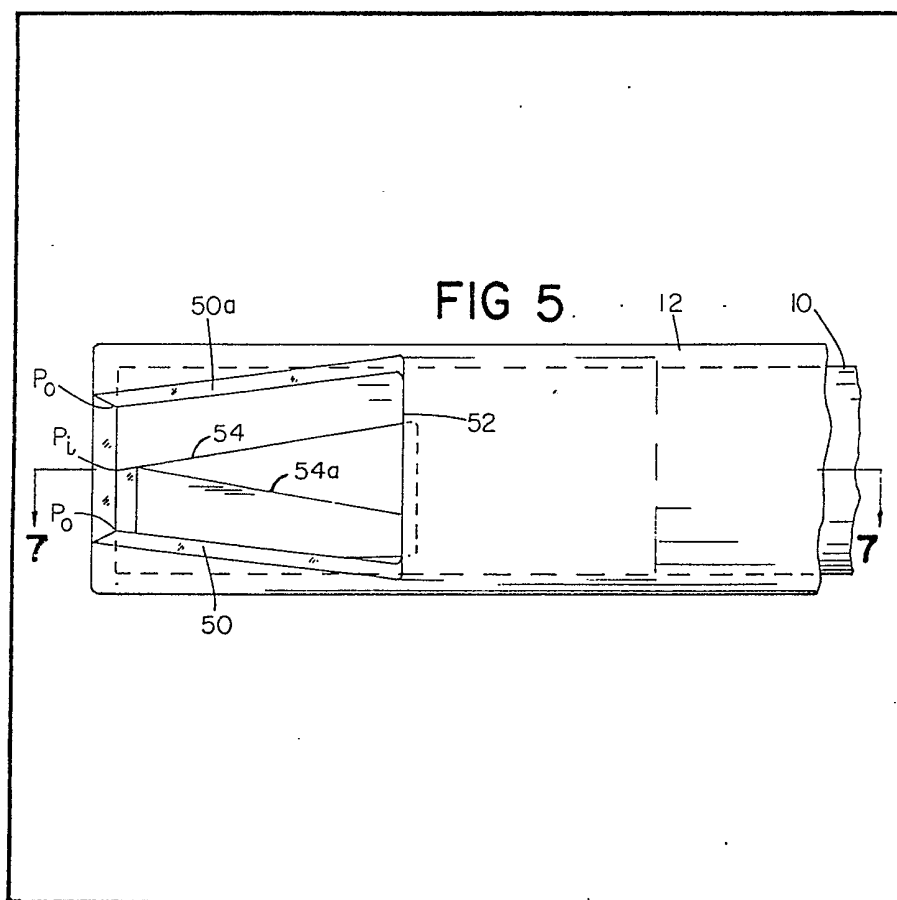


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GB 2007098A
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(71) Applicant
Dyonics Inc.,
70 Pine Street, Woburn,
State of Massachusetts
01801, United States of
America
(72) Inventors
Lanny L. Johnson,
Leonard Joseph Bonnel
(74) Agent
Boult, Wade & Tennant

(54) Surgical Cutting Device

(57) A surgical instrument for remote cutting comprises coaxial inner and outer tubes 10, 12 the inner tube 10 being rotatably driven whilst the outer tube 12 is stationery, wherein inner and outer tubes 10, 12 have windows in their side walls at their distal ends

providing diverging cutting edges 50, 50a, and 54, 54a such that on each rotation commence cutting at the extreme distal end and such that on further rotation the point of cutting action moves proximally, the distal ends of the inner and outer tubes being open at least at portions which correspond to the windows in the side walls.



