

INTRAOCULAR LENS

Technical Field

[0001]

The present invention relates to an intraocular lens, and more particularly to a multi-purpose intraocular lens which is compatible with various types of surgical procedures such as in-the-bag, out-of-the-bag, sewing fixation and intra-scleral fixation.

Description of Related Art

[0002]

For example, when a lens becomes cloudy due to cataract, visual acuity recovery is attempted by a surgical procedure of inserting an artificial lens into an eye instead of the cloudy lens.

[0003]

The intraocular lens to be implanted in the eye by a cataract surgery is composed of an optical part (lens portion) having an optical lens function instead of a crystalline lens and a supporting part for supporting the optical part. Usually, this type of intraocular lens is housed inside of a capsular bag which remains after the lens is removed. In this case, a cataract surgery (in-the-bag) as shown in FIG. 1 is performed.

[0004]

Further, when a posterior capsule (the portion on the back side of the eyeball) in the lens capsule is broken, the lens capsule becomes fragile and fixation sometimes cannot be performed within the capsule by the supporting part. In such a case, a cataract surgery (out-of-the-bag) is

performed in such a way that the intraocular lens is set by fitting the supporting part into a hairy groove while placing it on the cornea side viewed from the capsular bag (FIG. 2).

[0005]

However, for example, when the capsule itself has already been removed or does not exist, the following surgical procedure is known: the supporting part is sewn and fixed to a predetermined part of the eye using a suture thread. Such sewing and fixing is mainly performed by the following procedure method, that is, ciliary sulcus sewing (FIG. 3), ciliary flatness sewing, and sewing to the sclera.

[0006]

Under such circumstances, in recent years attention has been focused on a technique called "scleral fixation" which is different from in-the-bag, out-of-the-bag and conventional suturing procedures (FIG. 4). The surgical procedure of the intra-scleral fixation is a technique of implanting a tip of the supporting part of the intraocular lens into the sclera.

[0007]

The content of the surgical procedure of the intra-scleral fixation is also described in [0004] to [0006] of Patent Document 1. For example, in [0004] of Patent Document 1, there is a description such that the tip of the supporting part of the intraocular lens is inserted into a tunnel-like hole part formed in a circumferential direction in the sclera so that the tip is fastened by the tunnel, to thereby support the intraocular lens without being sewn.

[0008]

By adopting the surgical procedure of the intra-scleral fixation, it is known that the intraocular lens is stably set (for example, decentering and inclination of the optical part can be suppressed) rather than adopting a conventional suturing procedure. Hereinafter, the decentering and the inclination of the optical part are collectively referred to as a "decentering inclination". In addition, suturing is not indispensable for the intra-scleral fixation, and a burden on a surgeon and a patient who undergoes surgery can be remarkably reduced.

[0009]

In [0006] of Patent Document 1, it has been pointed out as a problem that development of intraocular lenses (specialized) suitable for the intra-scleral fixation is inadequate by using conventional intraocular lenses.

Prior Art Document

Patent Document

[0010]

Patent Document 1: Japanese Patent Laid Open Publication No.2014-14646

Summary of the Invention

Problem to be solved by the Invention

[0011]

As described in Patent Document 1, currently, the development of an intraocular lens suitable for the intra-scleral fixation is inadequate. For example, the intraocular lens described in Patent Document 1 is capable of fixing an intraocular lens as long as the tip of the supporting part can be

inserted into the sclera, but the tip of the supporting part has a folded shape, and therefore it is difficult to pass through the tunnel formed in the sclera in the first place, and the burden on a surgeon may be increased in some cases.

[0012]

In addition to the description of Patent Document 1, inventors of the present invention perform a test (tensile test) on the assumption that the intra-scleral fixation is performed for various commercially available intraocular lenses, and a problem is identified in performing the intra-scleral fixation. As a result, it is found that decentering inclination of the optical part of the intraocular lens still exists as a big point to be improved when the intra-scleral fixation is performed. Then, the inventors of the present invention obtain a knowledge that it is necessary to create an intraocular lens specialized for suppressing the decentering inclination (intraocular lens specialized for the intra-scleral fixation) when performing the intra-scleral fixation.

[0013]

On the other hand, according to the investigation by the inventors of the present invention, it has been found that there is the following demand for an intraocular lens specialized for the intra-scleral fixation. Certainly, recently, attention is focused on the difficulty of occurrence of decentering inclination, and the surgical procedure of the intra-scleral fixation is spreading. Therefore, the intraocular lens specialized for the intra-scleral fixation is required, by further increasing an excellence of the intra-scleral fixation. However, as described above, it is often preferable to apply a surgical procedure other than the intra-scleral fixation, depending on a state

of the lens capsule of a patient. In such a case, it is impossible for the surgeon to possess only the intraocular lens specialized for the intra-scleral fixation as an inventory. Then, it is necessary to separately prepare an intraocular lens capable of responding to other surgical procedures in addition to the intraocular lens specialized for the intra-scleral fixation. In such a case, an inventory burden is increased for the surgeon, which lacks convenience. Namely, even in a case of the intraocular lens specialized for the intra-scleral fixation, it is revealed by the investigation of the present inventor that there is a hidden demand for the intraocular lens capable of responding to other surgical procedures.

