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(54) **ULTRASONIC CUTTING TOOL**

ULTRASCHALL-SCHNEIDWERKZEUG

OUTIL DE COUPE ULTRASONIQUE

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Description

[0001] The present invention relates to an ultrasonic surgical tool, such as an ultrasonic laparoscopic tool for cutting soft body tissues. More particularly, but not exclusively, it relates to such a tool having an operative tip that is profiled to improve the ergonomics of its use.

[0002] Ultrasonically-vibrated cutting tools have proven of major benefit for surgery, particularly laparoscopic surgery (so-called "keyhole" surgery). An elongate, narrow surgical tool, usually together with a fibre-optic endoscope viewing system, is introduced through a small incision into a patient's body and directed to an exact region of tissue requiring surgery. In more complex procedures, further tools may be introduced, by way of further incisions, then directed to the same site, although this is avoided wherever possible. In any case, a basic aim of laparoscopic surgery is to minimise the size and number of incisions (or "ports") made into the patient's body.

[0003] The constraints inherent in working with long, narrow tools in a confined space under remote viewing (for example on a monitor screen) mean that ergonomic design of laparoscopic tools is of paramount importance.

[0004] Ultrasonically-vibratable tools bring significant benefits in such minimally invasive procedures, as they may be selectively energised so as to cut only target tissues, and they may easily be adapted to cauterise tissue as they cut. Thus, blood vessels may be both severed and sealed in one operation, for example, significantly reducing bleeding. Such haemostatic cutting is of particular benefit in laparoscopic surgery, where visibility is at a premium.

[0005] Torsional-mode ultrasonic vibrations have proven particularly effective, since they may be transmitted efficiently and precisely into selected target tissues with minimal extraneous leakage of ultrasonic energy, whereas the alternative longitudinal-mode (or compression-wave) ultrasonic vibrations may lead to undesirable propagation of energy longitudinally out of a distal end of a tool into adjacent (non-target) tissues.

[0006] A conventional ultrasonically-vibratable laparoscopic tool, whether torsional-mode or longitudinal-mode, comprises an operative element or elements extending longitudinally from a distal end of an elongate waveguide. A surgeon manipulates the tool by grasping a handgrip mounted adjacent the proximal end of the waveguide, which extends through a restricted port into a patient's body. The operative elements are thus ideally positioned to be employed on tissues substantially directly in line with the axis of the waveguide. However, to work on tissue located to one side of the axis of the waveguide, the surgeon must partially withdraw and realign the tool, constrained by the dimensions of the port and at all times manipulating the tool by its proximal end. The continual repositioning required in a complex procedure may rapidly lead to fatigue on the part of the surgeon. There is hence a need for an ergonomically superior tool

that allows the surgeon to work for longer and with improved control.

[0007] As mentioned above, another important ergonomic issue in laparoscopy is clear visualisation of the operative elements of the tool and the target tissue. An endoscope viewing system is inserted through a further incision, but this may arrive at the target tissue at such an acute angle to the tool that three dimensional visualisation is difficult.

[0008] It is hence an object of the present invention to provide an ultrasonic cuffing and/or coagulating tool that obviates the above disadvantages and allows a user to conduct laparoscopic surgery more conveniently and with improved control.

[0009] An ultrasonic surgical tool having the features of the preamble of Claim 1 is disclosed in European Patent Application No. EP1 138 264 A1.

[0010] According to the present invention, there is provided an ultrasonic surgical tool comprising elongate waveguide means operatively connected or connectable at a proximal end to a source of ultrasonic vibrations and provided adjacent a generally-cylindrical distal end with an operative element comprising a radially-extending ridge means defined between a substantially parallel pair of groove means extending longitudinally of the waveguide from a distal end thereof, **characterized in that** said operative element is curved in a plane transverse to that of the ridge means and wherein the source of ultrasonic vibrations comprises a source of torsional mode ultrasonic vibrations.

[0011] The operative element may be curved in a plane substantially perpendicular to that of the ridge means.

[0012] Preferably, the operative element is tapered towards its distal end.

[0013] Advantageously, the operative element comprises two convergent faces extending transversely to the plane of curvature of the operative element.

