Titre : EMBOUT ET APPAREIL DE PHACOEMULSIFICATION ET METHODE D'UTILISATION CONNEXE
Title: PHACOEMULSIFICATION TIP, APPARATUS AND METHOD FOR USING SAME

Abrégé/Abstract:
An apparatus comprising: a phacoemulsification handpiece having a tip, the tip having a tubular shaft, the shaft having a distal end; and one of (i) means for torsionally and ultrasonically vibrating the tip; (ii) means for ultrasonically vibrating the tip to produce a twisting motion in the shaft; or (iii) means for ultrasonically vibrating the tip to produce a whipping motion in the distal end of the shaft. The shaft can, for example, either be: angled or bent on an angle relative to a centerline of the shaft or curved relative to a longitudinal centerline along the entire length of the shaft. Various methods of using the apparatus include the steps of inserting the tip of the phacoemulsification handpiece into an eye having a lens; and (i) torsionally and ultrasonically vibrating the tip to liquefy or emulsify the lens; (ii) ultrasonically vibrating the tip to produce a twisting motion in the shaft to liquefy or emulsify the lens; or (iii) ultrasonically vibrating the tip to produce a whipping motion in the distal end of the shaft to liquefy or emulsify the lens.
Abstract of the Disclosure

An apparatus comprising: a phacoemulsification handpiece having a tip, the tip having a tubular shaft, the shaft having a distal end; and one of (i) means for torsionally and ultrasonically vibrating the tip; (ii) means for ultrasonically vibrating the tip to produce a twisting motion in the shaft; or (iii) means for ultrasonically vibrating the tip to produce a whipping motion in the distal end of the shaft. The shaft can, for example, either be: angled or bent on an angle relative to a centerline of the shaft or curved relative to a longitudinal centerline along the entire length of the shaft. Various methods of using the apparatus include the steps of: inserting the tip of the phacoemulsification handpiece into an eye having a lens; and (i) torsionally and ultrasonically vibrating the tip to liquefy or emulsify the lens; (ii) ultrasonically vibrating the tip to produce a twisting motion in the shaft to liquefy or emulsify the lens; or (iii) ultrasonically vibrating the tip to produce a whipping motion in the distal end of the shaft to liquefy or emulsify the lens.
PHACOEMULSIFICATION TIP, APPARATUS AND METHOD FOR USING SAME

Field of the Invention

This invention relates generally to the field of phacoemulsification and more particularly to torsional phacoemulsification cutting tips; and apparatus and methods for using cutting tips.

Background of the Invention

The human eye in its simplest terms functions to provide vision by transmitting light through a clear outer portion called the cornea, and focusing the image by way of the lens onto the retina. The quality of the focused image depends on many factors including the size and shape of the eye, and the transparency of the cornea and lens.

When age or disease causes the lens to become less transparent, vision deteriorates because of the diminished light which can be transmitted to the retina. This deficiency in the lens of the eye is medically known as a cataract. An accepted treatment for this condition is surgical removal of the lens and replacement of the lens function by an IOL.

In the United States, the majority of cataractous lenses are removed by a surgical technique called phacoemulsification. During this procedure, a thin phacoemulsification cutting tip is inserted into the diseased lens and vibrated ultrasonically. The vibrating cutting tip liquifies or emulsifies the lens so that the lens may be aspirated out of the eye. The diseased lens, once removed, is replaced by an artificial lens.

A typical ultrasonic surgical device suitable for ophthalmic procedures consists of an ultrasonically driven handpiece, an attached cutting tip, and irrigating sleeve and an electronic control console. The handpiece assembly is attached to the control console by an electric cable and flexible tubings. Through the electric cable, the console varies the power level transmitted by the handpiece to the attached cutting tip and the flexible tubings supply irrigation fluid to and draw aspiration fluid from the eye through the handpiece assembly.

