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Chapter 7

Ultra-Thin Descemet's Stripping Automated Endothelial Keratoplasty (UT-DSAEK)

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Abstract

The advantages of Descemet's Stripping Automated Endothelial Keratoplasty (DSAEK), the most commonly used lamellar technique for the treatment of endothelial diseases, have been already well established. This is a technically straightforward procedure easily adopted by every corneal surgeon, with the biggest drawback that many patients do not obtain postoperative vision of 20/20. Despite the fact that another surgical technique, Descemet's membrane endothelial keratoplasty (DMEK) certainly provides superior visual outcome then DSAEK, it is still not widely accepted among corneal surgeons. Main reasons are: DMEK is technically more difficult, still has high rebubling rate, it is not feasible in opaque corneas or specific eye conditions, and there is increased risk of loosing the donor tissue. Given that DSAEK is surgically safe and easy, and that very thin DMEK grafts bring quicker and better visual recovery, a so-called ultra-thin (UT) DSAEK technique with endothelial lamellar graft of less than 100 µm thickness was proposed in 2009. Not many studies have been published comparing the clinical results of ultra-thin DSAEK with most frequently used DSAEK and DMEK. First results from a prospective two-year study show that UT-DSAEK produces visual outcomes comparable to DMEK with lower complication rate. However, DMEK is still safer regarding graft rejection, and we do need more data to see how ultra-thin DSAEK performs in this respect. There are pros and cons to every medical procedure, and at this time the decision for either DSAEK or DMEK is usually based on patient's individual

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needs and surgeons' equipment and experience. Ultra-thin DSAEK provides the best of both worlds, and thus might become the future of endothelial keratoplasty.

Keywords: endothelial keratoplasty, descemet's stripping automated endothelial keratoplasty, DSAEK, ultra-thin descemet's stripping automated endothelial keratoplasty, ultra-thin DSAEK, lamellar grafts

Introduction

Penetrating keratoplasty (PK) or full-thickness corneal transplantation has been a gold standard of treatment for many corneal diseases for over a century. However, many corneal diseases do not affect all the corneal layers and surgeons have traditionally asked why they should replace the whole cornea if only one or several layers are affected and need replacement.

Preserving one or more layers of a recipient cornea is beneficial from several standpoints: preservation of the normal tectonic strength in the eye with higher resistance to traumatic rupture for the rest of the patient's life, avoidance of 'open sky' surgery with its related serious risks like haemorrhage or expulsion, quicker visual recovery and decreased risk of corneal graft rejection. Although surgeons were well aware of the theoretical advantages of lamellar surgery, it did not really gain in popularity until the development of good surgical techniques enabling safe surgery and quick visual recovery in patients receiving a lamellar graft. Depending on the corneal layer(s) affected by the disease, lamellar surgeries are considered to be either anterior lamellar (when only the anterior layers of the cornea are replaced); or posterior-endothelial lamellar (if only posterior corneal layers are replaced).

Endothelial keratoplasty (EK) is the selective replacement of a diseased endothelium with a healthy donor endothelium. It is the preferred way to restore vision when the inner cell layer of the cornea stops working properly as in the case of Fuchs´s dystrophy, bullous keratopathy, failed previous graft or other endothelial disorder. The idea of lamellar transplantation of the posterior cornea for endothelial diseases was proposed in 1950 by Jose Barraquer, but because of technical difficulties it took some time for this type of surgery to be widely accepted [1].

Gerrit Melles, the founder of modern EK, reported in 1998 a novel surgical technique for posterior lamellar keratoplasty, showing that the oedematous cornea can be cleared if provided with a new functioning endothelial cell layer via a posterior corneal graft. In his first report a graft was inserted through a large corneo-scleral incision and subsequently bending of the graft allowed a 5 mm incision to be used [2-8]. In a large prospective study in the United States, Terry and Ousley reported their results with posterior lamellar keratoplasty, a procedure they termed deep lamellar endothelial keratoplasty (DLEK), using both the 5-mm incision and the older 9-mm incision [9,10]. An improvement on DLEK was Descemet's stripping with endothelial keratoplasty (DSEK). In this procedure, pioneered by Mark Gorovoy and Francis Price, the host Descemet's membrane is stripped by the Melles technique, and then the donor posterior cornea is cut to leave a donor button consisting of posterior stroma, Descemet's membrane, and endothelium. This button is folded once, inserted into the anterior chamber via a small incision, and opened by gentle manipulation with a cannula. The graft is held in place by an air bubble until suction created by the donor endothelium adheres the graft to the host [11].

Initially, the lamellar cut was performed by manual dissection, but Gorovoy started performing lamellar cuts with automated microkeratome - naming this procedure DSAEK (Descemet's stripping automated endothelial keratoplasty) [12]. The number of DSAEK surgeries has dramatically increased since the 2000s, accounting for over 50% of all corneal transplants in the USA and approximately 30% of those in Europe. More and more surgeons are performing DSAEK because it is a safer surgery than PK. Moreover, DSAEK patients are more satisfied with their uncorrected visual acuity (UCVA) than those who undergo PK, especially regarding visual recovery rate [13-18].