[0014] A first said convergent face may thus be concavely curved and a second said convergent face convexly curved.

[0015] The operative element may comprise a substantially blunt distal tip.

[0016] Preferably, the ridge means extends in a plane generally bisecting those of the convergent faces.

[0017] Advantageously, the first, concave convergent face converges towards the plane of the ridge means more gradually than does the second, convex convergent face.

[0018] The operative element thus comprises more material between the plane of the ridge means and the concave convergent face than between the plane of the ridge means and the convex convergent face.

[0019] Preferably, the ridge means forms a cutting edge of the operative element.

[0020] Advantageously, the operative element comprises a jaw member controllably pivotably moveable into and out of engagement with the ridge means.

[0021] The jaw member may be curved correspond-

ingly with the ridge means.

[0022] The jaw member may comprise a contact surface so formed as to be cooperable with the ridge means.

[0023] In a preferred embodiment, the tool comprises a source of torsional mode ultrasonic vibrations.

[0024] The tool preferably comprises means whereby the operative element may be selectably rotated about a longitudinal axis of the waveguide so as to be presented to a desired element of tissue on which to act.

[0025] An embodiment of the present invention will now be more particularly described, by way of example and with reference to the accompanying drawings, in which:

Figure 1 is a plan view from above of a tip of an ultrasonic tool embodying the present invention, at a first stage of its production;

Figure 2 is a cross-sectional view of the tip of the tool shown in Figure 1, taken along the line II - II;

Figure 3 is a plan view from above of the tip of the tool shown in Figure 1, at a second stage of its production;

Figure 4 is a cross-sectional view of the tip of the tool shown in Figure 3, taken along the line IV - IV;

Figure 5 is a plan view from above of the tip of the tool shown in Figure 1, at a last stage of its production; and

Figure 6 is a distal end elevation of the tip of the tool shown in Figure 5.

[0026] Referring now to the Figures, and to Figure 1 and 2 in particular, a narrow elongate cylindrical waveguide 1 comprises a hard, corrosion resistant material, ideally titanium or an alloy thereof. Figure 1 shows the waveguide 1 after a first stage of the production of a tool tip thereon. Two parallel grooves 4 extend longitudinally of the waveguide 1 from its distal end 3, defining between them an upstanding rib 2. The grooves 4 blend into the cylindrical surface of the waveguide 1 at their proximal ends 6, and deepen towards the distal end 3 of the waveguide 1. The upstanding rib 2 extends in parallel to a longitudinal axis 9 of the waveguide 1. (For the purposes of this description, the rib 2 will be taken as a top of the waveguide 1, and a plane extending through the rib 2 and the longitudinal axis 9 is thus considered to be a vertical plane).

[0027] In a second stage of the production of the tip of the tool, the result of which is shown in Figures 3 and 4, the distal end 3 of the waveguide 1 is tapered by machining a pair of vertically extending flats 11, 12 into it. The flats 11, 12 converge towards the distal end 3, but if prolonged would only meet beyond it. They thus leave a narrow, flat distal tip 8, which is wider than the rib 2.

[0028] The flats 11, 12 begin each level with the other at their proximal ends, but extend at slightly different angles, a first flat 11 extending at a lesser angle to the rib 2 than a second flat 12. As a result, the tip 8 is asymmetric, slightly more material remaining to a side of the rib 2

adjacent the first flat 11 than to a side of the rib 2 adjacent the second flat 12.

[0029] In cross-section (Figure 4), the waveguide 1 now begins to take the form of a blade with a first 14 and a second 15 face formed by the respective flats 11, 12.

[0030] In the final stage of production, the result of which is shown in Figures 5 and 6, a distal portion of the waveguide 1 is bent round a vertically extending mandrel, so that the first face 14 adopts a concave profile 17 and the second face 15 adopts a slightly shallower convex profile 18. As a result, the rib 2 is also curved, and the tip 8 is deflected outwardly, away from the axis 9 of the waveguide 1, until it extends beyond a cylindrical volume extending distally from a distal extremity of the waveguide 1.

