in contrast to earlier attempts which added a
wire clamping fixture to the external tip 26 of the trans-
ducer. Such an arrangement caused an imbalance in the
system, resulting in the loss of energy in the wire probe.

Referring now to FIG. 7, the second feature of the
invention is directed to the utilization of a damper tube
membrane 70, typically 3" to 4" in length, which is placed
over the external portion of the wire probe 24 in the
region where the wire probe emerges from the trans-
ducer tip 26, and extends outwardly therefrom ter-
minal in a block of relatively thick, soft rubber 72 which
has two offset bores 74 and 76 formed therein with the
latter adapted to accommodate a catheter 16
with an off axis wire lumen 77 shown in FIG. 7. The
soft rubber block 72 is adapted to act as a damper and
catheter joint, and is held in position by a support mem-
ber 78 which is secured to a base member 80. Base
member 80 corresponds, for example, to the base mem-
ber 30 shown in FIG. 1. In order to provide additional
support for the damper tube 70 an intermediate damper
tube support member 82 including a rubber bushing 84
is placed approximately midway between the trans-
ducer tip 26 and the member 72.

In such a configuration, the linear vibrations im-
portant by the transducer assembly 28, including the
transducer tip 26, are not significantly damped but are
transmitted along the wire probe 24 and out of the
dumper tube 70. At that point, i.e. in the region of the
damper and catheter joint 72, the vibrational energy is
free to induce the desired random lateral motion in the
wire probe 24 necessary to shatter kidney stones. Addi-
tionally, the high mechanical stress caused by the
point of clamping the wire 24 to the transducer tip 26 as
well as the undamped motion of the vibrating wire where it
exits from the transducer contributing to the metal fa-
tigue problem have been alleviated.

The advantage of the ultrasonic kidney stone disinte-
gration instrument modified in accordance with the
teachings of this invention is a sizable increase in instru-
ment lifetime, typically by a factor of fifteen or more.

In summation, what has been shown and described is
an improvement in an instrument for disintegrating
kidney stones by the introduction of a grooved adjust-
able anvil in the transducer tip at the clamping point of
the wire probe to lessen concentrated stresses in the
wire as well as the introduction of a vibrational damper
system which minimizes lateral wire motion at the
transducer tip while nevertheless transmitting linear
motion thereto which acts to prolong the useful life of
the wire probe.

Having thus shown and described the invention in its
specific detail, the same has been provided by way of
explanation and not limitation and accordingly all modi-
fications, alterations and changes coming within the
spirit and scope of the invention are herein meant to be included.

I claim:

1. An apparatus for disintegrating urinary calculi such as kidney stones or the like lodged in the urinary tract, comprising:
catheter means;
waveguide means (24) fed through said catheter and brought into contact with the calculi (22) to be removed;
ultrasonic transducer means (28) coupled to said waveguide means (24) for imparting vibrations thereto;
vibrational output means (26) forming a portion of said ultrasonic transducer means (28);
coupling means coupling said waveguide means (24) to said output means (26) comprising a pair of movable opposing members (60, 65) at said output means which are adapted to be brought together such that one of said members (60) acts as an anvil for accepting the clamping load applied by the other (65) of said members on said waveguide means thereby preventing any substantial deformation of said waveguide means at the point of clamping (54); and
vibrational damping means (70, 72, 84) located adjacent said output means (26) and contacting said waveguide means for inhibiting lateral vibration of said waveguide means (24) in the region where said waveguide means leaves said output means while allowing substantially unimpaired longitudinal vibration thereof.

2. The apparatus as defined by claim 1 wherein said waveguide means (24) comprises a wire probe which is clamped to said output means (26) and fed through said catheter (16).

3. The apparatus as defined by claim 2 wherein said output means (26) includes a central longitudinal bore (40) formed in the end portion thereof for receiving said wire probe (24) and wherein said clamping means comprises a pair of members (60, 65) which are located in said end portion transverse to said longitudinal bore.

4. The apparatus as defined by claim 3 wherein said pair of members comprises a pair of screw type members fitted into respective threaded holes (42, 58) formed in the end portion of the output means (26) transverse to said longitudinal bore (40).

5. The apparatus as defined by claim 4 wherein said pair of screw type members comprise a first screw (60) having an inner end face (62) which includes at least one groove (64) formed therein for receiving and positioning said wire probe (24) in said longitudinal bore (40), and a second screw (65) having a flat inner end face (66) which is adapted to abut the grooved end face (62) of said first screw and said wire probe.

6. The apparatus as defined by claim 5 wherein said end face (62) of said first screw (60) includes a second groove (64) substantially transverse to said one groove.

7. The apparatus as defined by claim 4 wherein said screw type members comprise a first screw (60) having an end surface (62) including a linear groove (64) for accepting said wire probe (24) and acting as an anvil therefor and a second screw (65) having a flat end surface (66) opposing the end surface (62) of said first screw.

8. The apparatus as defined by claim 1 wherein said vibrational damping means comprises a predetermined length of vibrational damping material (70) located around said waveguide means (24).

9. The apparatus as defined by claim 8 wherein said waveguide means comprises a wire (24) and wherein said damping means comprises a sleeve (70) of damping material of a predetermined length fitted around said wire (24) in the region where said wire leaves said output means (26).

10. The apparatus as defined by claim 9 wherein said sleeve (70) comprises a tube of soft resilient material.

11. The apparatus as defined by claim 10 wherein said sleeve (70) comprises a tube of relatively tight fitting rubber.

12. The apparatus as defined by claim 11 wherein said coupling member (72) is comprised of resilient damping material.

13. The apparatus as defined by claim 12 wherein said coupling member (72) comprises a block of relatively soft rubber having a pair of offset bores (74, 76) formed therein, one (74) for receiving said damper tube (70) and said wire (24) and the other (76) for receiving said catheter (16) and said wire (24).

14. The apparatus as defined by claim 12 wherein said coupling member (72) comprises a block of relatively soft rubber having a pair of offset bores (74, 76) formed therein, one (74) for receiving said damper tube (70) and said wire (24) and the other (76) for receiving said catheter (16) and said wire (24).

15. The apparatus as defined by claim 12 and additionally including a damper tube support member (82) located between the end of said output means (26) and said coupling member (72).

16. The apparatus as defined by claim 15 wherein said damper tube support member (82) additionally includes a resilient bushing member (84) which is adapted to encircle and hold said damper tube (70).

17. The apparatus as defined by claim 16 wherein said damper tube support member (82) is located substantially midway between said output means (26) and said coupling member (72).

18. Apparatus for dislodging calculi lodged in the urinary tract, comprising:
   a catheter adapted to be inserted into a ureter to abut the calculi to be dislodged;
   waveguide means comprising a wire probe fed through said catheter and brought into contact with the calculi to be dislodged;
   ultrasonic transducer means coupled to said waveguide means for imparting vibrations thereto; and
   clamping means coupling said waveguide means to said output means comprising first and second movable opposing members adapted to be brought together whereby said first member acts as a support for accepting a clamping action applied by said second member on said waveguide means, said clamping means comprising a pair of screw members located in said transducer means, said first member including one groove formed in the end thereof and a second groove substantially transverse to said one groove for receiving said wire probe, said second member having a flat inner end face adapted to abut said grooved end face and said wire probe.

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