Stable visual acuity does not occur for at least six months to one year after a conventional PK, and sometimes it requires even longer. With DSAEK there is a faster recovery, and most patients have usable vision within six weeks after the operation; some have excellent vision after just one week [16-18]. The most important factor influencing the quality of vision after transplantation is the degree of astigmatism, which is highly unpredictable in PK and commonly 3 to 5 D of mean refractive cylinder, whereas after DSAEK patients can typically expect up to 1.5 D [18]. As previously mentioned, EK has several advantages over PK. However, the major concern of many surgeons has been the greater endothelial cell density loss during EK, which has been reported to be up to 41% at six months after DSAEK; this is indeed higher than the early cell loss reported in most PK series [18, 19]. The early cell loss with DSAEK is not surprising, because it entails more donor tissue manipulation than PK. However, studies with longer follow-up have shown that after one to three years ECD cell loss is similar in DSAEK and in PK [20-22]. Melles et al investigated a further refinement of lamellar transplantation and initiated transplantation of the Descemet's membrane alone, Descemet's membrane endothelial transplantation, or DMEK [23,24]. The main advantages of DMEK over DSAEK are better and faster visual recovery, near-normal anatomical restoration of the cornea and fewer immune reactions [25-30]. Namely, the number of eyes achieving 20/25 (0.8) or better vision with DMEK is much higher than in DSAEK, where despite the fact that patients are typically very pleased with the results objective visual acuity of 20/25 (0.8) is quite rare.

Despite the excellent vision achieved with this technique, DMEK unfortunately does have some drawbacks: the technique is technically more difficult and theoretically leads to higher endothelial cell density loss because of longer manipulation with a very thin donor graft, a rebubling rate of >50% is reported in the literature, it is not feasible in the case of corneal scarring or cloudy cornea, it is more time-consuming, its failure rate is relatively high according to some reports, and there is a higher risk of losing the tissue during donor preparation [25,31]. There are also eye conditions which preclude the use of DMEK for endothelial replacement technique as in the case of glaucoma tube shunt, iris defect or any sort of opening to the posterior chamber, and excessively deep or shallow anterior chamber.

The most widely accepted and performed endothelial lamellar surgery nowadays is still Descemet's stripping automated endothelial keratoplasty (DSAEK), followed by Descemet's membrane endothelial keratoplasty (DMEK). The main topic of this chapter is a new surgical approach called ultra-thin Descemet's stripping automated endothelial keratoplasty (UT-DSAEK).

Given that DSAEK is surgically safe and easy, and that very thin DMEK grafts bring quicker and better visual recovery, a so-called ultra-thin DSAEK with endothelial lamellar graft of less than 100 µm thickness was proposed in 2009 by Massimo Busin as a surgical method which combined the advantages of DSAEK and DMEK [32-34]. The real cut-off thickness for a lamellar graft to be considered ultra-thin has not been universally adopted by all corneal surgeons, although nowadays most of them agree that grafts thinner than 100 micrometres belong to the ultra-thin group.

How Important Is the Thickness of the Endothelial Grafts?

From the first DMEK cases it became obvious that this surgical technique provides excellent vision and is superior to DSAEK. Since the main characteristic of a DMEK graft is its extreme thickness (only Descemet membrane with endothelial cells is grafted!), several studies have been made in the last decade exploring the importance of endothelial graft thickness in visual recovery [35].

The factors that can affect the thickness of a donor lamella used during DSAEK include the pre-cutting thickness of a donor cornea, donor corneal curvature, back pressure in the artificial anterior chamber, and the translational speed of the microkeratome. Among the first such studies was the one published by Neff et al, in which the authors compared visual acuity of thin lamellas averaging 109 µm with thick lamellas averaging 162 µm, concluding that thinner lamellas bring statistically significant improvement in best-spectacle corrected visual acuity (BSCVA) [36].

A prospective study was also carried out in our institution, investigating BSCVA in 20 eyes that underwent UT DSAEK and 30 eyes that had conventional DSAEK, all for the treatment of pseudophakic bullous keratopathy. The median postoperative graft thickness in ultra-thin group was 78 µm as compared with 190 µm in the conventional DSAEK group. Postoperative slit-lamp appearance of an ultra-thin graft at one week after surgery is shown on Figure 1. Postoperative thickness of a lamellar graft can be determined with an anterior non-contact optical coherence tomography (anterior OCT).

Typical images of an ultra-thin DSAEK graft compared to a conventional DSAEK graft are shown in Figure 2. In terms of visual outcomes, the ultra-thin DSAEK group achieved much better postoperative BCVA both in quantity and speed of recovery compared with conventional DSAEK [21].

Similarly, Maier et al reported that DSAEK with corneal lamellar thickness < 120 µm is an interesting therapeutic alternative to DMEK since visual results are comparable [37]. However, there are also published studies in which the authors have found either a very small or no direct effect of DSAEK lenticule thickness on six-month postoperative visual acuity, contrary to previous studies [38-40]

Debate as to whether thinner DSAEK grafts indeed result in much better final visual recovery is still ongoing, but the trend among surgeons is to attempt to produce thinner grafts. Although donor graft thickness is a relevant factor in visual recovery after EK, it is certainly not the only one since the regularity of the cut performed with microkeratome, irregularities or scarring in the interface region and possibly the difference in corneal curvatures between donor and recipient corneas play a part as well [41-43].