[0031] The waveguide tip shown in Figure 5 forms the cutting blade of an ultrasonically-vibratable laparoscopic surgical tool. The waveguide 1 is connected at its proximal end to a generator of torsional-mode ultrasonic vibrations and to a handgrip graspable by a surgeon, and is provided along almost its entire length with a sleeve to isolate tissue through which it passes from ultrasonic vibrations transmitted along the waveguide 1. The rib 2, and in particular regions of the grooves 4 immediately flanking the rib 2 will best transmit ultrasonic energy into tissue contacted by the waveguide 1.

[0032] The tapering of the waveguide 1 towards the distal tip 8 produces a tool with a much finer dissecting profile than would an equivalent untapered distal end 3 of a waveguide 1. The tapering also facilitates the step of bending the waveguide 1 around the mandrel. One further benefit is that the taper towards the distal tip 8, which is now significantly displaced from the longitudinal/torsional axis 9, reduces the moment of inertia of the tip 8. This reduces any tendency to generate unwanted unbalanced transverse vibrational modes adjacent the distal tip 8. As can be seen from Figure 6, the distal tip 8 is pared down to a minimum consistent with supporting the rib 2. Were it much narrower, it might risk physically cutting into tissue as it is introduced into the body, whereas an ideal laparoscopic tool is functionally blunt until the moment that it is activated.

[0033] The shape of the tool shown allows it to be used as a very delicate probe or dissector until a distal portion of the rib 2 is brought into contact with the tissue to be treated, and is ultrasonically vibrated, at which point it becomes a very precise cutting/coagulating tool.

[0034] The shape is of particular advantage over existing tools when the waveguide 1 is made rotatable about the axis 9, for example using an arrangement such as that disclosed in our copending UK Patent Application No. 0500937.8. This allows the distal tip 8 to be applied to tissue all around the end 3 of the waveguide 1, by simply "dialling" a desired angular alignment of the distal tip 8, then for example sliding it under an adjacent vessel, and ultrasonically activating it to make the required cut.

[0035] A conventional operative tip of an ultrasonic laparoscopic tool extends longitudinally from the distal

end of the waveguide, and so can only easily act on tissue directly in front of the tool. The surgeon would then have to realign the entire elongate tool, constrained by the size of the incision through which it passes, to work on selected tissue that is not directly in the initial path of the tool. The form of tip 8 shown gives the surgeon a far greater radius of action without needing to reposition the whole tool, a significant ergonomic improvement.

[0036] The distal tip 8 profile shown is also usable with a controllably pivotable non-vibrated jaw mechanism, of the form used in conventional linearly-arranged tools. This comprises a jaw member (not shown) with a curvature corresponding with that of the rib 2, which would be brought down into contact with an upper surface of the rib 2 to trap tissue to be cut and coagulated therebetween. Optionally, a contact surface of the jaw member would be so profiled as to cooperate with the cross-sectional profile of the rib 2 and at least the flanking regions of the grooves 4 when it closes.

[0037] The distal tip 8 profile shown is of particular benefit in procedures such as a cholecystectomy on the gall bladder, in which curved cutting planes are preferred over simple flat cuts.

[0038] Clearly, with the distal tip 8 displaced outwardly from the waveguide 1, it is also easier to see in the field of view of a conventionally positioned endoscope viewer. This improved visibility aids the surgeon in carrying out swift and accurate procedures.

Claims

1. An ultrasonic surgical tool comprising elongate waveguide means (1), a source of ultrasonic vibrations operatively connected or connectable to a proximal end of said waveguide means, an operative element adjacent a generally cylindrical distal end of said waveguide means and comprising a radially-extending ridge means (2) defined between a substantially parallel pair of groove means (4) extending longitudinally of the waveguide means from a distal end thereof, **characterised in that** said operative element is curved in a plane transverse to that of the ridge means and wherein the source of ultrasonic vibrations comprises a source of torsional mode ultrasonic vibrations.
2. A tool as claimed in claim 1, wherein the operative element is curved in a plane substantially perpendicular to that of the ridge means.
3. A tool as claimed in either claim 1 or claim 2, wherein the operative element is tapered towards its distal end.
4. A tool as claimed in any one of the preceding claims, wherein the operative element has a substantially blunt distal tip

