ENDO-K PRO

INTERCORNEAL IMPLANT FOR CORNEAL TRANSPLANT

Most frequent questions raised by the ophthalmologists during the Endo-K Pro implant Accreditation Courses

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Product with CE marking

TECHNICAL CHARACTERISTICS

Brand name	**ENDO-K PRO**			
References	**EQP75**	**EQP80**	**EQP85**	**EQP90**
Outer diameter	7.50 mm	8.00 mm	8.50 mm	9.00 mm
Description and Indications	Device of medical grade PMMA, designed for its implantation between the corneal endothelium and the corneal graft in corneal transplant surgeries. *Characteristics:* • Double circular ring, with different diameters. • PMMA single piece. • No injector needed. • Easy manipulation and integration. Medical device for ophthalmological use, indicated for its implantation between the patient's corneal endothelium and the donor corneal graft in corneal transplant surgeries. EQP device helps to avoid unwanted secondary effects that could make surgical intervention failure. In general, ENDO-K PRO device allows to: • Mechanical separation of patient's corneal endothelium and donor corneal graft. • Corneal graft survival help. • Unwanted secondary effects prevention in corneal transplant surgeries.			
Material	Polymethyl Methacrylate (PMMA) with UV filter			
Sterilization method	Ethylene oxide (EtO)			
Presentation	Unitary implant, sterile packaging			
Shelf-life	4.5 years			

ON THE ENDO-K IMPLANT

What are the available Endo-K Pro diameters?

The current available Endo-K Pro implant diameters are of 7.50, 8.00, 8.50 and 9.00 mm.

What are the cutting and implant recommendation for the primary cases?

The clinical trial was carried out with trepanation diameters of 7.50 and 8.00 mm; the Endo-K pro diameters were of 8.00 and 8.50 mm, this is, 0.5 mm bigger than the trepanation diameters. Nowadays, the same criteria remains.

What are the cutting and implant recommendation in the case of a previous penetrating transplant?

It is recommended for the first cases not to use the Endo-K Pro implant in patients with a previous penetrating transplant. If the lamellar dissection reaches the penetrating transplant scar, there is a risk of perforation of the stromal bed.

In the case of performing the surgery in a patient with a previous penetrating transplant, this shall have, at a minimum, a diameter of 8 mm and shall be properly centered; the partial trepanation shall be carried out on the inside of the scar and a 7.5 mm implant shall be employed.

If the penetrating transplant is small and not centered, the partial trepanation shall be wide and centered. The lamellar dissection has a higher risk, so the residual bed shall have, at least, 100 microns, in order to avoid a perforation in the previous scar.

Which should be the diameter of the trepanation?

As the Endo-K Pro diameters are of 7.50, 8.00, 8.50 and 9.0 mm, the trepanation diameters shall be of 7.00, 8.50, 8.00 and 8.50 respectively. In the same vein, the diameter of the donor cornea shall be 0.25 mm bigger than that of the trepanation.

Does the central plate of the Endo-K Pro have dioptric power or is it neutral?

At the moment it is neutral but one of the planned modifications of the implant is the addition of a dioptric power to compensate a possible aphakia; the implant has extensive possibilities of technological development.

To add dioptric power would entail few modifications on the implant, as the central plate, with a 3 mm diameter, allows the addition of high power.

Does the Endo-K Pro implant impede the neovascularization of the donor cornea?

No, it does not. The peripheral ring is placed at a predescemetic level and thus it does not influence in a higher or lower neovascularization of the graft. The corneal graft can be vascularized like in a penetrating transplant.

If the cause is a limbal deficiency, or a herpetic relapse, the vessels can enter the graft. Thus, the prevention of the entry of neovessels to the graft is not considered within the advantages of the implant, as it is the case with the Krumeich ring.

In some cases with a thick receiving stromal bed, around 100 microns or higher, it has been possible to see neovessels entering the bed.

Does the Endo-K Pro implant avoid the rejection of the donor cornea?

From the start, the donor cornea is being isolated from the inside of the

ocular globe, greatly diminishing the associated inflammatory and immunological factors.

Up to date, the problems that have been associated with the Endo-K Pro are not related to the graft rejection, but with the postoperative handling of situations that were unknown at the time, within the normal learning curve.