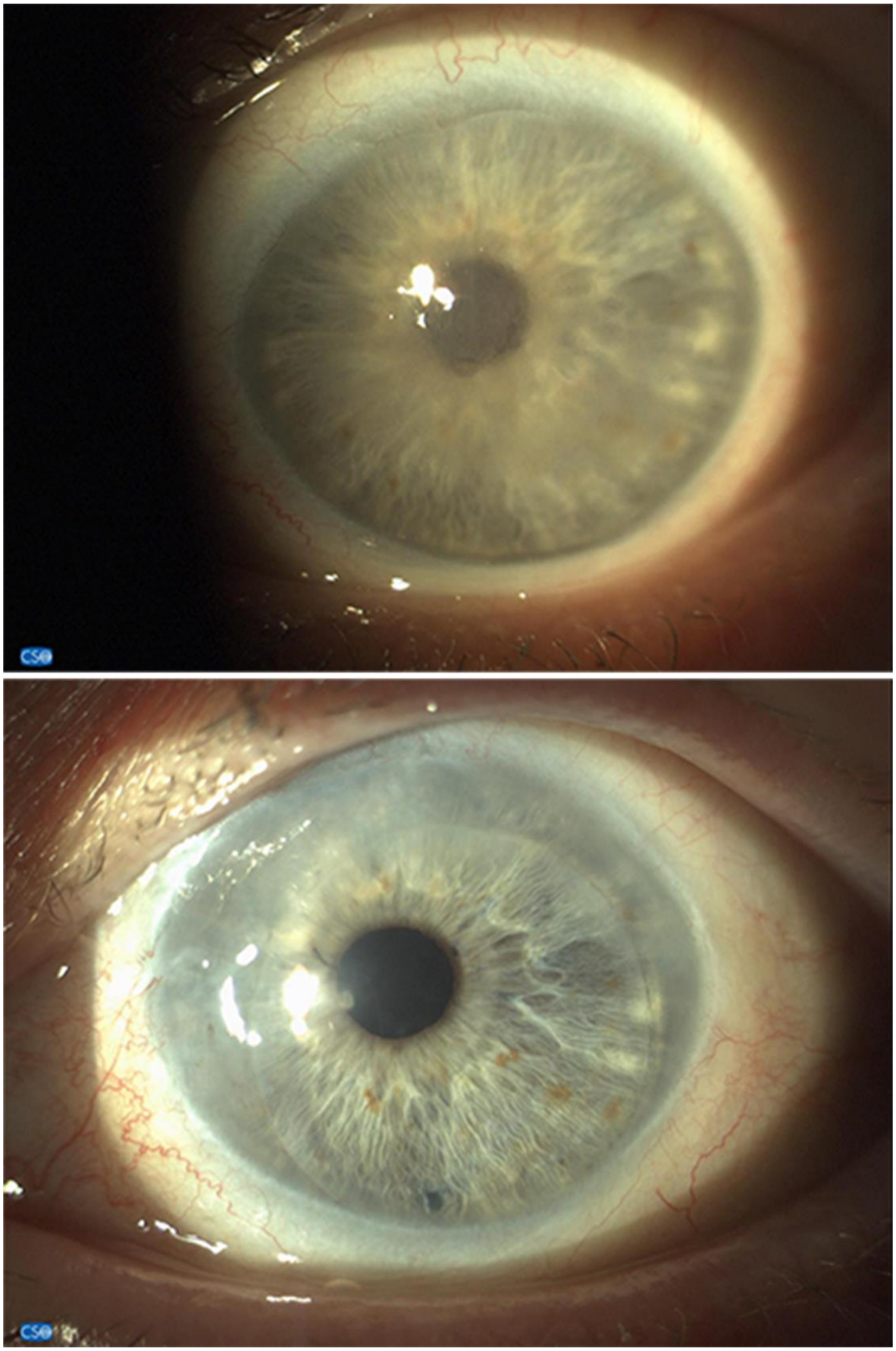


Figure 1. Ultra-thin DSAEK graft in a patient with pseudophakic bullous keratopathy at one week after surgery: preoperative (up) and postoperative (down) slit-lamp images.