The operative part of the handpiece is a centrally located, hollow resonating bar or horn directly attached to a set of piezoelectric crystals. The crystals supply the required
ultrasonic vibration needed to drive both the horn and the attached cutting tip during phacoemulsification and are controlled by the console. The crystal/horn assembly is suspended within the hollow body or shell of the handpiece by flexible mountings. The handpiece body terminates in a reduced diameter portion or nosecone at the body's distal end. The nosecone is externally threaded to accept the irrigation sleeve. Likewise, the horn bore is internally threaded at its distal end to receive the external threads of the cutting tip. The irrigation sleeve also has an internally threaded bore that is screwed onto the external threads of the nosecone. The cutting tip is adjusted so that the tip projects only a predetermined amount past the open end of the irrigating sleeve. Ultrasonic handpieces and cutting tips are more fully described in U.S. Pat. Nos. 3,589,363; 4,223,676; 4,246,902; 4,493,694; 4,515,583; 4,589,415; 4,609,368; 4,869,715; 4,922,902; 4,989,583; 5,154,694 and 5,359,996.

In use, the ends of the cutting tip and irrigating sleeve are inserted into a small incision of predetermined width in the cornea, sclera, or other location. The cutting tip is ultrasonically vibrated along its longitudinal axis within the irrigating sleeve by the crystal-driven ultrasonic horn, thereby emulsifying the selected tissue in situ. The hollow bore of the cutting tip communicates with the bore in the horn that in turn communicates with the aspiration line from the handpiece to the console. A reduced pressure or vacuum source in the console draws or aspirates the emulsified tissue from the eye through the open end of the cutting tip, the cutting tip and horn bores and the aspiration line and into a collection device. The aspiration of emulsified tissue is aided by a saline flushing solution or irrigant that is injected into the surgical site through the small annular gap between the inside surface of the irrigating sleeve and the cutting tip.

One phacoemulsification tip that has gained widespread acceptance has a belled or flared distal end. Such a tip is described in U.S. Patent No. 4,816,018 (Parisi). Such a design allows for larger lens material purchase as well as increased holding force when vacuum is applied to the tip while maintaining a smaller bore in the shaft of the tip. This combination of features increases anterior chamber stability, by reducing sudden outflow from the anterior chamber when the distal end becomes occluded and this occlusion breaks.

Another phacoemulsification tip is an angled or “bent” tip with or without a flared distal end. These tips are described in U.S. Patent No. 6,039,715 (Mackool), U.S. Patent
No. 5,653,724 (Imonti) and U.S. Patent No. 5,154,694 (Kelman). These tips have a predominantly straight shaft with the far distal portion of the shaft being bent on an angle. Bent tips are used by a great many surgeons, and are particularly useful when used in conjunction with a oscillatory phacoemulsification handpiece, such as those described in U.S. Patent No. 6,352,519 (Anis, et al.) and U.S. Patent No. 6,602,193 (Chon) and commercially available as the NeoSoniX® handpiece from Alcon Laboratories, Inc., Fort Worth, Texas, however; when used with these handpieces, bent tips still required some longitudinal movement in addition to oscillatory movement.

**Brief Summary of the Invention**

Certain exemplary embodiments can provide an apparatus comprising: (a) a phacoemulsification handpiece having a tip, the tip having a tubular shaft, the shaft having a distal end; and (b) means for torsionally and ultrasonically vibrating the tip.

Certain exemplary embodiments can provide an apparatus comprising: (a) a phacoemulsification handpiece having a tip, the tip having a tubular shaft, the shaft having a distal end; and (b) means for ultrasonically vibrating the tip to produce a twisting motion in the shaft.

Certain exemplary embodiments can provide an apparatus comprising: (a) a phacoemulsification handpiece having a tip, the tip having a tubular shaft, the shaft having a distal end; and (b) means for ultrasonically vibrating the tip to produce a whipping motion in the distal end of the shaft.