The selection of the patient is also important. The limbal deficiency problems or the previous penetrating transplants are the origins of some of the graft failures with Endo-K Pro.

While the intraocular factors harmful for the graft would be controlled by the physical isolation that the residual bed offers, the external factors such as the limbal deficiency still have a negative potential for the graft. In these cases, the implantation of the Endo-K Pro would allow some extra time to improve the corneal-conjunctival surface. Naturally, it is possible to associate surface surgeries such as amniotic membrane transplant (with or without PRGF membrane) during or after the Endo-K Pro.

In summary, the Endo-K Pro implant is indicated both for patients with intraocular problems as well as patients with surface problems. In these last cases, the transplant protected by the pseudochamber could fail just as a penetrating transplant could, but it would be possible to gain some time to recuperate the corneal limbus.

Are there prosthesis developed for pediatric patients?

The Endo-K Pro has been implanted in one 14 years old patient, in which on top of the same surgery, a lensectomy with an intraocular lens implant was performed.

Although the indication for the implant is for patients over 18 years old, as no data has been collected in pediatric populations, in theory there should be no inconvenience in using the Endo-K Pro at pediatric ages. The indication would need to be justified and the appropriate diameter would need to be chosen.

It is important to remember that the number one requirement for the Endo-K Pro implant is not so much the age of the patient, but if they are aphakic or pseudophakic.

Is it convenient to have the intraocular pressure (IOP) controlled before the surgery?

It is recommended, but not indispensable. The ideal situation would be to the IOP controlled by any habitual means before the surgery. The Endo-K Pro implantation is more comfortable with a normal IOP but it can also be done if it is high.

Moreover, the Endo-K Pro surgery can always be combined with the pertinent pressure lowering technique (cyclophotocoagulation, filtering surgery, valves...). These techniques can also be associated in the early or late postoperative care.

Is it necessary to study the irido-corneal angle to indicate the Endo-K Pro?

It is not necessary, but it is convenient. An angular closing does not contraindicate the Endo-K Pro implant; on the contrary, it is indicated due to the bad prognosis of a penetrating transplant in these cases. The irido-corneal angle is not modified with the technique.

The anterior segment OCT is a very useful tool in order to explore the iridian diaphragm before the surgery. All kind of morphological alterations can be seen that, in any case, will not be altered by the surgery.

What valve is recommended with the Endo-K Pro?

Any of the usual techniques can be used, such as the Baerveldt valve or the Ahmed valve. They can be implanted before, during or after the Endo-K Pro surgery, and the tube of the valve can be left in front or behind the iris.

The technique allows to maintain intact a valve that works properly. It is not necessary to relocate the tube of the Ahmed valve to the posterior chamber.

It is also possible to use as an alternative the partial cyclo-photo-coagulation. This is a very easy to perform technique and very useful in cases with IOP in the limits.

Can anti-metabolites be used if valves are implanted?

Yes. The usual anti-metabolite can be used. The valves can be implanted before the surgery, in a combined surgery or after the surgery, during the postoperative care of the Endo-K Pro.

What should be done to protect the graft in the case of an ICE syndrome?

Nothing special. The anterior synechias do not affect the endothelium of the donor cornea. The receptor stromal bed acts as a barrier. We have several cases intervened for this cause and their evolution is one of the most satisfactory ones.

ON THE SURGICAL TECHNIQUE

What are the best and worst cases, to initiate oneself on the techniques?

One ideal case to initiate oneself on the technique is the case of corneal edema, aphakia and intraocular silicone oil. The deep anterior lamellar dissection is carried out without difficulty and the intraocular pressure is usually controlled.

Also good is the case of corneal edema secondary to a complicated intraocular surgery, associated or not to a glaucoma. If the intraocular pressure is controlled, the surgery and postoperative period usually run smoothly, without complications.

The worst cases are those that have a previous penetrating transplant, at the pocket to introduce the peripheral ring of the Endo-K Pro cannot be carved correctly. The donor endothelium is in permanent contact with the PMMA ring and ends up harmed. Thus, the Endo-K Pro with a diameter of 7.50 mm has been created to provide a solution for these cases.

Any advice for those initiating themselves in the technique?