[0014]

As a result thereof, the inventors of the present invention is forced to provide the intraocular lens having seemingly contradictory performances such as “a performance specialized for the intra-scleral fixation” and “a versatility for a wide variety of surgical procedures”.

[0015]

An object of the present invention is to provide an intraocular lens having versatility for a wide variety of surgical procedures in terms of a specialized performance of scleral fixation.

Means for solving the problem

[0016]

The inventors of the present invention investigate a method for solving the abovementioned problem, and further perform various tests as described above. In the various tests, various known intraocular lenses were tested. As a result, a configuration of the present invention

described below is adopted.

[0017]

According to a first aspect of the present invention, there is provided an intraocular lens, including:

- a soft optical part having a lens function;

- a wide soft supporting part stretching from the optical part and formed at a base end integrally with the optical part; and

- a hard supporting part connected to the soft supporting part at the base end and stretching in a stretching direction of the soft supporting part, wherein a tip portion of the hard supporting part is formed into a narrow shape with a maximum width of 0.3 mm or less.

According to a second aspect of the present invention, there is provided the intraocular lens of the first aspect, wherein the hard supporting part further includes a mid-width base end portion connected to the wide soft supporting part, and the base end portion and the narrow-shaped tip portion are connected to each other.

According to a third aspect, there is provided the intraocular lens of the first or second aspect, wherein the tip portion of the hard supporting part is formed into a narrow shape with a maximum width of 0.2 mm or less.

According to a fourth aspect of the present invention, there is provided the intraocular lens of any one of the first to third aspects, wherein the tip portion of the hard supporting part is warped toward the optical part.

According to a fifth aspect of the present invention, there is provided the intraocular lens of any one of the first to fourth aspects,

wherein a constriction is provided in the hard supporting part.

Advantage of the Invention

[0018]

According to the present invention, there is provided an intraocular lens having versatility for a wide variety of surgical procedures in terms of a specialized performance of scleral fixation.

Brief description of the drawings

[0019]

FIG. 1 is a schematic cross-sectional view showing an appearance of a cataract surgery (in-the-bag).

FIG. 2 is a schematic cross-sectional view showing an appearance of a cataract surgery (out-of-the-bag).

FIG. 3 is a schematic cross-sectional view showing an appearance of ciliary sulcus sewing.

FIG. 4 is a schematic view showing a manner of intra-scleral fixation.

FIG. 5 is a schematic view showing an intraocular lens according to an embodiment, wherein FIG. 5(a) is a plan view and FIG. 5(b) is a side view.

FIG. 6 is a schematic plan view showing a preferable example (warped shape) of the intraocular lens according to this embodiment of the present invention, wherein FIG. 6(a) is a view before inserting the intraocular lens into a lens capsule, and FIG. 6(b) is a view after insertion.

FIG. 7 is a schematic plan view showing a preferable example

(constriction) of the intraocular lens according to this embodiment.

FIG. 8 is a schematic view showing a method for manufacturing the intraocular lens according to this embodiment.

FIG. 9 is a schematic plan view showing the intraocular lens (Modification 1) according to this embodiment.

FIG. 10 is a schematic plan view showing the intraocular lens (Modification 2) according to this embodiment.

FIG. 11 is a schematic plan view showing the intraocular lens (Modification 3) according to this embodiment.

FIG. 12 is a schematic plan view showing the intraocular lens (Modification 4) according to this embodiment.

FIG. 13 is a schematic plan view showing the intraocular lens (Modification 5) according to this embodiment.

Detailed description of the Invention

[0020]

Hereinafter, embodiments of the present invention will be described in detail with reference to the drawings. This embodiment will be described in the following order.

1. Intraocular lens

(A) Optical part

(B) Supporting part

(B-1) Soft supporting part

(B-2) Hard supporting part

(B-2-1) Base end portion

(B-2-2) Tip portion

2. Method for manufacturing an intraocular lens
3. Method for using an intraocular lens
4. Effect of this embodiment
5. Modified example

[0021]

For a configuration not described below, a known configuration may be suitably adopted. In particular, the contents of the document disclosed by inventors of the present invention (Japanese Patent Laid Open Publication No. 2013-22273) may be applied to this embodiment. This document mainly focuses on sewing and fixing, and when performing non-sewing and fixing, it is described as an in-the-bag in [0041] to [0046] of this document. As shown in each figure of the document, there is a contradictory problem in that the tip end of the supporting part is too wide, thus seemingly not suitable for the intra-sclera fixation, and in that "a performance is specialized for the intra-sclera fixation" and "the lens has a versatility for a wide variety of surgical procedures". Then, in order to solve such a seemingly contradictory problem, among infinitely existing intraocular lenses, the trigger for selecting the configuration of the intraocular lens described in this document is not yet known.

[0022]

Further, in this specification, "tip end" refers to the side in a direction away from the optical part when viewing the optical part as a center, and vice versa, the "base end" refers to the side in a direction approaching the optical part.