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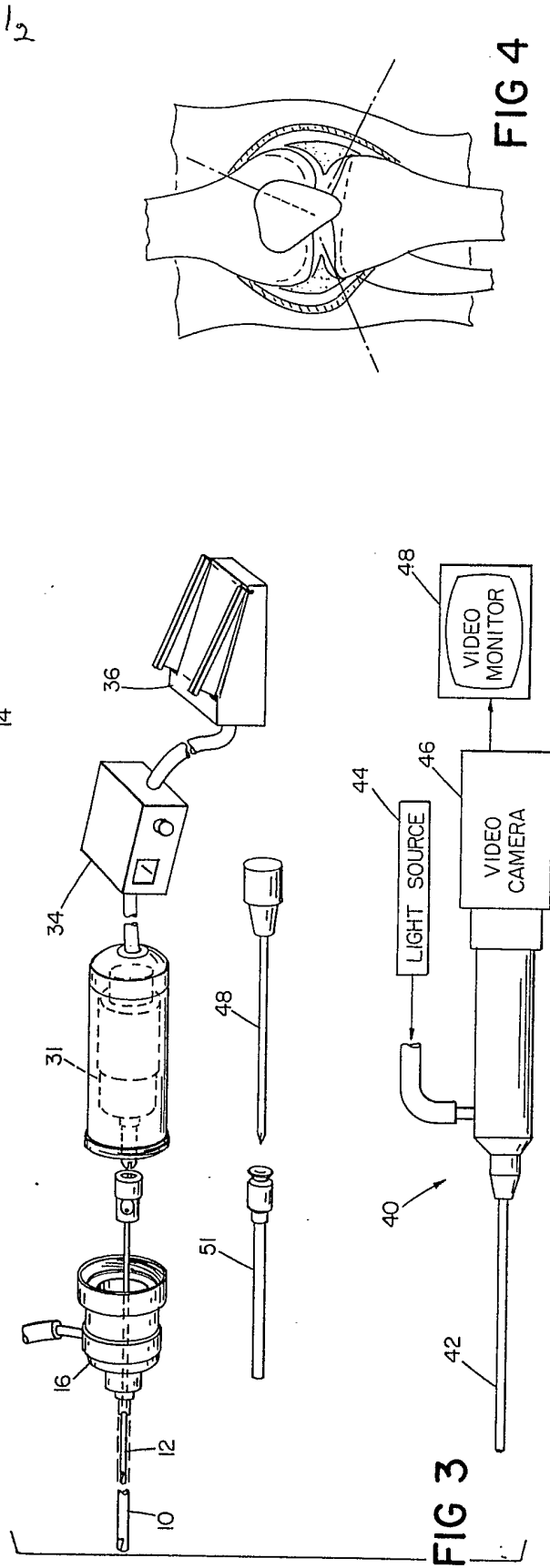
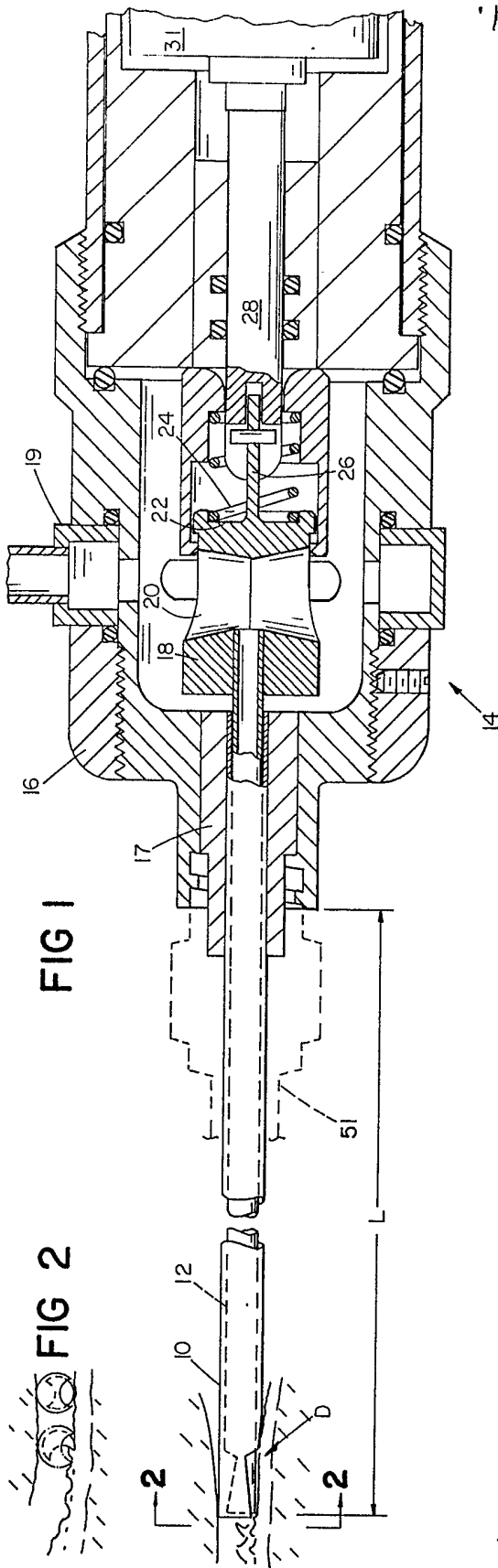