In the first place, for them to have previous experience in the deep anterior lamellar dissection of the corneal with the Melles spatulas. This is, to have experience in DALK (Deep Anterior Lamellar Keratoplasty) performed by manual dissection.

It is very important to create properly the peripheral corneal pocket where the Endo-K Pro will be placed; it is fundamental for the ring to be placed at the predescemetic level in order to avoid extrusions.

It is also convenient to properly fix the Endo-K Pro implant with a silk 8/0 suture before suturing the graft on top. There are three ways to suture, as specified during the course. Two of them include the radii and the peripheral ring of the Endo-K Pro and another, just the ring.

How is the dissection technique with the spatulas?

The dissection technique that we recommend is the Anwar technique, from the late 70s. The blunt Melles spatulas are employed, beginning the dissection from the border of the trepanation. Unlike with the Melles technique, the entry is not performed by the corneal limbus.

The dissection starts with a mini-crescent, from the same border of the partial trepanation, until reaching the deepest layers of the cornea (less than 100 microns of stromal bed). Afterwards, the dissection with spatulas is continued until reaching a predescemetic level (50-75 microns). During the whole dissection the pachymetric control of the residual bed is recommended.

Is the intraoperative OCT necessary?

It is not necessary for the surgery. For didactic purposes it is interesting to observe how the dissection is completed, how the ring is introduced in the pocket and how the pseudochamber is formed. The control of the thickness of the residual bed through the corneal pachymeter is what is important.

However, the anterior segment OCT is very important for the postoperative follow-up, as it provides information of the pseudochamber.

Should the crystalline be extracted before implanting the Endo-K Pro?

For the implantation of the Endo-K Pro, it is mandatory for the patient to be aphakic or pseudophakic. In any case, a patient for which the Endo-K Pro is being considered, the usual is for them to be already intervened of lensectomy, with or without the intraocular lens implant.

Otherwise, like for a patient with a causticization or a traumatism, the moment of implantation of the Endo-K Pro can be taken advantage of to carry out the phacoemulsification of the crystalline.

In pseudophakic patients, it is the same for the intraocular lenses to be in the posterior or anterior chambers. Their placement does not affect the Endo-K Pro implant.

Is a minimum endothelial count of the donor cornea required?

Corneas between 2000 and 2500 cells per mm2 can be used. With this technique, the surgical trauma of the donor cornea is lesser, and the postoperatory is also carried out with less inflammation. It has a better prognosis than a penetrating transplant.

Moreover, the number of endothelial cells can be started to be measured very early, after 15 days. The surgical trauma is minimum and the cornea recovers very fast. The postoperative inflammation also is lesser due to the cornea being isolated by the pseudochamber.

Why is the receptor stromal bed eliminated during the surgery?

In order to maintain the donor cornea isolated, during the surgery and the first postoperative months, when the inflammatory phenomena are more important.

After 3 months from the intervention, the stromal bed is fibrosed and it adheres to the Endo-K Pro plate. Therefore, the pseudochamber remains sealed, even if a central orifice beneath the central plate is created.

It is important to remember that the endothelium is nourished by the aqueous humor that disseminates through the residual bed, that in these cases acts like a simple membrane.

Removing the stromal bed at the moment of the surgery would imply the loss of the concept of sealing or immunological or inflammatory isolation of the donor. If it is removed later, all of those problems are significantly diminished.

Is the viscoelastic left in the pseudochamber after finalizing the surgery?

It is convenient to leave cohesive viscoelastic. After some time, the viscoelastic disappears from the pseudochamber, moment in which it can be observed how the receptor stromal bed is displaced forwards. If both corneas end up in contact, it shall be injected again.

Would it be possible to leave air, instead of viscoelastic, at the end of the surgery?

In theory yes, air, or better, gas SF6 at 20% could be left. But in our experience, the viscoelastic is maintained for longer. Amongst the viscoelastics, the dispersive is more effective to maintain both corneas more separated and for longer.

The viscoelastic also helps to create a mattress over which the graft can be sutured more comfortably.

Anyways, the viscoelastic is not completely necessary and it is possible to leave only physiological saline at the end of the surgery; the Endo-K Pro is the one in charge of maintaining the corneas separated.