[0023]

Further, in this specification, "wide width", "mid-width", and

"narrow width" are obtained by comparing widths of a position where the width is the maximum at each part (soft supporting part, hard supporting part, base end portion and tip portion of the hard supporting part) in the arm-like supporting part. To give an example, "width" refers to the length of a rectangular diagonal line when a cross section of each part is rectangular, "width" refers to a long diameter when the cross section of each part is an ellipse or a substantially ellipse, and "width" refers to the diameter when the cross section is a circle or an approximate circle. "Wide width", "mid-width", "narrow width" can also be rephrased as "ultra-thick", "medium-thick" or "ultra-thin".

[0024]

In this embodiment, for the sake of exemplifying a case that the cross section of each part is substantially rectangular, the width in plan view will be mentioned. Further, the width in this embodiment is obtained by measuring a distance between an arbitrary point on the inner side of the supporting part (the side close to the curvature center of the supporting part) and a point faced thereto on the outer side of the supporting part (the side far from the curvature center of the supporting part) which is a distance between points X and X' in FIG. 5. The width in this embodiment is also obtained by measuring a distance between an arbitrary point on the inner side of the supporting part (the side close to the curvature center of the supporting part) like the point Y or the point Z of the supporting part in FIG. 5, and (Point Y' or point Z') having a shortest distance on the outer side of the supporting part (the side far from the curvature center of the supporting part).

[0025]

<1. Intraocular lens 1>

As shown in FIG. 5, an intraocular lens 1 of this embodiment roughly includes an optical part 2 having a lens function and a supporting part 3 supporting the optical part 2. FIG. 5 is a schematic view showing the intraocular lens 1 of this embodiment, wherein FIG. 5(a) is a plan view, and FIG. 5(b) is a side view.

Each configuration will be described with reference to FIG. 5.

[0026]

(A) Optical part 2

The optical part 2 is a relatively soft part having a lens function, and is formed in a convex lens shape having a circular shape in plan view. The diameter of the optical part 2 may be set to any dimension as long as it is suitable for inserting the intraocular lens 1 into a capsular bag in an eye. As a specific example of dimension setting, a diameter D of the optical part 2 is preferably set within a range of 5 mm to 7 mm, and more preferably 6.5 mm. By using the optical part 2 having a relatively large diameter when fixing the intraocular lens 1 in the eye, it is possible to reduce an influence of the decentering inclination as compared with a case of the optical part 2 having a small diameter.

[0027]

The thickness of the optical part 2 may be set according to a desired refractive index or the like. The optical part 2 is made of a soft material that allows the optical part 2 to be folded. As used herein, the term "foldable" is used to mean that the intraocular lens 1 can be folded at least in half including the optical part 2. Accordingly, the soft material constituting the optical part 2 is a material having flexibility high enough

to fold the optical part 2. Specifically, for example, the soft material such as a silicone resin, an acrylic resin, a hydrogel, a urethane resin, or the like can be used.

[0028]

(B) Supporting part 3

The supporting part 3 is formed so as to stretch outward from an outer peripheral part of the optical part 2. The supporting part 3 supports the optical part 2 when the intraocular lens 1 is inserted into the eye. Two supporting parts 3 are formed in one intraocular lens 1. Each supporting part 3 is formed so that an arc is drawn in a counterclockwise direction in the figure from a portion where an axis passing through the center C of the optical part 2 (indicated by a one-dot chain line in the drawing) intersects the outer peripheral part of the optical part 2. Each supporting part 3 has a common structure as follows.

[0029]

The supporting part 3 stretches outward in the form of an arm from the outer peripheral part of the optical part 2. In addition, the supporting part 3 has a wide soft supporting part 31 stretching from the optical part 2 and integrally molded with the optical part 2 at its base end, and a hard supporting part 32 connected to the soft supporting part 31 at its base end and stretches in a stretching direction of the soft supporting part 31. Specifically, a main portion of the supporting part 3 is constituted as a soft supporting part 31, and a tip end portion excluding the soft supporting part 31 is constituted as a hard supporting part 32. The intention of using the expression "the hard supporting part 32 stretches in a stretching direction of the soft supporting part 31" is that as indicated in Patent Document 1, it

means that the tip end of the supporting part 3 is not J-shaped. In other words, even in a case of a preferable example described later (the tip portion 32b has a warped shape), it belongs to this embodiment as long as the hard supporting part 32 stretches in a direction not largely deviated from the stretching direction of the soft supporting part 31.

[0030]

The outer surface of the supporting part 3 draws a circular arc smoothly continuing from the soft supporting part 31 to the hard supporting part 32. The soft supporting part 31 and the hard supporting part 32 are divided, with an arc line as a boundary line when drawing the arc line of a radius R from the center C of the optical part 2. That is, a portion inside of the arc line of the radius R is defined as the soft supporting part 31, and a portion outside of the arc line of the radius R is defined as the hard supporting part 32.

[0031]

In this embodiment, an example of providing two supporting parts 3 is given, but three or more supporting parts 3 may be formed. In this embodiment, the two supporting parts 3 have the same configuration and are disposed so as to be point symmetrical when viewed from the center C of the optical part 2. Therefore, reference numerals in the figure are attached to only one supporting part 3.