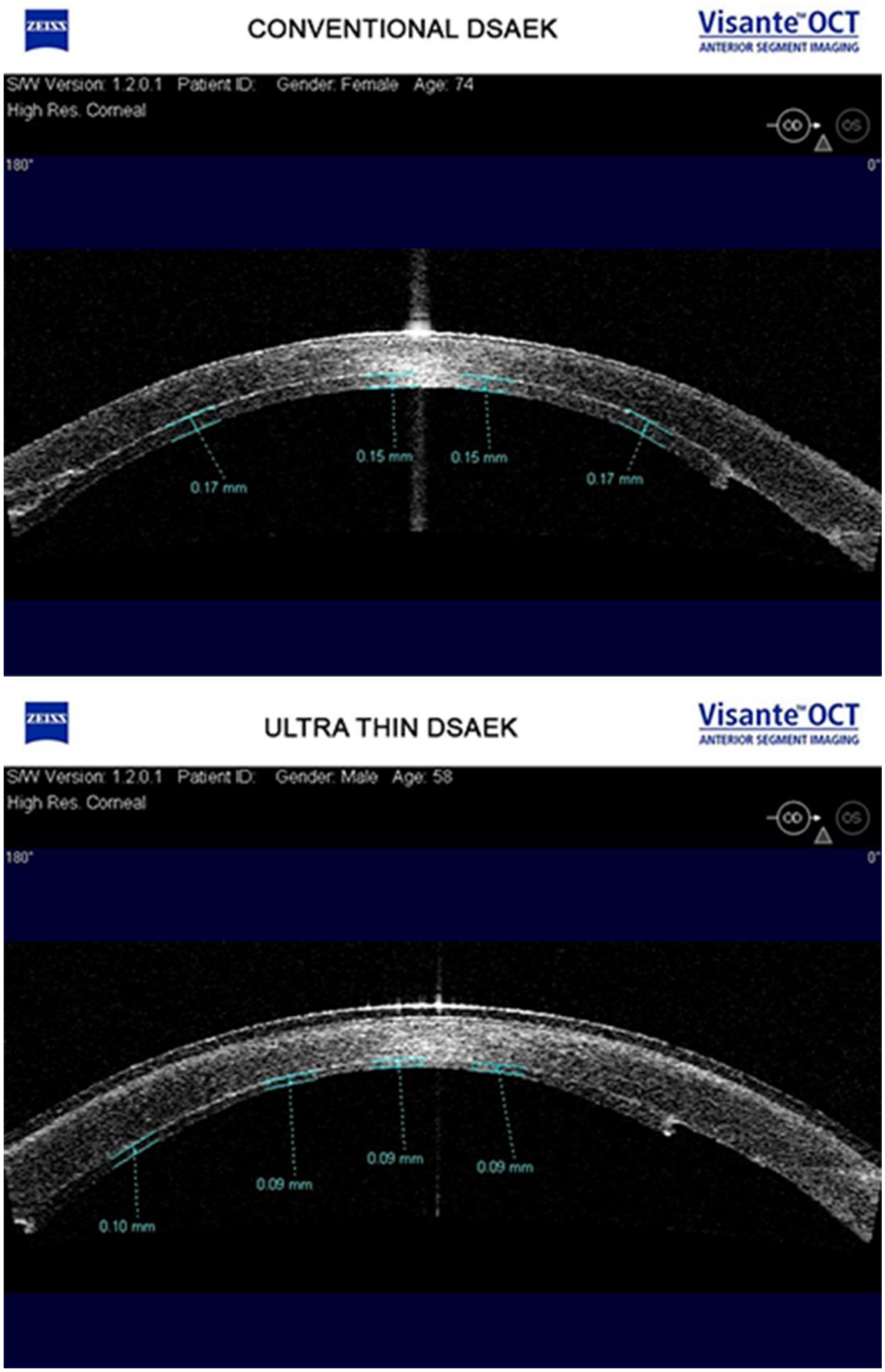


Figure 2. Comparison of optical coherent tomography (OCT) scan presenting a conventional DSAEK graft (up) with an ultra-thin DSAEK graft (down) one month after surgery.

Ultra-Thin DSAEK: Surgical Technique

Donor Selection for Ultra-Thin DSAEK

Corneal transplantation safety and success are very dependent on donor selection, perhaps even more so in the case of lamellar keratoplasty. General donor medical assessment and contraindications on the use of donor ocular tissue as set by the European Eye Bank Association (EEBA) medical standards are almost the same as for PK, apart from the need for every single layer of a donor cornea to be healthy. Selection of suitable donor tissue has been simplified so that only part of the donor corneal tissue is needed, and every healthy layer of a donor cornea can be used (or one healthy cornea for two procedures!). This permits an increase in the donor pool and corneal grafting activity, since even donors with one inappropriate corneal layer (e.g. stroma and epithelium in the case of endothelial keratoplasty or endothelium in the case of anterior keratoplasty) can be used for lamellar surgery. This is of great importance in countries confronted with corneal graft shortages [44]. Proper donor selection includes slit-lamp, specular microscopy and pachymetric analysis of the donor cornea to estimate which part is acceptable for which type of corneal surgery. Depending on the type of LK, there are several specific requirements. If the donor tissue is scheduled for Descemet's stripping automated endothelial keratoplasty (DSAEK), endothelial cell density (ECD) as high as possible is recommended and a healthy endothelium with a minimum diameter of 7.0 to 7.5 is needed in order to transplant enough endothelial cells (EC) for a functional graft. Bearing in mind the increased chance of intra-operative EC loss in EK compared with PK, a donor cornea with high preoperative number of EC is a good choice in the case of EK, especially if the surgery is performed by inexperienced surgeon. Namely, during the learning curve of DSAEK surgery it would be wise to choose donor corneas with a high preoperative EC count in case of higher than expected ECD loss during surgical procedure.

It is very important to select a donor tissue for EK with at least 3 mm of scleral rim so it can fit safely on the artificial anterior chamber used for a lamellar cut. Otherwise, if the rim is too small to fit securely onto the anterior chamber prior to microkeratome cut, tissue preparation for EK might be impossible. In Europe, most surgeons still prepare donor tissue for EK in the operating theatre prior to endothelial keratoplasty, but the donor lamella can also be prepared in the Eye Bank as ‘pre-cut’ or ‘ready for surgery’ tissue in the manner widely accepted in the USA.

Preliminary studies show that the BSCVA, ECD loss and donor detachment rates are comparable for surgeon-dissected and Eye Bank dissected corneal tissue used for DSAEK [45, 46]. Tissue preparation for ultra-thin DSAEK is also most widely performed by surgeons; however in some eye banks which have all the necessary equipment it is also prepared by a qualified laboratory technician. Very thin lamellar grafts as needed for ultra-thin DSAEK can be achieved by two different surgical approaches, double-pass and single-pass technique.

Double-Pass Technique

In 2009 Busin presented a promising novel approach to DSAEK surgery in which he combined the advantages of both DMEK grafts (very thin tissue) and DSAEK grafts (much easier surgical preparation and manipulation of the graft). It was originally called ultra-thin