Have the Endo-K Pro or the receptor bed ever broken during the surgery?

No, in no case have the implant or the stromal bed broken. Although it may seem like applying a lot of pressure during the provisional suture in order to fix the Endo-K Pro, the stromal bed has never been broken. It is important to remember that its thickness shall be greater than 50 microns.

For this reason, it is not recommended to use the "big bubble" technique to implant the Endo-K Pro. Although we have not used, it leads to the conclusion that there are more possibilities for a descemetic bed to break. This technique would not be appropriate in these patients, as the main objective is not to obtain a fast visual recovery, but to maintain the stromal bed in all occasions.

When taking the Endo-K Pro out of its carrier, it is recommended to place a drop of viscoelastic on top before taking it with the clamps. Thus, the risk of it springing from the carrier or being harmed is avoided.

ON THE POSTOPERATORY AND THE FOLLOW-UP

What is the usual distance between the Endo-K Pro plate and the donor corneal endothelium?

It is usually always bigger than 3.0 mm, like in a normal anterior chamber. In any case, it depends on the resistance of the Endo-K Pro radii to deformation, on the intraocular pressure and on the curvature of the donor cornea. The new reinforced design of the Endo-K Pro maintains the height of the pseudochamber more stable in the face of the pushing of the intraocular pressure.

Are the radii of the implant deformed if the pseudochamber collapses?

On the contrary, the pseudochamber collapses if the radii are deformed. In cases of very high intraocular pressure, the radii are deformed and the plate is displaced forwards, losing the pseudochamber.

With the reinforced version of the Endo-K Pro, this problem is solved. Moreover, the control that we now carry out before, during or after the surgery has contributed to maintaining the pseudochamber stable.

A different problem is the bulging of the bed between the radii. If a bed of 50, 60 or 70 microns has been left, it can protrude between the radii. In order to correct this tendency, an orifice is created using lase Nd:YAG close to the union of one of the radii with the central plate. After this, it can be observed how the pseudochamber is filled with aqueous humor and the bed is flattened.

When the central residual stroma is removed, is the isolation of the pseudochamber lost? Is the viability of the donor cornea compromised? Is the immunological isolation lost?

On this topic, it has been observed that the residual stroma is adhered to the central late. Even if the stromal bed is removed in the central 2.5 mm (with laser Nd:YAG or with femtosecond laser) the remaining bed is still adhered to the plate and maintains the pseudochamber stable.

6 months after the surgery, the stromal bed is fibrosed and remains completely adhered to the central plate of the implant. Even at the third month, this fibrosis of the pre-descemetic stroma can already begin to be observed.

The isolation of the pseudochamber is important if there is intraocular silicone oil; if the silicone enters to the pseudochamber, the graft will fail at medium term. As with this profile of patient the visual prognosis is very limited, it is recommended to maintain the residual bed as long as possible.

On the other hand, the aqueous humor passes through the residual bed between the radii of the implant, nourishing the endothelium of the donor cornea. It has been verified how the aqueous humor fills the pseudochamber, substituting the viscoelastic left at the end of the surgery.

The receptor stromal bed acts as a substance filter towards the pseudochamber. It is important to remember that in the cases for which the Endo-K Pro is indicated, the endothelium of the receiving cornea is completely damaged and it does not fulfill any function.

In terms of the immunological protection, it is being studied. As it has been mentioned, there is a physical isolation from harmful pro-inflammatory intraocular factors such as anterior synechias, a displaced intraocular lens, the tube of a valve or the silicone oil.

Regarding the injection of the viscoelastic in the pseudochamber, is the viscoelastic necessary for the maintenance of the viscoelastic? How many times shall it be injected, which needle shall be employed? Where should it be injected?

The design of the Endo-K Pro has as an objective to forego the injection of viscoelastic that was carried out, as a norm, in the keratoplasty protected by a pseudochamber. Thus, this injection should not be necessary. Anyways, at the end of the surgery viscoelastic is usually left in order to ensure the separation of both cornea during the first postoperative days and, also to maintain the anterior curvature of the donor cornea as physiological as possible.

The injection of the viscoelastic could be carried out, in theory, as many times as necessary, specially during the first three months. However, the reality is that it is only necessary to perform it occasionally.