[0032]

(B-1) Soft supporting part 31

The soft supporting part 31 is elastically deformable in a radial direction of the optical part 2. The soft supporting part 31 stretches totally elongatedly and the material itself constituting the soft supporting

part 31 has moderate flexibility. Specifically, the soft supporting part 31 is formed integrally with the optical part 2 and made of the same soft material as the optical part 2 described above. The term "integral molding" as used herein means that the optical part 2 and the soft supporting part 31 are integrally made of the same member, and does not mean that the optical part 2 and the soft supporting part 31 are formed as separate members and connected to each other.

[0033]

Due to adopting the above configuration, when the intraocular lens 1 receives an external force directed toward the center C of the optical part 2 through the hard supporting part 32 at the time of performing the in-the-bag or the out-the-bag, the soft supporting part 31 can be elastically deformed in a direction approaching the optical part 2 in accordance with this external force. On the contrary, when the intraocular lens 1 receives an external force that is away from the center C of the optical part 2 through the hard supporting part 32 at the time of sewing fixation or intra-scleral fixation, the soft supporting part 31 can be elastically deformed in a direction away from the optical part 2 in accordance with this external force.

[0034]

The base end portion 32a (root portion) of the soft supporting part 31 is widely formed in a mountain-tapered shape and is connected to the optical part 2 at a widest portion. Further, the soft supporting part 31 stretches elongatedly so as to draw an arc obliquely outward from the wide base end portion 32a. The tip portion (the part on the side opposite to the root portion) of the soft supporting part 31 is formed to be slightly wider.

The width of the soft supporting part 31 is gradually decreased from the base end portion 32a to the tip portion of the soft supporting part 31.

[0035]

(B-2) Hard supporting part 32

The hard supporting part 32 is made of a material different in hardness from the optical part 2 and the soft supporting part 31 described above. Specifically, the hard supporting part 32 is constituted by a hard material harder than the soft supporting part 31. The hard material used for the hard supporting part 32 may be acceptable if it can guarantee a strength of not causing a breakage to a portion where a suture is tightly bound, when the suture is tightly bound to the hard supporting part 32. Specifically, for example, a hard resin material such as PMMA (polymethyl methacrylate) can be used. A distal end of the hard supporting part 32 is slightly rounded so as not to damage a tissue of an eyeball even if it is brought into contact with the tissue of the eyeball. Further, the soft supporting part 31 and the hard supporting part 32 constituting the supporting part 3 are structurally integrated, except that the materials of the respective portions are different.

[0036]

The hard supporting part 32 has a mid-width base end portion 32a connected to the wide soft supporting part 31 and a tip portion 32b having a narrow width shape (ultra-thin shape in other words) with a maximum width of 0.3 mm or less.

[0037]

(B-2-1) Base end portion 32a

The base end portion 32a constituting the hard supporting part 32 is

a portion connecting the soft supporting part 31 described above and a narrow-shaped tip portion 32b described later, which is another portion constituting the hard supporting part 32, and which is a portion for smoothly performing a change of a width when viewed from an entire supporting part 3. More specifically, the base end portion 32a plays a role of gradually narrowing the hard supporting part 32 toward the tip end side by changing a curvature of the inside curving while maintaining the curvature of an outside curve of the supporting part 3.

[0038]

(B-2-2) Tip portion 32b

The tip portion 32b is a portion positioned at tip end of the hard supporting part 32. The maximum width of the tip portion 32b is set to 0.3 mm or less, so as to be formed into a narrow shape (in other words, ultra-thin shape). In this embodiment, various synergistic effects can be obtained by making the hard tip portion 32b narrower in addition to the various configurations described above (particularly, the integral molding of the soft optical part 2 and the soft supporting part 31). Detailed description will be given hereafter.

[0039]

First, when the maximum width of the tip portion 32b is 0.3 mm or less, the tip portion 32b can be easily inserted into the sclera when the intra-scleral fixation is performed. For example, by using a method similar to that described in [0004] and [0029] to [0034] of Patent Document 1, the tip portion 32b of this embodiment is inserted into a tunnel-like hole part formed in the circumferential direction of the sclera. At that time, when the maximum width of the tip portion 32b is a very narrow width of

0.3 mm or less, easiness of inserting the tip portion 32b into the tunnel-like hole part is remarkably improved, and a burden of a surgical procedure by a surgeon is remarkably reduced.

[0040]

Further, high stability is unexpectedly exhibited also in terms of stability after intra-scleral fixation, that is, difficulty in occurrence of decentering inclination. When the intraocular lens 1 is fixed by the tip portion 32b of the two supporting parts 3, in terms of a common sense, it is considered that the optical part 2, which is shaped such that the tip portion 32b is suspended in an extremely thick shape, is more stably disposed than the optical part 2 suspended by the extremely thin tip portion 32b. However, since the intraocular lens 1 of this embodiment is a lens specialized for a specific situation such as the intra-scleral fixation, such a conventional idea is not acceptable in some cases. More specifically, in the intra-scleral fixation, the intraocular lens 1 is placed under a certain special circumstance that the tip portion 32b is gripped by a meat layer constituting the sclera. In such a case, the tip portion 32b having a narrow shape is more likely to be enveloped by the meat layer than the tip portion 32b having a wide shape. As a result, even if the tip portion 32b has an extremely narrow shape having the maximum width of 0.3 mm or less, in other words, since the tip portion 32b has an extremely narrow shape, the occurrence of the decentering inclination during the intra-scleral fixation can be effectively suppressed. In addition, as described above, the easiness of inserting the tip portion 32b into the tunnel-like hole part is remarkably improved.