FIG 6

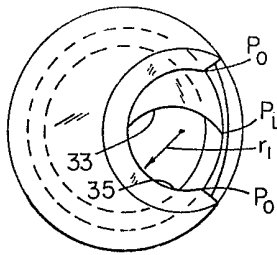


FIG 5

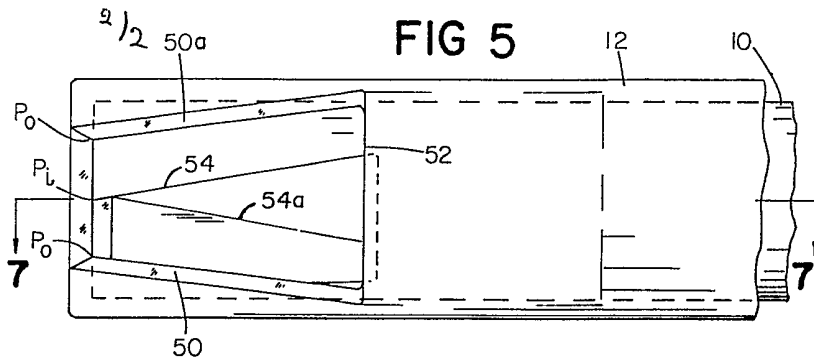


FIG 8

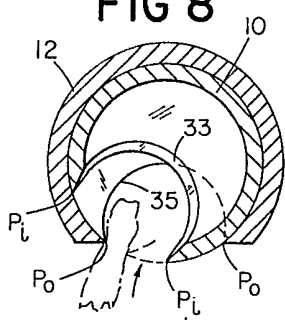


FIG 7

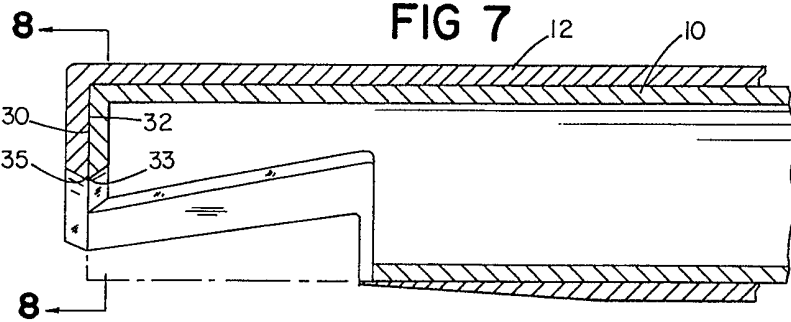


FIG 9

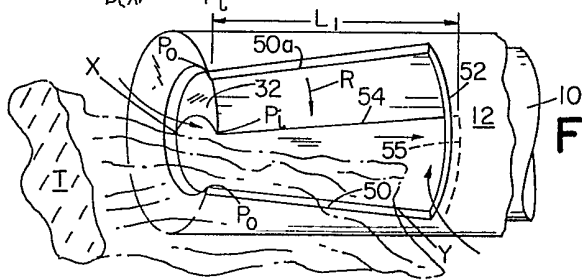


FIG 9a

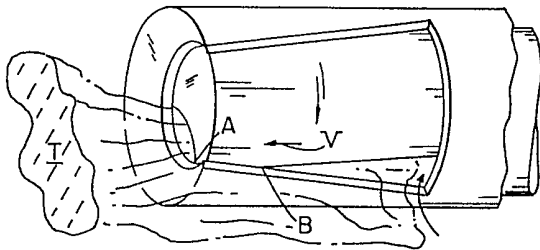


FIG 9b

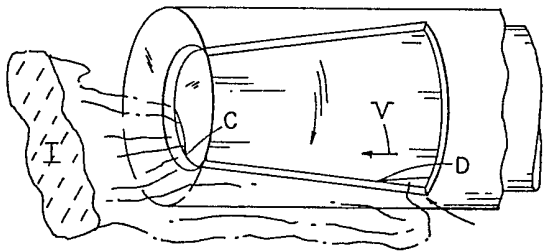


FIG 9c

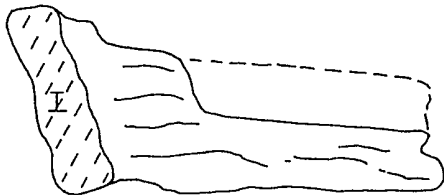
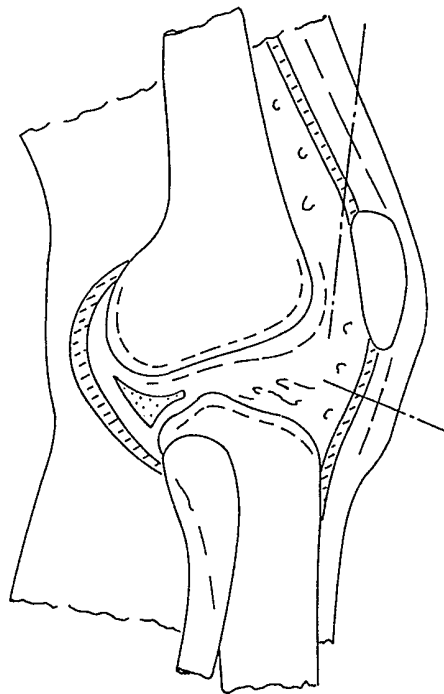


FIG 4a



SPECIFICATION

Surgical Instrument

This invention concerns an improved surgical instrument of the remote cutting type, in which an inner tubular member having a cutting edge rotates within an outer tubular member with a coacting edge, while vacuum or suction is applied, through the instrument, to the cutting site.

Instruments of this type have been proposed for surgery in sites of the body that are difficult to make accessible. However, these instruments appear to have serious deficiencies preventing their use on rubbery and tough substances such as cartilage, hence many important surgical procedures have not been possible. Prior efforts in the field are represented, in the patent literature by U.S. Patents Nos. 2,369,925; 3,618,611; 3,732,858 and 3,844,272 and in commerce by the intra-articular shaver sold by Dyonics, Inc., corresponding to copending U.S. application Serial No. 848,982 by Bonnell, et al.

The present invention provides a surgical instrument of the type comprising coaxial inner and outer tubes, having coacting cutting edges in a distal region, the inner tube being rotatably driven while the outer tube is stationary, and means to maintain fluid, flow from the cutting region through the instrument, wherein a limited segment of the side of each tube is open, said opening extending to the distal end of said tube, and at least the portion of the end of each tube that corresponds with the respective opening in the side of the tube being open, whereby at a first position of rotation of the inner tube, body tissue can protrude through the volume of the inner tube, portions of said tubes bounding said side openings cooperatively defining an initial tissue-penetrating point where portions of the tubes first come together during rotation of said inner tube, said point located at the distal extremity of the sides of the tubes, and cutting edges extend from said initial tissue-penetrating point longitudinally along the sides of the tubes, whereby following initiation of gripping and cutting at said point located inwardly on the tissue from an exposed edge of the tissue, cutting can proceed proximally.