For the injection of the viscoelastic it is recommended to use a fine needle of 30g (insulin needle) and introduce it through the donor cornea, just in front of one of the suture points, and in the meridian where one of the Endo-K Pro radii is located. The viscoelastic will be injected after touching the radius of the implant with the tip of the needle in order to avoid the possibility of dragging the donor endothelium during the maneuver.

When shall be endothelectomy carried out?

It is recommended to carry out the endothelectomy (removing of the receptor stromal bed) as late as possible when considering the transplant to be viable. A minimum of 6 months should be waited.

Does the femtosecond laser harm the central plate when cutting the receptor bed?

The laser does mark the central plate but it does not break it. When stablishing the cutting range of the laser, it is programmed so that it reaches the plate thus having the security that the full thickness of the bed is cut. No problems have been observed in this regards.

Shall the receptor stromal bed be extracted if cut with Nd:YAG laser?

No, it is not necessary. The bed is simply separated from the central plate and remains floating in the anterior chamber. If cut with the femtosecond, it is necessary to extract it because it does not separate from the plate. For this, a vitrectomy clamp introduced through the limbus (20g) is used.

Can the endothelial cells diminish when removing the receptor stromal bed?

The problem is in the way of eliminating the residual bed. If the Nd:YAG laser is used, there is no decrease of cells, but it is an indispensable condition for the receptor stroma thickness to be less than 75 microns.

If the femtosecond laser or the vitrectomy clamp need to be used, the maneuvers of extraction of the stromal bed, once cut, shall be carried out through the limbic way in order to avoid cellular loss. If the patient has a good visual prognosis, the benefit overcomes the risk of endothelial loss. The anterior segment OCT allows to determine the limbus area by which it is the most favorable to enter the anterior chamber.

In some of the first intervened cases, the entry was performed by the transplant scar in order to extract the bed, maneuver that produced an important endothelial damage.

What influence does the Endo-K Pro have in the residual postoperative astigmatism?

In the cases where the Endo-K Pro is indicated, the problem of the

postoperative astigmatism is not relevant. They are very serious cases and with a very limited visual prognosis.

Anyways, the keratometric astigmatism in the cases where the suture has been completely removed, is relatively low. It can be speculated that the peripheral ring of the implant, bring rigid, equilibrates the different tensions of the suture points and modulates the scarring of the cornea.

Can the use or corticoids in this technique cause ocular hypertension?

The treatment regimen with corticoids in the postoperatory, is the same as in the cases of DALK; it is not necessary for it to be as intense as in the penetrating transplants. Thus, there are the same possibilities of the IOP increasing if the patient responds to corticoids.

Is it necessary to associate any special treatment?

As always, the cases with herpetic antecedent, an antiviral orally is recommended, such as valaciclovir (Valtrex, for example). And in the face of a retransplant, always use an immune-regulator, such as mycophenolate mofetil (CellCept, for example).

Regarding the intraocular pressure (IOP, how is it controlled during the postoperatory? Do the measurements correspond to reality? Shall any hypotensor be maintained long term?

In the first place, it is important to mention that the technique by itself does not alter the intraocular pressure, as it does not penetrate in the anterior chamber. If it is controlled before the surgery, it will also be after, unless the usual corticoid treatment causes an increase of the IOP during the postoperatory.

The control of the IOP during the postoperatory can be carried out by the usual methods. In a first approximation, we recommend evaluating the IOP by direct ocular globe palpation. Afterwards, it can be measured with the usual applanation tonometry or, better, with rebound tonometry (iCare 100 or 200).

The viscoelastic in the pseudochamber can distort the IOP evaluation, both in the pseudochamber as well as the inside of the ocular globe. Thus, the subjective evaluation through palpation is important, especially during the first weeks, until the viscoelastic is completely diluted.

It is important to remark that the pressure in the pseudochamber does not always correspond with the one inside the ocular globe; it depends on the barrier effect generated by the residual stromal bed.

An indirect sign of the pressure imbalance is in the protrusion of the residual bed between the radii of the implant. The bigger the IOP in the anterior chamber and the thinner the residual stromal bed, the more protrusion produced and the more contact between the donor endothelium and the receptor bed.