5. A tool as claimed in any one of the preceding claims, wherein the operative element comprises two convergent faces extending transversely to the plane of curvature of the operative element, preferably with a first said convergent face being concavely curved and a second said convergent face convexly curved.
6. A tool as claimed in claim 5, wherein the ridge means extends in a plane generally bisecting those of the convergent faces, and the first concave convergent face converges towards the plane of the ridge means more gradually than does the second convex convergent face.
7. A tool as claimed in any one of the preceding claims, wherein the operative element further comprises a jaw member controllably moveable pivotably into and out of engagement with the ridge means.
8. A tool as claimed in claim 7, wherein the jaw member or its contact surface is curved correspondingly with the ridge means.
9. A tool as claimed in any one of the preceding claims, further comprising means whereby the operative element may be selectably rotated about a longitudinal axis of the waveguide so as to be presented to a desired element of tissue on which to act.
10. A tool as claimed in claim 7, wherein the jaw member has a curvature corresponding with that of the ridge means, the jaw member being operable to be brought down into contact with an upper surface of the ridge means and to trap tissue to be cut and coagulated therebetween.

Patentansprüche

1. Chirurgisches Ultraschallinstrument, das einen langgestreckten Wellenleiter (1) umfasst, eine Ultraschallschwingungsquelle, die mit einem proximalen Ende des Wellenleiters verbunden oder verbindbar ist, ein operatives Element, das einem generell zylindrischen distalen Ende des Wellenleiters benachbart ist und einen sich radial erstreckenden Steg (2) umfasst, der zwischen einem im Wesentlichen parallelen Paar von Vertiefungen (4) definiert ist, die sich in Längsrichtung des Wellenleiters von dessen distalem Ende erstrecken, **dadurch gekennzeichnet, dass** das operative Element in einer Ebene quer zum Steg gebogen ist und wobei die Ultraschallschwingungsquelle eine Torsionsschwingungsquelle umfasst.
2. Instrument nach Anspruch 1, bei dem das operative Element in einer Ebene im Wesentlichen senkrecht zur Stegebene gebogen ist.

3. Instrument nach Anspruch 1 oder 2, bei dem das operative Element in Richtung seines distalen Endes konisch zuläuft.
4. Instrument nach einem der vorangehenden Ansprüche, bei dem das operative Element eine im Wesentlichen stumpfe distale Spitze aufweist. 5
5. Instrument nach einem der vorangehenden Ansprüche, bei dem das operative Element zwei konvergente Anlageflächen umfasst, die sich quer zur Krümmungsebene des operativen Elements erstrecken, wobei vorzugsweise eine erste konvergente Anlagefläche konkav und eine zweite konvergente Anlagefläche konvex gebogen ist. 10
6. Instrument nach Anspruch 5, bei dem der Steg sich in einer Ebene erstreckt, die generell diejenige der konvergenten Anlageflächen unterteilt, und wobei die erste konkave konvergente Anlagefläche gradueller auf die Ebene des Stegs zuläuft als die zweite konvexe konvergente Anlagefläche. 15
7. Instrument nach einem der vorangehenden Ansprüche, bei dem das operative Element weiterhin ein Klemmelement umfasst, das kontrollierbar drehbar in Eingriff mit dem Steg und daraus heraus bewegbar ist. 20
8. Instrument nach Anspruch 7, bei dem das Klemmelement oder seine Kontaktfläche entsprechend dem Steg gebogen ist. 25
9. Instrument nach einem der vorangehenden Ansprüche, das weiterhin ein Mittel umfasst, durch das das operative Element wählbar um eine Längsachse des Wellenleiters gedreht werden kann, um es so einem gewünschten Gewebeelement präsentiert werden zu können, an dem gearbeitet werden soll. 30
10. Instrument nach Anspruch 7, bei dem das Klemmelement eine Krümmung entsprechend derjenigen des Stegs aufweist, wobei das Klemmelement so betätigbar ist, dass es nach unten in Kontakt mit einer oberen Fläche des Stegs gebracht werden kann, um zu schneidendes und koagulierendes Gewebe dazwischen einzuklemmen. 35