The invention features an initial cutting point at which cutting portions of the tubes first come together during a cutting cycle, this point defined at the distal extremity of the side of the tubes, and there being cutting edges that extend from this initial point longitudinally along the sides of the tubes, whereby following initiation of gripping and cutting at a point spaced inwardly on the tissue from the exposed tissue edge, cutting can proceed proximally. In an instrument capable of severing discrete pieces of cartilage, cutting edges also extend transversely across the ends of the tubes and cutting proceeds from the initial point in two angular directions towards the exposed edges of the tissue to complete the cut.

Preferred embodiments feature instruments wherein, viewed from the end of the tubes: the

initial point of cutting is defined by oppositely directed, pointed portions of the ends of the tubes; the initial cutting point defined by cusp-shaped portions; and with ends of the tubes having substantially flat end closures set substantially at a right angle to the axes of the tubes, the mating cutting edges in the ends of the tubes are of the form of substantially circular arcs having centers that are eccentric relative to the axes of the tubes. Preferred embodiments also feature instruments wherein, viewed from the side of the tubes: the initial point of cutting is defined by the intersection of elongated edges on the respective tubes, these edges set at a diverging angle to each other in the direction away from the distal end; and each cutting edge along the side of a tube extending in a plane angled to the plane which projects through the axis of the tube and through the respective initial cutting point. Also in preferred embodiments the instrument defines two initial cutting points corresponding to respectively opposite directions of rotation; at the end of the tubes both of the initial points of cutting are defined by cusp-shaped portions, preferably the cutting edges of the ends of the tubes corresponding to circular arcs; and preferably when viewed from the side, each tube defines a pair of elongated cutting edges which diverge from each other longitudinally in the direction away from their respective cutting points; preferably each such pair of cutting edges is joined by a transversely extending proximal edge.