If in the preoperatory, the IOP was controlled with medical treatment, the same treatment shall be maintained as well in the postoperatory. If the patient did not follow a treatment before the surgery, it shouldn't be introduced afterwards.

As mentioned in another response, the problem of the IOP shall be controlled before, during or after the implantation of the Endo-K Pro, by any of the usual means (medical or surgical). To implant an Endo-K Pro des not influence the decision taking in terms of the method of choice.

Up to this day, there have been no cases of IOP increase after the surgery. If it was controlled before, afterwards too. As the ocular globe is not perforated, the anterior synechias or a possible angular closing are not modified. Prepupilar or retropupilar, the receptor stromal bed does not obstruct the tube orifice.

Can a DSAEK or a DMEK be performed if the donor cornea fails?

In the event of a decompensation of the donor cornea, a new full thickness transplant shall be carried out, without the need to remove the Endo-K Pro implant. At the moment the hasn't been a plan to perform a DMEK graft within the pseudochamber.

In this regard, one of the research lines of the Institute on the Endo-K Pro is, precisely, the injection of endothelial cells of the pseudochamber. In theory, these cells shall upholster the interior of the pseudochamber and recuperate the donor cornea. This idea is more viable than introducing an endothelial roll in such a reduced space.

A different topic is the presence of one or more DMEK transplants before carrying out the keratoplasty associated to the Endo-K Pro. In these cases it is not necessary to remove the previous transplant.

However, if a DSAEK instead of a DMEK has been carried out, it is convenient to remove the stroma-Descemet-endothelium grafted complex. The sum of the thicknesses, DSAEK + receptor stromal bed would limit the vision of the patient and difficult the removal of both tissues. Before starting the Endo-K Pro surgery, the DSAEK is removed by a paracentesis of 2.2 mm carried out at the limbus level.

Have fibrin membranes appeared related to the central plate at the Endo-K Pro?

Certainly, we have a couple of cases in which a fine fibrin membrane behind the central plate. We have seen them, for example, weeks after removing the receptor stromal bed, They are very tenuous and don't have as much of a clinical significance as in the Boston keratoprosthesis. Moreover they are easy to diagnose with the slip lamp and to eliminate with the Nd:YAG laser. We are studying their relationship with any determined Clinical profile.

On the other hand, these we have also found these fibrin membranes over the central plate, within the pseudochamber. They a usually related with the presence of hematic remains in the pseudochamber (due to the lamellar dissection of to the suture points in very vascularized receptor corneas). They do not represent a relevant clinical problem; they can also be removed with the Nd:YAG laser.

Does the receptor stromal bed opacificate?

The receptor stromal bed (50-100 microns) is usually opacified from the beginning, depending on the severity of each case. If it is very thick, it is hydrated in the postoperatory and its thickness increases; if it is very thin, it does not hydrate but it is opacified more. This is, the scarring process of the bed depends on its initial thickness.

What is the maximum follow-up time of the pseudochamber?

When considering the cases of keratoplasty protected by pseudochamber without implantation of Endo-K Pro we already have cases of 10 years of evolution. If both corneas do not adhere, the prognosis of the transplant is good.

When referring to the cases with Endo-K Pro, the maximum actual follow-up is of 3 years. The first patients were intervened in August 2018 and nowadays, 5 patients maintain the pseudochamber. Logically, the learning curve of the technique has been the main reason of various failures and we trust on obtaining better results with the small improvements that we have introduced during these 3 years.

Can the suture points be removed like in a DALK?

Exactly the same. The more tense points can be removed starting from the sixth month, specially if the astigmatism is high, but not before.

It is recommended to remove a pair of points at 6 months and another at 9 months. Between the 12 and 15 months all of the points can be removed. Nonetheless, in transplants with reconstructive purpose, it can be maintained longer, as long as there are no tolerance issues.

Can the Endo-K Pro be implanted in a second time?

The main idea for the Endo-K Pro is to avoid a penetrating transplant. I case of not having the implant at the moment of the surgery it is recommended to carry out a deep anterior lamellar transplant the first time and leave the Endo-K Pro for a second time. It is true that two corneas are used, but in such complex cases, the survival of the graft is higher than when carrying out a penetrating transplant. ■

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