Certain exemplary embodiments can provide a phacoemulsification tip, comprising: a tubular shaft, the shaft being curved relative to a longitudinal centerline line along the entire length of the shaft.

Certain exemplary embodiments can provide a method, comprising: (a) inserting a phacoemulsification handpiece having a tip into an eye, the tip having a tubular shaft, the shaft having a distal end; and (b) torsionally and ultrasonically vibrating the tip.

Certain exemplary embodiments can provide a method, comprising: (a) inserting a phacoemulsification handpiece having a tip into an eye, the tip having a tubular shaft, the shaft having a distal end; and (b) ultrasonically vibrating the tip to produce a twisting motion in the shaft.
Certain exemplary embodiments can provide a method, comprising: (a) inserting a phacoemulsification handpiece having a tip into an eye, the tip having a tubular shaft, the shaft having a distal end; and (b) ultrasonically vibrating the tip to produce a whipping motion in the distal end of the shaft.

Embodiments provide a surgical method using a bent phacoemulsification tip and vibrating the tip torsionally so as to produce a whipping motion in the distal end of the tip.

Embodiments provide a method of vibrating a phacoemulsification cutting tip with increased efficiency, particularly during torsional ultrasound movement.

Embodiments provide a method of vibrating a phacoemulsification cutting tip having a bent tip.

**Brief Description of the Drawings**

FIG. 1 is a perspective view of a handpiece and control console that may be used with the various embodiments of the present invention.

FIG. 2 is a perspective view of the distal end of a typical prior art straight shaft phacoemulsification tip.

FIG. 3 is an elevational view the distal end of an angled or bent phacoemulsification tip.

FIG. 4 is an elevational view the distal end of a phacoemulsification tip according to an embodiment of the present invention.

**Detailed Description of the Invention**

As best seen in FIG. 1, a surgical console 320 suitable for use with various embodiments may be any commercially available surgical control console such as the INFINITI® surgical systems available from Alcon Laboratories, Inc., Fort Worth, Texas. Console 320 is connected to a handpiece 9 through an irrigation line 322 and an aspiration line 324. The flow through the lines 322 and 324 is controlled by a user, for example, via a footswitch 326. Power is supplied to the handpiece 9 through an electrical cable 400 to enable torsional and/or ultrasonic vibration of a phacoemulsification tip 110.

An example prior art phacoemulsification tip 10 having a shaft 12 that is straight all the way to a distal tip 14 is shown in FIG. 2. The phacoemulsification tip 110 that may
be used in the various embodiments of the present invention is shown in FIG. 3. The tip 110 contains a shaft 112 that is straight up to a distal end 113. The distal end 113 is angled or bent on an angle relative to a centerline 115 of the shaft 112 from an intersection 117 of the shaft 112 and the distal end 113 all the way to a distal tip 114.

The inventors have surprisingly discovered that torsional ultrasonic vibration of the tip 110 causes a twisting of shaft 112 that is not present if tip 110 is rotarily oscillated. Such twisting causes the distal tip 114 to assume a whipping motion, which although less that the rotary motion generated in the distal tip 114 when tip 110 is rotarily oscillated, the whipping motion greatly increases the cutting efficiency of the tip 110. In particular, the tip 110 (after being inserted into the handpiece 9) is inserted an eye and is either (i) torsionally and ultrasonically vibrated; (ii) ultrasonically vibrated (to produce a twisting motion in the shaft 112); and (iii) ultrasonically vibrated (to produce a whipping motion in the distal end 114 of the tip 112).

Another example of a phacoemulsification tip 210 according to an embodiment of the present invention that can be used in the apparatus and method implementations described above is shown in FIG. 4. The tip 210 includes a shaft 212 that is not straight but instead is bent on a slight arch along the entire length of the shaft 112. So constructed, lateral displacement $L_2$ of distal tip 214 from a reference line 215 is less than lateral displacement $L_1$ of the distal tip 214 from the centerline 115. Such a construction makes it easier for the surgeon to locate the distal tip 214 and maintain a more comfortable distance from the posterior capsule during use, but still benefits from the increase cutting efficiency discussed above.