[0041]

Further, when the maximum width of the tip portion 32b is a very narrow width of 0.3 mm or less, it also has a good influence on various types of surgical procedures other than the intra-scleral fixation, that is, in-the-bag, out-of-the-bag, and sewing and fixing, in combination with various configurations described above.

[0042]

For example, in the case of the in-the-bag, the intraocular lens 1 is inserted into the lens capsule, and the supporting part 3 is fitted in the vicinity of an equator of a bag-shaped lens capsule. At this time, when the maximum width of the tip portion 32b is a very narrow width of 0.3 mm or less, the supporting part 3 fits into the vicinity of the equator of the lens capsule extremely easily and stably, which leads to a stable arrangement of the optical part 2 in the intraocular lens 1, which in turn leads to the difficulty in occurrence of the decentering inclination.

[0043]

Further, in the case of the out-of-the bag, the supporting part 3 is fitted into the ciliary sulcus groove, and therefore as in the case of the in-the-bag, when the maximum width of the tip portion 32b is a very narrow width of 0.3 mm or less, the supporting part 3 fits into the ciliary sulcus groove easily and stably, which leads to a stable arrangement of the optical part 2 in the intraocular lens 1, which in turn leads to the difficulty in occurrence of the decentering inclination.

[0044]

Further, in the case of the sewing and fixing, when the tip portion 32b has an extremely narrow shape having the maximum width of 0.3 mm or less, this is convenient when sewing each tissue of the eye and the tip

portion 32b.

For example, when the maximum width of the tip portion 32b is large, it is necessary to sew the tissue of the eye in a wide range when suturing each tissue in accordance with the width of the tip portion 32b, and the load added on a patient becomes large.

Further, when the maximum width of the tip portion 32b is a very narrow width of 0.3 mm or less, it becomes possible to tightly sew the tip portion 32b locally, and a sewing thread hardly comes off. On the contrary, when the maximum width of the tip portion 32b is large, it becomes difficult to collect a winding spot at one place during winding the sewing thread around the tip portion 32b, and the tip portion 32b cannot be tightly sutured locally.

[0045]

A specific position of the tip portion 32b in this embodiment may be arbitrary set from an uppermost tip end of the hard supporting part 32 as long as it is a distance enough to perform the intra-sclera fixation. As a preferable example, it is preferable that the maximum width of the tip portion 32b is 0.3 mm or less at a portion from the uppermost tip end of the hard supporting part 32 at least up to 5 mm, more preferably at least up to 7 mm, further preferably at least up to 10 mm, and also preferably, at a portion of 15 mm from the uppermost tip end.

[0046]

As described above, various exceptional effects can be obtained by combining the tip portion 32b of this embodiment and the abovementioned various configurations.

[0047]

In addition to the above effects, another synergistic effect can be obtained by adopting a preferable shape of the tip portion 32b. The preferable shape is such that the tip portion 32b is warped toward the optical part 2 (FIG. 6(a)). In other words, the tip portion 32b is warped toward the optical part 2 as compared with a portion up to the tip portion 32b in the supporting part 3. Hereinafter, this shape is simply referred to as "a warped shape". Regarding the degree of "warpage" in this embodiment, it is warping closer to the optical part 2 than the curved shape outside of the original base end portion 32a, and the curvature of the outside of the supporting part 3 due to the warpage is less than 90° (preferably 45° or less, more preferably 30° or less). That is, the J-shape as described in Patent Document 1 is not included in the "warpage" of this embodiment.

[0048]

Here, the reason why the warped shape is employed for the tip portion 32b is based on the application of the intraocular lens 1 of this embodiment to the in-the-bag. For example, when the in-the-bag procedure is adopted, the intraocular lens 1 is compressed by the lens capsule, and a pressure is transmitted from the vicinity of the equator of the lens capsule to the tip portion 32b. Then, as shown in FIG. 6(b), the portion having the warped shape at the tip portion 32b is deformed so as to follow the lens capsule. That is, by inserting the intraocular lens 1 into the lens capsule, a contact area between the lens capsule and the supporting part 3 can be increased, the intraocular lens 1 (optical part 2) can be stably arranged, and eventually the occurrence of the decentering inclination can be more efficiently suppressed. This deformation is also possible because

of the extremely narrow shape of the maximum width of the tip portion 32b being 0.3 mm or less.

[0049]

As a specific position of the warped shape in this embodiment is, as a preferable example, a portion from the uppermost tip end of the hard supporting part 32 at least up to 3 mm, more preferably at least up to 5 mm, further preferably at least up to 7 mm, and further preferably, a portion of 10 mm from the uppermost tip end, are preferably formed into a warped shape.

[0050]

As another preferable shape, a constriction is formed at the tip portion 32b (FIG. 7). The constriction referred to herein means a state in which both sides of the constricted part are wider and the constricted part is relatively narrow in width. In the case of adopting sewing at the time of inserting the intraocular lens 1 by forming the constriction, sewing is performed at the constricted part, thereby hardly allowing the sewing thread to come off.