Partial or total minisectomies (removal of the meniscal cartilage from the knee) are performed by an appropriately sized instrument inserted into the joint space by a needle-like puncture incision. Discrete pieces of the meniscal cartilage are severed by rotation of the inner tube at speeds of the order of 200 rpm or below and the discrete pieces are transported away in succession through the inner tube under the influence of vacuum.

The invention will be illustrated by the following description of a preferred embodiment with reference to the accompanying drawings, in which:—

Figure 1 is a longitudinal, cross-sectional view of the preferred embodiment;

Figure 2 is an end view taken on line 2—2 of the preferred embodiment;

Figure 3 is an exploded view of the instrument of Figure 1 on a reduced scale along with other instruments used in a surgical procedure;

Figure 4 is a plan view partially in cross-section of the knee joint of a human with broken lines indicating directions of access for the instrument;

Figure 4a is a side view of the knee of Figure 4;

Figure 5 is a side view of the distal end of the instrument of Figure 1 on an enlarged scale;

Figure 6 is an end view of Figure 5;

Figure 7 is a longitudinal, cross-sectional view taken on line 7—7 of Figure 5;

Figure 8 is a transverse, cross-sectional view taken on line 8—8 of Figure 7; and

Figures 9, 9a, 9b and 9c are perspective views, partially diagrammatical, illustrating the cutting action of the instrument.

Referring to Fig. 1, inner and outer tubes 10 and 12 extend from their distal cutting region D, at the surgical site, over length L to handle/motor assembly 14. The outer tube 10 is fixed to outer body 16 by intermediate end member 17. The inner tube 12 extends beyond end 17 to attachment 18. This attachment has transverse evacuation passages 20, end abutment surface 22 engaged by spring 24, and a drive extension 26 which is engaged with the motor drive shaft 28. Spring 24 urges the inner tube 12 to the left so that distal end surface 32 of the inner tube (Fig. 7) continually bears against the distal end surface 30 of the outer tube. This maintains a proper cutting relationship between end cutting edges 33, 35. Motor 31 in the housing propels drive shaft 28. The body 16 has a suction exit port 19 connected to a conventional suction line. Fluid and cut particles from the surgical site are thus drawn through the inner tube 12, passage 20 and exit port 19. A battery 34 (Fig. 3) is remote from the motor and foot switch. This power pack is activated by foot pedal 36 in the conventional way.

The cutting instrument is used with illuminating/viewing instrument 40 (Fig. 3) comprised of a probe 42 containing light conductive glass fibers and an image-transmitting endoscope lens system. Through the glass fibers light from a light source 44 is conducted to the surgical site and through lens system an image is conducted back from the site to video camera 46. The camera produces a continual view of the surgical site on video monitor 48 which the surgeon views while he manipulates the instruments to perform the desired surgery.

For surgery of the knee, for instance, the surgical instrument is introduced to the surgical site along the lines of access such as indicated in Figs. 4 and 4a while the illuminating/viewing instrument 40 is introduced along another line of access so that the end of the instrument can be viewed continually. Saline is introduced along another line to extend the joint cavity. Entry to the surgical site is achieved through tiny incisions made by a trocar 48 acting through a cannula 51. After the incision, with the cannula in place, the trocar is withdrawn and the respective instrument is inserted through the cannula (see Fig. 1). The instrument has the unique ability of removing cartilage such as the meniscal cartilage between bones of the knee, as is suggested by these views. In Figure 2, two end views of the instrument are shown. At the left the pointed cutting edges are shown coming together in tong-like action on a portion of tissue. At the right, rotation of the inner tube has caused the cut to be completed.