DSAEK. Instead of the conventional approach in which the donor corneal lamellar graft is prepared with one microkeratome pass, in the ultra-thin procedure donor tissue is created with two microkeratome passes [32, 34]. The first step of the procedure is called debulking step and the second one refinement step. Prior to the cut, the donor corneo-scleral rim is placed gently on the artificial anterior chamber (AAC) to avoid damage to the delicate endothelial cells. Once the tissue is mounted and aligned on the AAC, a tight seal is made to maintain high pressure within the chamber. Constant pressure in the AAC is maintained by placement of the infusion bottle at height of 120 cm above the tissue and by clamping the tubing at 50 cm from the entrance to the chamber. The thickness of the tissue is then measured by pachymetry (ultrasound pachymetry preferably) for proper selection of the microkeratome head. According to some authors, for the first microkeratome pass it is important to perform peripheral thickness measurements as well [47]. If the surgeon is using a cornea obtained from organ culture as a storage method, a microkeratome head of 300 to 350 micrometres is used in most cases for the first, debulking cut, aiming to remove approx. 2/3 of anterior stroma. If the cornea was previously stored in a cold-storage medium, somewhat thicker pre-cut values can be expected, and microkeratome of 350 or even 400 micrometres is used more often. Donor corneas with a thickness greater than 600 micrometres may not be ideal for a double-pass technique, since predictability of the depth of the microkeratome cut in corneas with stromal swelling is rather poor. Preliminary studies have been published showing that donor corneas for ultra-thin DSAEK can be additionally de-swollen to improve the quality of graft interface after a double-pass cut (preconditioning of the cornea) [48, 49]. To ensure uniform dissection, first microkeratome cut should be performed in relatively slow (at least 4 seconds), continuous manner and the obtained anterior lamella can be used for anterior lamellar keratoplasty if needed. Before the second, refinement cut, the thickness of the residual stromal bed must be measured to evaluate a proper microkeratome head for a second cut. Namely, even when performed perfectly, there are some limitations to microkeratome cuts since the same microkeratome head can provide different final tissue thicknesses. If the obtained thickness of the tissue is lower than 150 microns a second cut should not be made because of the high risk of perforation. The tissue must be rotated from the starting position before the second cut is initiated, and this is done by rotation of the dovetail of the chamber for 180 degrees. Rotation of the tissue is necessary, since by starting the cut from opposite direction, the second cut gets deeper exactly where the first cut was shallower, and the risk of perforation will be minimized. Moreover, the obtained shape of the graft is more planar resulting in decreased postoperative hyperopic shift. A second or refinement cut is usually made with a 50, 90, 130 to 200 microkeratome head, depending on the thickness of the residual bed, in order to achieve a donor lenticule of 100 micrometres or fewer. Again, the cut should be made slowly and steadily for at least 6 seconds. Complications during cutting may be perforation or failure to achieve perfect dissection (unequal thicknesses of the graft) [34]. Since the goal of a cut is to obtain very thin tissue, preparation of ultra-thin DSAEK tissue may lead to a higher perforation rate than the conventional cut for DSAEK, if the mentioned precaution measures are not taken. Factors which may influence the success of an ultra-thin cut are as follows: donor tissue characteristics (over-thick tissue is not appropriate!), processing techniques, and proper choice of microkeratome head size [47]. When starting the procedure it is better to aim for values around 100 microns or a little more to avoid perforation, and only once one is acquainted with the procedure and more confident with the second cut, should one go below 100 microns.

Single-Pass Technique

With the development of novel microsurgical devices which provide microkeratome heads able to perform very deep anterior lamellar dissection, some surgeons started ultra-thin graft preparation with only one cut of the microkeratome, the so-called single-pass technique. Single-pass mikrokeratomes (MK) are motor-driven linear microkeratomes which allow single-pass dissection of ultra-thin endothelial lamellae with a standard deviation of ≤ 20 μm. A microkeratome head of desired size depending on the corneal pachymetry is used in such approaches to cut the donor cornea placed on the anterior chamber by only one pass of the microkeratome head in order to achieve a very thin donor lamella of around 100 microns or less [50]. It has been shown that single-cut ultra-thin DSAEK tissue processing can be performed safely without peripheral corneal thickness measurements; unlike the double-pass technique which according to some authors requires peripheral thickness measurements for the first but not the second MK pass [47].

Laser-Assisted Cut

Attempts have been made to create a thin lenticule even with femtosecond laser photodisruption. However, confocal microscopy has shown that femtosecond laser-assisted cuts result in rougher surfaces and worse BCVA compared with mechanical dissection [51-53]. Femtosecond laser cuts have been tried also from the inverse side by cutting the posterior lamellar graft from the endothelial side, to avoid variable graft thickness obtained after corneal aplanation which is necessary to perform conventional cut from epithelial side. Despite the fact that grafts obtained from endothelial side were thin and of uniform thickness, in 10 DSAEK cases receiving such a graft postoperative vision was poor due to substantial interface haze [54]. With the further development of femtosecond laser cuts this technique might become an option; however, given the current quality of femtosecond lamellar cuts it is better to use a microkeratome for ultra-thin DSAEK grafts. A modified form of the ultrathin DSAEK preparation with excimer laser so-called “microkeratome and excimer laser-assisted endothelial keratoplasty (MELEK)” has been also tried as new technique in the field of lamellar keratoplasty. In this technique the graft is prepared by a single cut of a microkeratome leading to average thickness of the residual stromal lamella of 173 microns before laser ablation; and finally to an average of 111 microns after stromal excimer-laser thinning and smoothing [55]. However, more data are necessary to objectively test advantages and disadvantages of this novel procedure.