The constriction mentioned here may be formed by narrowing the width of the constricted part, or may be formed by forming a wide part on both sides of the constricted part. Further, although an example in which constriction is formed at the tip portion 32b has been described, it may be formed at the base end portion 32a. If it is advantageous to sew in the vicinity of the tip portion 32b in accordance with a surgical procedure, a constriction may be formed in the tip portion 32b. Although it is preferable to form the constriction on the inner side of the curve for facilitating the surgical procedure, it may be on the outside of the curve or

on both sides thereof.

[0051]

Further, the maximum width of the tip portion 32b is preferably 0.2 mm or less. As the maximum width of the tip portion 32b becomes narrower, each of the abovementioned effects is further increased. A lower limit may be arbitrary set and is not required to be specifically defined, as long as the above effect can be exhibited. However, for example, 0.1 mm or more, or 0.15 mm or more may be preferable. Further, the width of the tip portion 32b may be gradually decreased toward the uppermost tip end within a range of 0.3 mm or less, or it may be a predetermined constant width of 0.3 mm or less.

[0052]

Incidentally, as an example of dimensions of the embodiment shown in FIGS. 5 and 7, the total length of the intraocular lens 1 is 13.5 mm, the width of the tip portion of the soft supporting part 31 is gradually decreased from the base end portion (root) of 0.5 mm to the tip portion 0.4 mm, and the width of the tip portion 32b of the hard supporting part 32 is 0.1 mm. In addition, a horizontal distance between a geometric center of the optical part 2 and the tip portion 32b is 1 mm in a state that the outer shape of the base end portion (root) of two soft supporting parts 31 is aligned in a vertical direction.

Further, when viewed in cross section, the width of the tip portion 32b of the hard supporting part 32 is 0.1 mm, and the width of the base end portion (root) of the soft supporting part 31 is 0.15 mm.

[0053]

<2. Method for manufacturing the intraocular lens 1>

Subsequently, a method for manufacturing the intraocular lens 1 of this embodiment will be described. The method for manufacturing the intraocular lens 1 can be mainly divided into three steps. The process will be described below.

Further, when viewed in cross section, the width of the tip portion 32b of the hard supporting part 32 is 0.1 mm, and the width of the base end portion (root) of the soft supporting part 31 is 0.15 mm.

[0054]

(First step)

First, as shown in FIG. 8(A), by using a known molding method, for example, PMMA (hard material) is used to obtain an annular hard material part 100. A circular hole 110 is opened in the center of the hard material part 100.

[0055]

Next, as shown in FIG. 8(B), for example, a raw material liquid 200 to be soft acrylic material (soft material) is injected into the circular hole 110 of the hard material part 100 to complete the polymerization. Thereby, a soft material part 250 having a circular shape in plan view is formed on the inner side of the hard material part 100. As a result, a lens material 300 having a structure in which the hard material part 100 and the soft material part 250 are integrated is obtained.

[0056]

(Second step)

Next, as shown in FIG. 8(C), a surface shape of the lens material 300 is adjusted in accordance with the surface shapes of the optical part 2 and the supporting part 3. Specifically, by performing surface formation

processing on the front and back surfaces of the lens material 300 using a precision lathe device, the surface shape of the lens material 300 is adjusted in accordance with the convex curved surface of the optical part 2, the inclined surface of the root part of the supporting part 3, and other flat surfaces. Thereby, a disk-shaped intermediate member (workpiece of lens material) 350 reflecting the front and back surface shapes of the intraocular lens 1 is obtained.

[0057]

(Third step)

Next, the outer shape of the intermediate member 350 is adjusted in accordance with the outer shapes of the optical part 2 and the supporting part 3. Specifically, unnecessary portions as the intraocular lens 1 are removed from the intermediate member 350 by subjecting the intermediate member 350 to external form processing such as milling processing.

[0058]

In the method for manufacturing the intraocular lens 1 of this embodiment, as shown in FIG. 8, the intraocular lens 1 is formed from a rotationally symmetrical circular disk-shaped lens material 300 interposing the disk-shaped intermediate member 350 reflecting the shape of the front and back surfaces of the intraocular lens 1. By using the rotationally symmetrical disk-shaped lens material 300, it is possible to effectively suppress the decentering inclination. This is because the symmetry of the intraocular lens 1 manufactured by the above manufacturing method is higher than in the case of forming the supporting part 3 as a separate member from the optical part 2 and attaching the supporting part 3 to the optical part 2. Then, for example, when two supporting parts 3 are

provided to be opposed to each other with the optical part 2 interposed therebetween, it is possible to pull the supporting part 3 in a well-balanced manner when pulling the two supporting parts 3 in a direction to be separated away (that is, at the time of sewing fixation or intra-scleral fixation), and the stability of the optical part 2 pulled by the supporting part 3 is greatly improved. This also applies to pressing the two supporting parts 3 in a direction to approach them (that is, during in-the-bag and out-of- the bag).