Referring to enlarged scale Figs. 5 through 9, the outer tube 10 and the inner tube 12 are closed by substantially planar end surfaces 30 and 32. Bearing of end surface 32 against end surface 30 is achieved by action of the spring 24

(Fig. 1) to ensure proper relation of the end cutting edges. Close-fitting of the tubes similarly assures proper relation of the side cutting edges. To define these cutting edges both tubes have end and side openings. The details of openings, initial cutting point and cutting edges will now be described.

Initial Cutting Point and Cutting Edges

Although the embodiment shown is for cutting in both directions of rotation, description will first be given for direction of rotation R of Figs. 9—9a. Referring to Fig. 9, fixed outer tube 12 defines a fixed distally-extreme cutting point P_o , formed by cut away of the side wall of the tube. An elongated cutting edge 50 bordering the opening is defined by the wall of the tube. It extends longitudinally from point P_o in a plane set at a downward angle to a plane projected through point P_o and the axis of the tube. Edge 50 extends distance L, and terminates at transverse edge 52, which also borders the opening and is formed by the wall of the tube.

The end plate of the outer tube, which defines the end bearing surface 30, is cut away to define the end cutting edge 35. The cut is of circular form, commencing at point P_o and of radius substantially less than the radius of the outer tube so that the opening is eccentric to the axis of the tube.

The inner tube 10 has a corresponding shape. From the distally extreme point P_i , an elongated cutting edge 54 borders the opening in, and is defined by the wall of the inner tube 10. It lies in an upwardly angled plane relative to a plane projected through point P_i and the axis of the tube. Edge 54 also extends for length L, and beyond, terminating in a transverse edge 55, formed in the wall of inner tube 10, beyond the transverse edge of the outer tube.

Thus the inner and outer side-cutting edges are set at an angle to each other. When points P_o and P_i coincide, the edges diverge in the proximal direction.

Referring to Fig. 5 is still be seen that the side of the outer tube is constructed symmetrically about a plane through the tube axis. Thus edge 50_a extends from upper point P_o at an angle, diverging with respect to edge 50, until it terminates at transverse edge 52, so that the width of the opening in the side of the tube increases in the proximal direction.

The side of the inner tube is identically constructed with an edge (not shown) diverging in the proximal direction from edge 54 until it terminates at the proximal transverse edge 55.

The ends of the inner and outer tubes are each characterized by the arcuate cutting edge extending from one peripheral point to the other, thus defining a crescent-shaped cutting edge terminating at two cusp-shaped points at the periphery.

In a typical instrument useful for removing the meniscal cartilage of the knee, the outer diameter of the inner tube 10 and the matching inner

diameter of the outer tube 12 is approximately .135 inch with slight running clearance, the wall thicknesses is approximately .010 inch, and the tubes are made of stainless steel. The outer tube length, L , is approximately 4 inches. The length, L_1 , of the side cutting edge 50 of the outer tube 12, is approximately 1/4 inch, the length of the edge 54 of the inner tube is 5/16 inch, the radius of the end cutting edge 35 is approximately .040 inch, and the radius of end cutting edge 33 is approximately .035 inch. The space between the opposed points P_o and P_i is approximately .025 inch. The motor is adapted to rotate the inner tube at speeds of the order of 200 rpm or below. This speed can be made to depend upon the cutting load, and may be in the 60 to 90 rpm range when the instrument is severing the maximum size fragments of cartilage.

Operation

In Fig. 9 the distal end of the instrument has been positioned to cut tissue T. The instrument is shown with the edge of the tissue extending through the instrument from point X to point Y, with the distally extreme fixed point P_o of the outer tube engaging the tissue spaced from the tissue edge. In Fig. 9 the point P_i of the inner tube is shown closing toward point P_o of the outer tube in a motion similar to that of a grasping forceps.

As the motion proceeds these points first firmly grasp the middle of the tissue and then progressively cut it. In Fig. 9b P_i has passed P_o in an initial scissors-like severing of the tissue, this cutting action proceeding to radiate in two directions from this initial point. In Fig. 9a the instantaneous point of scissors-like cutting occurs at end and side points A and B and, in later Fig. 9b, at end and side points C and D. With slightly more rotation the cut is complete, and if the instrument is withdrawn, as depicted in Fig. 9c, the portion indicated is seen to have been cut away.