Transplantation of Ultra-Thin Donor Graft

After a successful ultra-thin cut, the anterior part of a donor cornea (if healthy) can be preserved for anterior lamellar transplantation unless legal regulations in a particular country forbids the use of one donor tissue in two recipients. At the dissected posterior part of the cornea the periphery is marked with a 9.0 marker stained with trypan blue and a letter F (or similar) is marked on the anterior surface to control proper positioning of the graft in the anterior chamber. The surgeon then removes the tissue from the anterior chamber, taking care to keep the tubing bent in order to prevent collapse of the chamber and consequent endothelium damage [34]. The final punch of a donor endothelial graft is made from the endothelial side with a corneal trephine of desired diameter, after placement of the tissue onto a conventional donor punch system. Prior to removing the trephine, pull the rim upwards to prevent incomplete punch. It is wise to measure the vertical meridian of the recipient cornea before making a final punch in order to achieve endothelial graft of the correct size for each eye. Approximately 0.5 mm of recipient bed should remain free of the donor tissue; thus the donor tissue should be punched from the endothelial size aiming for 0.5-1 mm smaller graft diameter then the vertical diameter of a recipient cornea. Usually this means that the desired diameter is 8 to 9 mm. A larger donor will have more endothelial cells, but depending on the size of the eye and anterior chamber it may be more difficult to insert, and it may overlap with the superior incision and side-ports. A too small donor will not contain as many endothelial cells and it may cause visual acuity loss if the donor is not perfectly centered.

For a surgeon with experience of DSAEK grafts the remaining steps of the surgical procedure are easy since they are almost the same as for DSAEK. The only difference is that an ultra-thin graft tends to curl since it is much thinner than the conventional DSAEK lamella, so the manipulation with the tissue is somewhat different. Surgery is started by epithelium removal to improve visibility, if needed. Some aqueous is removed with 25-27G needle and replaced by air. With the bent needle, diseased recipient Descemet's membrane is stripped from the stroma, being careful not to engage the overlying corneal stroma so that a smooth posterior corneal surface is preserved, and the Descemet's is placed close to nasal limbus. Two paracenthesis are made on nasal (3.0-3.2 mm) and temporal (1 mm) side, and the recipient endothelium is removed using forceps. The anterior chamber (AC) maintainer is placed through the superior incision to fill the anterior chamber, and then the inferior iridectomy is made with vitreoretinal scissors. The surgeon should use a different glide for the insertion of ultra-thin tissue then in conventional DSAEK; the one which has a loading platform to scoop the graft from the punch, thus eliminating the need to transfer the graft with forceps (the graft may easily roll if elevated with forceps). Once in a glide, centre the ultra-thin graft, remove any remaining fluid and advance the graft to the tip with a delicate forceps. Place the tip of the glide in the nasal side-cut and insert the graft into the AC with the help of delicate forceps (e.g. 23-gauge forceps) inserted from the temporal side. Keep the AC maintainers on, fulfilling the chamber, throughout this step. Allow the tissue to open and then remove the AC maintainer. The graft is attached to the recipient stroma with an air-bubble placed beneath the tissue filling the anterior chamber, as in a conventional DSAEK. The incision sites are sutured tightly with 10-0 Nylon sutures. Finally, add more air beneath donor tissue with a 30G needle via long peripheral tunnel till the AC is full of air. Peribulbar steroid and antibiotic is given at the end of surgery. Patient should remain in supine position for at least 2 hours, and then checked at slit-lamp. If the intraocular pressure is very high and the air is still covering the peripheral iridectomy at 6 o'clock position, remove some air at the slit-lamp. Our patients are regularly checked for first three postoperative days, then again at 1 week, monthly thereafter for 3 months, and then every second month. All the mentioned surgical steps are very similar to the conventional DSAEK, and the results of visual recovery seem to be completely comparable to DMEK.

Complications

Like in any other surgical procedure, some complications may occur with the use of ultra-thin DSAEK technique. Many of them can be avoided with careful planning of the surgery and postoperative follow-up. For example, the diameter of the lamellar graft should be planned carefully, since we need to graft sufficient number of endothelial cells, but grafts of large diameter may lead to several problems. For example, if one tries to insert a 9 or 9.5

mm graft into an average anterior chamber, the graft may reach the angle and disable easy access to the anterior chamber for air-fluid exchange at the end of the case, or cause peripheral anterior synechiae. In general, smaller diameter buttons will cause fewer complications, because the insertion is easier, less air is needed for adhesion, and there is a decreased chance of peripheral synechiae formation; and it has been clearly shown that grafts of 8.5 mm does not offer any clinical advantage over 8-mm grafts with respect to postoperative endothelial cell counts at two years after surgery [56]. Positioning of the side-ports is also very important. If the side-ports are not made far enough in the periphery, and away from the ultra-thin graft edge, both dislocation of the lamellar graft or collection of aqueous in the interface may occur during air-fluid exchange. Proper sizing of the nasal incision is also crucial to avoid trauma to the endothelium caused by tissue compression, which may occur if the incision is too small [57]. With the thinner tissue, as with ultra-thin DSAEK grafts, the chance of endothelium damage from tissue compression during insertion might become smaller. After insertion of the lamellar graft into the AC and its proper centration, it is important to elevate the intraocular pressure to around 30 to 40 mmHg, to obtain enough pressure to adhere the graft onto the stroma. Main postoperative complications of every EK procedure are: graft detachment, primary graft failure, graft rejection and infection. Complications of ultrathin DSAEK reported in a study by Busin et al were: failure to achieve perfect dissection in 7.2% of cases, total graft detachment in 3.9%, primary failure in 1.4% and secondary failure in 1.4% [34]. Both graft detachment and primary failure rate are much lower as compared to DMEK procedure showing the safety of this novel technique. However, probability of one-year graft rejection after ultra-thin DSAEK is still somewhat higher (2.4%) as compared to 1% with DMEK grafts [29]. Additional studies and long term results for ultra-thin DSAEK are still lacking to fully understand benefits and disadvantages of the technique.

There are yet no reports on infection after ultra-thin DSAEK, but there have been clinical reports on bacterial and fungal infection deep in the interface after conventional DSAEK [58, 59]. The timing of clinical symptoms may be the best indication as to the specific cause of infection since bacterial infections usually develop rapidly, within a few days, while fungal contamination develops over a period of weeks to months. In case of infection, penetrating keratoplasty will be required to eradicate the infection.