[0059]

<3. Method for using the intraocular lens 1>

Next, a method for using the intraocular lens 1 of this embodiment will be described. There are various use forms of the intraocular lens 1, depending on the type of the surgical procedure. Description regarding the existing in-the-bag, out-of-the-bag, and sewing and fixing methods, may be found in a publicly-known document, or a document disclosed by the present inventors as mentioned above, and in this embodiment, the case of performing the intra-scleral fixation will be described. However, basic fundamental intra-scleral fixation techniques are the same as those described in [0004] and [0029] - [0034] of Patent Document 1. That is, a scleral incision is made from one place of an under layer of a scleral half-layer valve in a sclera to form an intra-scleral tunnel in a circumferential direction with respect to a visual axis.

On the other hand, the intraocular lens 1 is inserted into an eye from, for example, an incision formed in a cornea using an injector or the like. At that time, the tip portion 32b of one supporting part 3 is kept in a state that a part thereof is exposed to the outside from the incision of the cornea.

[0060]

With the scleral half-layer valve opened, the tip portion 32b of the other supporting part 3 inserted into the eye is pulled out of a posterior chamber through the scleral incision using an instrument such as forceps, and is exposed from a lower part of the scleral half-layer valve to the outside of the eye. Then, the tip portion 32b exposed to the outside of the eye is inserted into the above-formed intra-scleral tunnel using the instrument such as forceps. When the above procedures are completed, the two scleral half-layer valves are closed. According to the above procedure, the intra-scleral tunnel tightens the supporting part 3, so that the supporting part 3 is restrained and held in the intra-scleral tunnel, and the intraocular lens 1 is fixed in the eye without bent sewn. In the intra-scleral fixation, the intraocular lens 1 can be fixed even without sewing. However, sewing is not denied. In order to strengthen the fixation, sewing of about several stitches may be performed.

[0061]

<4. Effect of this embodiment>

According to this embodiment, in addition to the effects listed above, the following effect is also achieved.

[0062]

In performing the intra-scleral fixation, it is possible to provide the intraocular lens 1 specialized in suppressing the decentering inclination which is a big problem for the intra-scleral fixation (that is, the intraocular lens 1 specialized for the intra-scleral fixation).

[0063]

For the surgeon, if only the intraocular lens 1 of this embodiment

specialized for the intra-scleral fixation is possessed as an inventory, the surgeon can respond to a surgical procedure other than the intra-scleral fixation. In such a case, the inventory burden on the surgeon is reduced and the convenience is improved. As a result, even in a case of the intraocular lens 1 specialized for the intra-scleral fixation, it is possible to satisfy hidden demands for the intraocular lens 1 which can also respond to other surgical procedures.

[0064]

Further, by using the intraocular lens 1 of this embodiment, deformation of the lens capsule itself can be suppressed even if surgical procedures other than scleral fixation is applied, and the decentering of the optical part 2 of the intraocular lens 1 can be suppressed.

[0065]

As described above, according to this embodiment, it is possible to provide the intraocular lens 1 having versatility for a wide variety of surgical procedures in terms of a specialized performance of scleral fixation.

[0066]

<5. Modified example>

The technical scope of the present invention is not limited to the abovementioned embodiment, and includes various modifications and improvements within the scope of deriving the specific effects obtained by the constituent features of the invention and combinations thereof.

[0067]

(Base end portion 32a and tip portion 32b)

In this embodiment, the case that the base end portion 32a and the

tip portion 32b are integrally made of the same hard material has been described. On the other hand, it is also possible to adopt a configuration in which the tip portion 32b is formed as a separate member and the base end portion 32a is later connected to the tip portion 32b. Further, in the same way, the base end portion 32a may be later connected to the soft supporting part 31. Alternatively, the hard supporting part 32 integrally formed with the base end portion 32a and the tip portion 32b may be later connected to the soft supporting part 31.

Further, this embodiment shows an example of providing the base end portion 32a, but it is also acceptable to adopt a configuration in which the tip portion 32b is directly connected to the soft supporting part 31.

[0068]

(Warped shape of the tip portion 32b)

In this embodiment, the warped shape of the tip portion 32b is cited as a preferable modified example with respect to the present invention. On the other hand, the abovementioned "warped shape" itself can be an independent invention. Although it is re-listed partially, when adopting the in-the-bag procedure, the intraocular lens 1 is compressed by the lens capsule, and when the pressure is transmitted from the vicinity of the equator of the lens capsule to the tip portion 32b, the arrangement of the optical part 2 becomes unstable and the decentering inclination may occur (problem). Therefore, as shown in FIG. 6(b), the warped shape is provided at the tip portion 32b (means). In such a case, the warped portion is deformed so as to follow the lens capsule, and when the intraocular lens 1 is inserted into the lens capsule, a contact area between the lens capsule and the supporting part 3 can be increased, it is possible to

stably arrange the intraocular lens 1 (optical part 2), and eventually it is possible to more effectively suppress the occurrence of the decentering inclination (effect). At this time, for example, each of the two supporting parts 3 is connected to the optical part 2 only at one end.

[0069]

The above configuration is summarized as follows.

There is provided an intraocular lens, including:

"an optical part having a lens function; and

a supporting part stretching from the optical part and connected to the optical part only at one end,

wherein the tip end of the supporting part is warped toward the optical part as compared with a portion up to the tip end of the supporting part."