The location of the initial cutting point in the distal extremity of the side of the tube provides a number of advantages that make cutting of rubber-like cartilage possible. The tongs or forceps-like initial contact captures the tissue and prevents it from being forced away from the instrument. The two-way angled cutting that then proceeds provides a balanced action, which is found simultaneously to avoid problems of stalling, ensures decisive severing, and prevents undue deflections.

From the beginning of the cut the reaction force from the side cut, e.g. at points B and D, acts on the inner tube in the distal direction of vector v , tending to urge the inner tube to bear against the end of the outer tube. This effect tends to overcome a reaction force in the opposite direction applied at end points A and C on the inner tube.

Rotation in opposite direction by reversal of the motor direction as by the foot switch, produces the same cutting action, by the opposite points and cutting edges of the instrument.

65 Claims

1. A surgical instrument of the type comprising coaxial inner and outer tubes, having coacting cutting edges in a distal region, the inner tube being rotatably driven while the outer tube is stationary, and means to maintain fluid flow from the cutting region through the instrument, wherein

a limited segment of the side of each tube is open, said opening extending to the distal end of said tube,

and at least the portion of the end of each tube that corresponds with the respective opening in the side of the tube being open,

whereby at a first position of rotation of the inner tube, body tissue can protrude through the volume of the inner tube,

portions of said tubes bounding said side openings cooperatively defining an initial tissue-penetrating point where portions of the tubes first come together during rotation of said inner tube, said point located at the distal extremity of the sides of the tubes,

and cutting edges extend from said initial tissue-penetrating point longitudinally along the sides of the tubes,

whereby following initiation of gripping and cutting at said point located inwardly on the tissue from an exposed edge of the tissue, cutting can proceed proximally.

2. The instrument according to claim 1 characterized in that

a limited segment only of the distal end of each tube is open,

said openings corresponding to the segments of the sides of the tubes that are open,

and cutting edges extend from said initial tissue-penetrating point, both transversely across the ends and longitudinally along the side of each tube,

whereby following initiation of gripping and cutting at said point located inwardly on the tissue from an exposed edge of the tissue, cutting can proceed in two directions at substantial angles to one another toward the exposed edge of the tissue to complete the cut.

3. The surgical instrument of claim 1 or 2 wherein viewed from the side of the tubes, the initial tissue-penetrating point at the distal extremity of the side of the tubes is characterized by the intersection of elongated edges on the respective tubes, said edges set at an angle diverging from each other in the direction away from the distal end.

4. The surgical instrument of claim 3 characterized in that a cutting edge along the side of a tube extends in a plane angled to the plane which projects through the axis of the tube and through the respective initial tissue-penetrating point.

5. The surgical instrument of any of the preceding claims characterized in that said tubes cooperatively define two of said initial tissue-penetrating points corresponding to respectively opposite directions of rotation, both of said points

located at the distal extremity of the sides of the tubes.

6. The surgical instrument of claim 3, 4, or 5 wherein each tube viewed from the side is characterized by defining a pair of elongated cutting edges which diverge from each other longitudinally in the direction away from their respective initial tissue-penetrating points.

7. The surgical instrument of claim 6 characterized in that the proximal regions of said pair of elongated cutting edges of a tube are joined by a transversely extending proximal edge, said cutting edges and said proximal edge bounding an opening in the side of the tube.

8. The instrument of any of the foregoing claims wherein, viewed from the end of the tubes, the initial tissue-penetrating point is characterized by oppositely directed, pointed portions of the end of the tubes.

9. The instrument of any of the foregoing claims characterized in that said initial tissue-penetrating point is defined by pointed portions of said tubes that are cusp-shaped.

10. The surgical instrument of claim 9 characterized in that the instrument defines two of said initial tissue-penetrating points, corresponding to respectively opposite directions of rotation, and wherein, viewed from the end of the tubes, both of said initial tissue-penetrating points are defined by cusp-shaped portions.

11. The surgical instrument of any of the foregoing claims characterized in that at their ends the tubes have substantially flat end closures set substantially at a right angle to the axes of the tubes and the mating cutting edges in the ends of said tubes are defined by said flat ends closures.

12. The instrument of any of the foregoing claims 2—11 having mating cutting edges in the ends of said tubes, characterized in that said mating cutting edges are in the form of substantially circular arcs having centers that are eccentric relative to the axes of the tubes.

13. A surgical instrument substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.