Revendications

1. Instrument chirurgical à ultrasons comprenant des moyens de guide d'ondes allongés (1), une source de vibrations ultrasonores, raccordée ou pouvant être raccordée de manière opérationnelle à une extrémité proximale desdits moyens de guide d'ondes, un élément opérationnel adjacent à une extrémité distale généralement cylindrique desdits moyens de guide d'ondes et comprenant des moyens de crête (2) s'étendant de manière radiale définis entre une paire sensiblement parallèle de moyens de rainure (4) s'étendant longitudinalement par rapport aux moyens de guide d'ondes à partir de leur extrémité distale, **caractérisé en ce que** ledit élément opérationnel est incurvé dans un plan transversal par rapport à celui des moyens de crête et dans lequel la source de vibrations ultrasonores comporte une source de vibrations ultrasonores à mode torsionnel. 40
2. Instrument selon la revendication 1, dans lequel l'élément opérationnel est incurvé dans un plan sensiblement perpendiculaire à celui des moyens de crête. 45
3. Instrument selon la revendication 1 ou la revendication 2, dans lequel l'élément opérationnel est progressivement rétréci vers son extrémité distale.
4. Instrument selon l'une quelconque des revendications précédentes, dans lequel l'élément opérationnel a une pointe distale sensiblement émoussée.
5. Instrument selon l'une quelconque des revendications précédentes, dans lequel l'élément opérationnel comprend deux faces convergentes s'étendant de manière transversale par rapport au plan de courbure de l'élément opérationnel, de préférence avec une première desdites faces convergentes incurvée de manière concave et une deuxième desdites faces convergente incurvée de manière convexe.
6. Instrument selon la revendication 5, dans lequel les moyens de crête s'étendent dans un plan coupant généralement en deux ceux des faces convergentes et la première face convergente concave converge vers le plan des moyens de crête plus progressivement que ne le fait la deuxième face convergente convexe.
7. Instrument selon l'une quelconque des revendications précédentes, dans lequel l'élément opérationnel comprend également un élément de mâchoire qui peut être déplacé de manière contrôlée en le pivotant en prise et hors de prise avec les moyens de crête.
8. Instrument selon la revendication 7, dans lequel l'élément de mâchoire ou sa surface de contact est incurvé(e) de manière correspondante aux moyens de crête.
9. Instrument selon l'une quelconque des revendications précédentes, dans lequel la source de vibrations ultrasonores comprend une source de vibrations ultrasonores à mode torsionnel. 50

10. Instrument selon la revendication 7, dans lequel l'élément de mâchoire présente une courbure correspondant à celle des moyens de crête, l'élément de mâchoire pouvant être manoeuvré afin de l'amener en contact avec une surface supérieure des moyens de crête et de saisir entre eux du tissu à découper et coaguler.