Post Operative Results with Ultra-Thin DSAEK Technique

The ultra-thin DSAEK technique has been introduced quite recently as a novel surgical approach, and thus not many studies have been published comparing the clinical results of this method with those most frequently used like DSAEK and DMEK. Massimo Busin et al published the largest two-year prospective study showing that DSAEK using donor grafts thinner than 131 μm produces visual outcomes comparable to those of DMEK but without DMEK's higher complication rate. The authors used a double-pass microkeratome technique to create DSAEK grafts with a mean central graft thickness of 78 μm three months after surgery. They evaluated the two-year visual outcomes and graft survival rates of this procedure in 250 consecutive patients operated on by the same surgeon. The percentage of patients achieving 20/20 (1.0) BSCVA at three, six months, one year and two years was 12.3%, 26.3%, 39.5% and 48.8%, respectively. This is almost identical to previously published results for DMEK and better than previously published results for standard DSAEK [34]. Some studies have shown higher percentages of eyes achieving 20/20 (1.0) vision with DMEK, but their follow-up was limited to six months to one year [26, 27, 30]. Graft survival probability with ultra-thin DSAEK at one and two years was 97.8% and 96.2%, respectively [34]. The negative cylinder was practically unchanged, similarly to what is recorded after DMEK. Mean endothelial cell loss was approximately 35% at one year, which is similar to that recorded after DSAEK and DMEK [20, 26]. The authors note that the speed of visual recovery after ultra-thin DSAEK was somewhat slower than that recorded after DMEK. However, this delay could be a consequence of the substantially lower preoperative visual acuity in this series in comparison with the DMEK series published to date [34].

The study performed in our clinic, comparing the visual outcome between PK, conventional DSAEK and ultra-thin DSAEK grafts in patients with pseudophakic bullous keratopathy (PBK), showed that ultra-thin DSAEK grafts provide faster and more complete visual rehabilitation than conventional DSAEK and PK. The eyes in the conventional DSAEK group were further subdivided into three subgroups based on first-day postoperative endothelial graft thickness: thin grafts with a lamellar thickness below 180 μm, medium-thick grafts of between 180 and 250 μm and thick grafts over 250 μm. In terms of visual outcomes, the ultra-thin DSAEK group achieved much better postoperative BCVA both in quantity and speed of recovery compared with all conventional DSAEK groups. Mean BCVA in ultra-thin DSAEK was almost 20/25 (0.75) already at one month, becoming 20/25 (0.8) at month three and still improving to almost 20/20 (0.9) at two years. The thinner DSAEK grafts of fewer than 180 microns recorded the best visual acuity among the three DSAEK subgroups and attained a superior mean BCVA of 20/32 (or 0.66) then PK. By contrast, thick grafts of ≥ 180 microns never reached the same BCVA score of either ultra-thin, thin DSAEK grafts or even PK (Figure 3) [21].

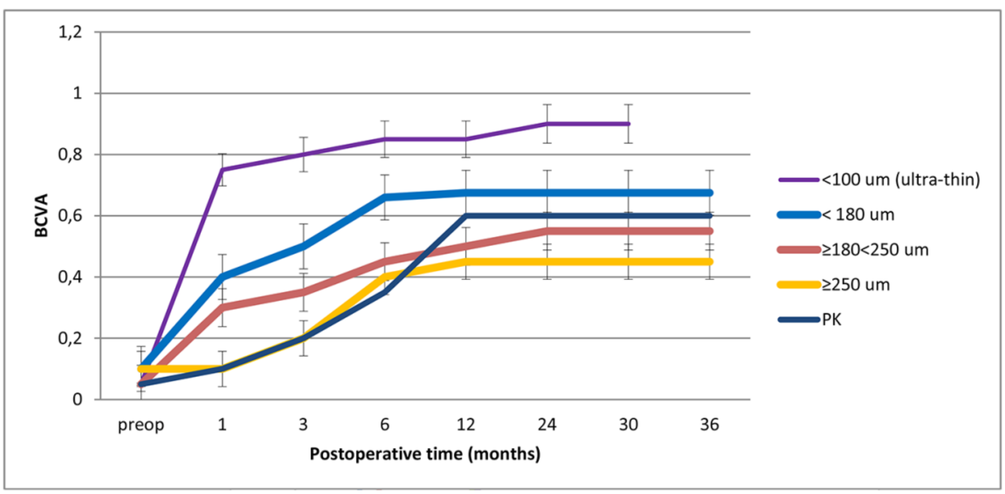
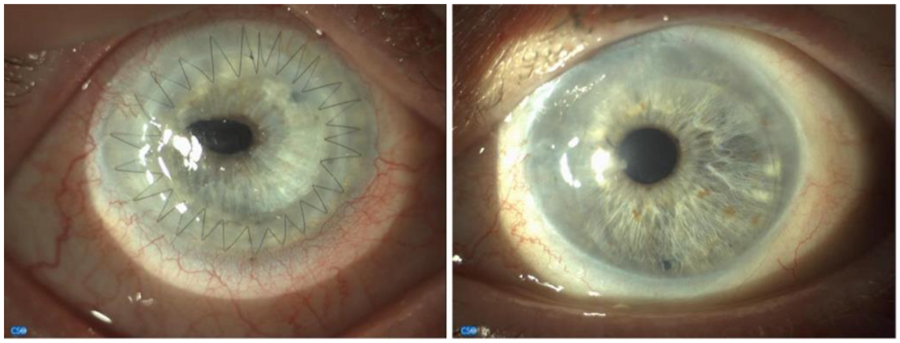
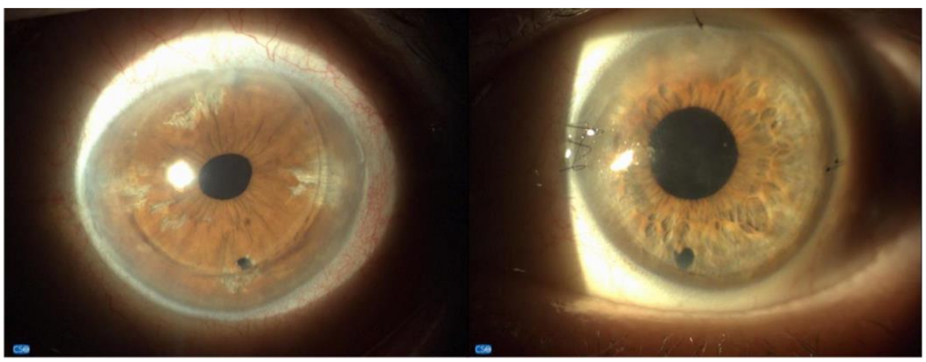