[0070]

(Modified aspect of the intraocular lens 1)

Hereinafter, a modified aspect of the intraocular lens 1 will be described with reference to FIGS. 9 to 13 respectively. Contents that are not particularly mentioned are similar to those in the abovementioned embodiment.

[0071]

In the aspect shown in FIG. 9, the hard supporting part 32 is formed to be relatively long. With this configuration, it is easier to perform a surgical procedure when the intra-scleral fixation is performed.

In this example, the total length of the intraocular lens 1 is 13.5 mm, the width of the tip portion of the soft supporting part 31 is 0.4 mm, and the width of the tip portion 32b of the hard supporting part 32 is 0.13 mm. In

addition, a horizontal distance between a geometric center of the optical part 2 and the tip portion 32b is 4.2 mm in a state that the outer shape of the base end portion (root) of two soft supporting parts 31 is aligned in a vertical direction.

In the aspects described below including this example, the abovementioned constriction is provided on the inner side of the curved shape of the hard supporting part 32.

[0072]

In the aspect shown in FIG. 10, conversely, the hard supporting part 32 is formed to be relatively short. Thereby, it is possible to facilitate the surgical procedure of the in-the-bag while specializing the intraocular lens 1 for the intra-scleral fixation.

In this example, the total length of the intraocular lens 1 is 13.5 mm, the width of the tip portion of the soft supporting part 31 is 0.4 mm, and the width of the tip portion 32b of the hard supporting part 32 is 0.13 mm. In addition, the horizontal distance between the geometric center of the optical part 2 and the tip portion 32b is 3.4 mm in a state that the outer shape of the base end portion (root) of two soft supporting parts 31 is aligned in a vertical direction.

[0073]

In the aspect shown in FIG. 11, while providing the warped shape in the tip portion 32b as described above, the base end portion (root) of the soft supporting part 31 is formed to be relatively narrow and the base end portion 32a of the hard supporting part 32 is formed to be relatively long. For the warped shape, the above effect can be obtained. In addition, an advantageous effect can be obtained when in-the-bag procedure is

performed. When the intraocular lens 1 is deployed after folding the supporting part 3 and inserting the intraocular lens 1 into the lens capsule, a deployment direction at the beginning of the supporting part 3 can be set in the horizontal direction and the intraocular lens 1 can be appropriately deployed.

In this example, the total length of the intraocular lens 1 is 13.5 mm, the width of the tip portion of the soft supporting part 31 is 0.43 mm, the width of the tip portion 32b of the hard supporting part 32 is 0.13 mm, and the width of the side close to the tip portion 32b in the vicinity of the constriction is 0.147 mm. In addition, the horizontal distance between the geometric center of the optical part 2 and the tip portion 32b is 3.1 mm in a state that the outer shape of the base end portion (root) of two soft supporting parts 31 is aligned in a vertical direction.

[0074]

The aspect shown in FIG. 12 is based on the aspect shown in FIG. 11. In addition, the width of the tip portion 32b of the hard supporting part 32 is made relatively wide. Thereby, it is possible to improve the strength of the supporting part 3, and it is possible to reduce the possibility of breakage of the supporting part 3 during the surgical procedure.

In this example, the total length of the intraocular lens 1 is 13.5 mm, the width of the tip portion of the soft supporting part 31 is 0.43 mm, and the width of the tip portion 32b of the hard supporting part 32 is 0.16 mm. In addition, the horizontal distance between the geometric center of the optical part 2 and the tip portion 32b is 3.2 mm in a state that the outer shape of the base end portion (root) of two soft supporting parts 31 is aligned in a vertical direction.

[0075]

In the aspect shown in FIG. 13, from the aspect shown in FIG. 12, the width of the tip portion 32b of the hard supporting part 32 is further made wide. Therefore, it is possible to further reduce the possibility of breakage of the supporting part 3 during the surgical procedure.

In this example, the width of the tip portion 32b of the hard supporting part 32 is 0.18 mm, and the other dimensions are the same as those of the aspect shown in FIG. 12.

Description of Signs and Numerals

[0076]

- 1 Intraocular lens
- 2 Optical part
- 3 Supporting part
- 31 Soft supporting part
- 32 Hard supporting part
- 32a Base end portion
- 32b Tip portion

CLAIMS

1. An intraocular lens, comprising:
 - a soft optical part having a lens function;
 - a wide soft supporting part stretching from the optical part and formed at a base end integrally with the optical part; and
 - a hard supporting part connected to the soft supporting part at the base end and stretching in a stretching direction of the soft supporting part, wherein a tip portion of the hard supporting part is formed into a narrow shape with a maximum width of 0.3 mm or less.
2. The intraocular lens according to claim 1, wherein the hard supporting part further comprises a mid-width base end portion connected to the wide soft supporting part, and the base end portion and the narrow-shaped tip portion are connected to each other.
3. The intraocular lens according to claim 1 or 2, wherein the tip portion of the hard supporting part is formed into a narrow shape with a maximum width of 0.2 mm or less.
4. The intraocular lens according to any one of claims 1 to 3, wherein the tip portion of the hard supporting part is warped toward the optical part.
5. The intraocular lens according to any one of claims 1 to 4, wherein a constriction is provided in the hard supporting part.