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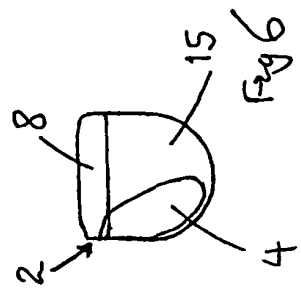
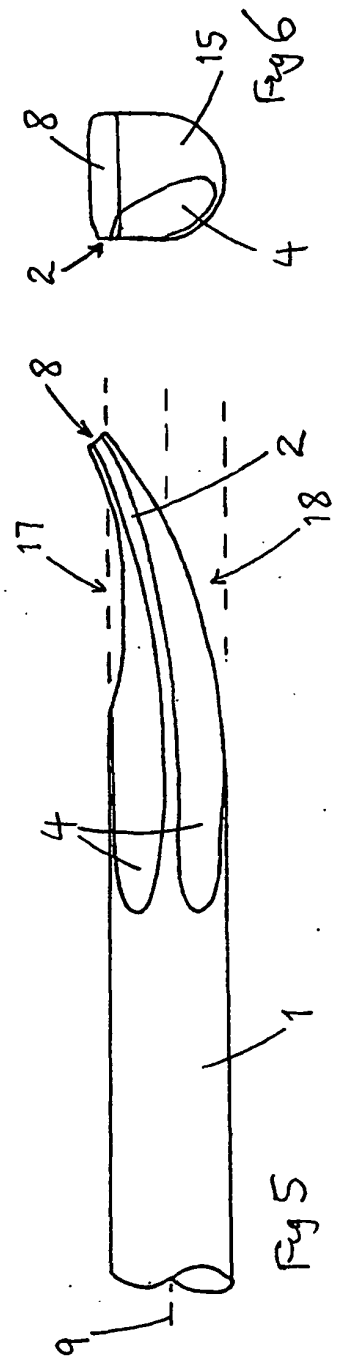
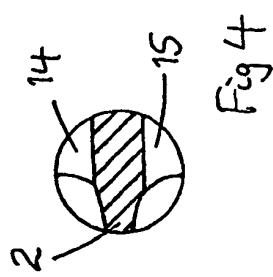
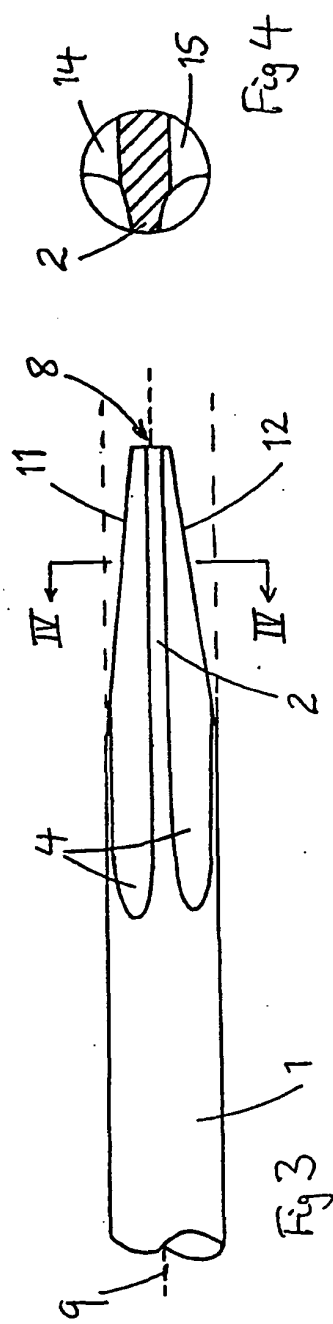
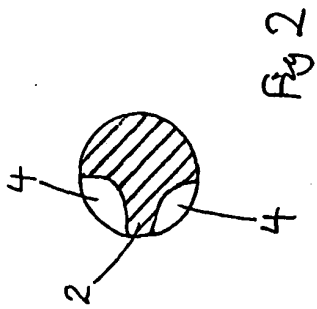
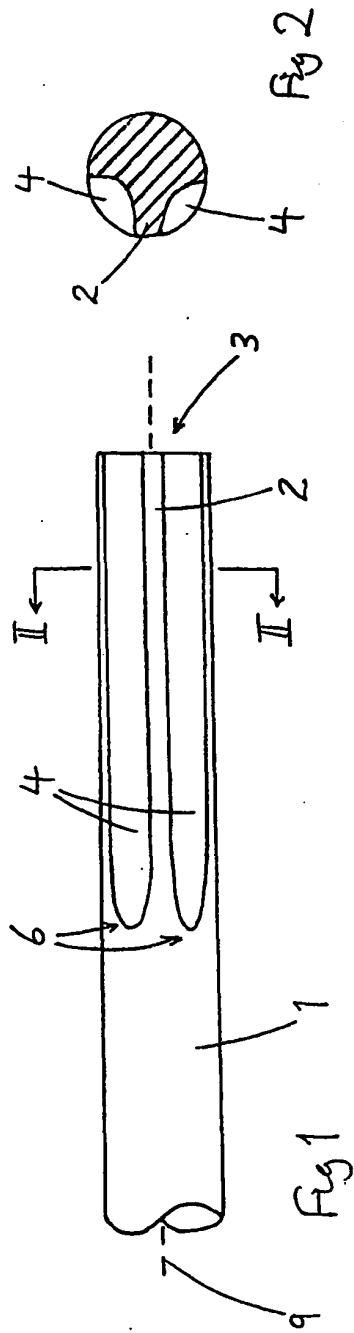
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REFERENCES CITED IN THE DESCRIPTION

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- GB 0500937 A [0034]

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摘要(译)

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