Figure 3. Comparison of best corrected visual acuity (BCVA) between ultra-thin Descemet`s stripping automated endothelial keratoplasty (<100 μm, ultra-thin), conventional Descemet`s stripping automated endothelial keratoplasty (DSAEK in three subgroups according to thickness of lamellar graft: <180 μm, ≥180<250 μm, ≥250 μm) and penetrating keratoplasty (PK).



Postoperative best corrected visual acuity	PK	UT DSAEK
1 week	0.15	0.55
3 months	0.35	0.95
6 months	0.65	1.00

Figure 4. Comparison of slit-lamp image and visual outcome in the same patient operated for pseudophakic bullous keratopathy by two different surgical techniques: penetrating keratoplasty (PK, right) and ultra-thin Descemet`s stripping automated endothelial keratoplasty (UT-DSAEK, left).



Postoperative best corrected visual acuity	DSAEK	UT DSAEK
1 week	0.4	0.5
3 months	0.75	0.9
6 months	0.8	0.95

Figure 5. Comparison of slit-lamp image and visual outcome in the same patient operated for pseudophakic bullous keratopathy by two different surgical techniques: Descemet`s stripping

automated endothelial keratoplasty (DSAEK, right) and ultra-thin Descemet`s stripping automated endothelial keratoplasty (UT-DSAEK, left).

The difference in visual recovery was dramatically different between the PK and UT-DSAEK eyes; as illustrated in the case study of a patient who had PK in one eye and ultra-thin DSAEK in his fellow eye which showed that the patient obtained BSCVA of 20/60 (or 0.35) in the PK eye three months after surgery whereas he had 20/20 (or 0.95) in the UT-DSAEK eye (Figure 4). Comparing the visual outcome in a case operated with conventional DSAEK and ultra-thin DSAEK, visual acuity was better in UT-DSAEK, reaching BCVA of almost 20/20 (or 0.9) at three months after surgery, as compared with 20/25 (or 0.75) in conventional DSAEK (Figure 5) [21].

When we checked the difference in endothelial cell density loss between PK, DSAEK and ultra-thin DSAEK cases in a longer follow-up, we could not find any significant difference in ECD loss between the investigated groups (Figure 6) [21].

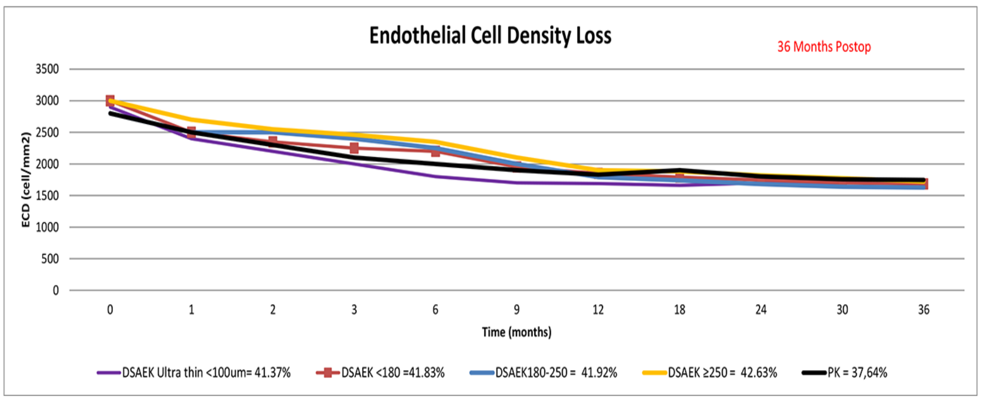


Figure 6. Postoperative endothelial cell density loss (ECD) in patients operated on for pseudophakic bullous keratopathy, either by ultra-thin Descemet`s stripping automated endothelial keratoplasty (ultra-thin DSAEK), conventional DSAEK (in three subgroups according to thickness of lamellar graft: <180 μm, ≥180<250 μm, ≥250 μm) or penetrating keratoplasty (PK). The percentage of ECD loss in each group is represented in the legend.

Conclusion

At the moment the range of different endothelial keratoplasty procedures allows us to manage each case based on the patient's individual needs, but ultra-thin DSAEK seams to be a good choice to combine the advantages of two well-known EK procedures: DSAEK and DMEK. However, more studies in a larger number of cases among different surgeons are needed to finally prove how ultra-thin DSAEK performs, and whether it is indeed the future of endothelial keratoplasty.

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