The cutting tips 110 and 210 can be made from stainless steel or titanium, but other materials may also be used. The cutting tips 110 and 210 can have an overall length of between 0.50 inches and 1.50 inches, with 1.20 inches being one particular example. The cutting tips 110 and 210 may be formed using conventional metalworking technology and can be electropolished to remove any burrs.

The shafts 112 and 212 are generally tubular, with an outside diameter of between 0.005 inches and 0.100 inches and an inside diameter of between 0.001 inches and 0.090 inches. The distal ends 114 and 214 of the shafts 112 and 212, respectively, may be cut square or cut at any suitable angle between $0^\circ$ and $90^\circ$. 
In summary, and in one example, the inventors have discovered that angled phacoemulsification tips can be advantageous used in combination with torsional ultrasound handpieces. An example of a torsional ultrasound handpieces is more fully disclosed in U.S. Patent No. 6,077,285 (Boukhny).

This description is given for purposes of illustration and explanation. It will be apparent to those skilled in the relevant art that changes and modifications may be made to the invention described above without departing from its scope or spirit.
Claims:

1. An apparatus comprising:
   (a) a phacoemulsification handpiece having a tip, the tip having a tubular shaft, the shaft having a distal end; and
   (b) means for torsionally and ultrasonically vibrating the tip.

2. An apparatus comprising:
   (a) a phacoemulsification handpiece having a tip, the tip having a tubular shaft, the shaft having a distal end; and
   (b) means for ultrasonically vibrating the tip to produce a twisting motion in the shaft.

3. An apparatus comprising:
   (a) a phacoemulsification handpiece having a tip, the tip having a tubular shaft, the shaft having a distal end; and
   (b) means for ultrasonically vibrating the tip to produce a whipping motion in the distal end of the shaft.

4. The apparatus of any one of claims 1 to 3, wherein the shaft is angled or bent on an angle relative to a centerline of the shaft.

5. The apparatus of any one of claims 1 to 3, wherein the shaft is curved relative to a longitudinal centerline along the entire length of the shaft.

6. A method of using the apparatus of claim 1, 4 or 5, comprising:
   inserting the tip of the phacoemulsification handpiece into an eye having a lens;
   and
torsionally and ultrasonically vibrating the tip to liquefy or emulsify the lens.
7. A method of using the apparatus of claim 2, 4 or 5, comprising:
inserting the tip of the phacoemulsification handpiece into an eye having a lens;
and
ultrasonically vibrating the tip to produce a twisting motion in the shaft to liquefy
or emulsify the lens.

8. A method of using the apparatus of claim 3, 4 or 5, comprising:
inserting the tip of the phacoemulsification handpiece into an eye having a lens;
and
ultrasonically vibrating the tip to produce a whipping motion in the distal end of
the shaft to liquefy or emulsify the lens.

9. A phacoemulsification tip, comprising: a tubular shaft, the shaft being curved
relative to a longitudinal centerline line along the entire length of the shaft.

10. A method, comprising:
(a) inserting a phacoemulsification handpiece having a tip into an eye, the tip
having a tubular shaft, the shaft having a distal end; and
(b) torsionally and ultrasonically vibrating the tip.

11. A method, comprising:
(a) inserting a phacoemulsification handpiece having a tip into an eye, the tip
having a tubular shaft, the shaft having a distal end; and
(b) ultrasonically vibrating the tip to produce a twisting motion in the shaft.

12. A method, comprising:
(a) inserting a phacoemulsification handpiece having a tip into an eye, the tip
having a tubular shaft, the shaft having a distal end; and
(b) ultrasonically vibrating the tip to produce a whipping motion in the distal end
of the shaft.
FIG. 2
(Prior Art)

FIG. 3