Modified Microkeratome-Assisted Posterior Lamellar Keratoplasty Using a Tissue Adhesive

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Objective: To compare graft stability and astigmatic change using suture vs tissue adhesive in an experimental model of microkeratome-assisted posterior lamellar keratoplasty.

Methods: A 300-µm-thick partial flap keratectomy was performed in human donor corneoscleral rims using an artificial anterior chamber and a manual microkeratome. The flap stopped at the left central opening border, providing a wide hinge to add stability. After flap reflection, a 6.25-mm trephination was performed to obtain a disc of posterior stroma, Descemet membrane, and endothelium. The disc was positioned in a sutureless fashion, and the flap secured with either 5 interrupted sutures or a chondroitin-sulfate-aldehyde–based adhesive. Increasing intrachamber pressures were created to detect graft stability. Videokeratographic data were recorded to evaluate astigmatic change.

Results: The mean (SD) astigmatic change was 3.08 (0.84) diopters (D) in the sutured group and 1.13 (0.55) D in the glued group ($P = .008$). Mean (SD) resisted pressures were 95.68 (27.38) mm Hg and 82.45 (18.40) mm Hg in the sutured and glued groups, respectively ($P = .97$).

Conclusion: This modified technique of microkeratome-assisted posterior lamellar keratoplasty showed excellent graft stability in both groups. Flaps sealed with the novel tissue adhesive had reduced astigmatic changes in our experimental model.

Clinical Relevance: Sutureless microkeratome-assisted posterior lamellar keratoplasty using tissue adhesive may become a new alternative in the surgical treatment of corneal endothelial disorders.

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ENDOTHELIAL CELL DYSFUNCTION accounts for most penetrating keratoplasties performed in developed countries.1 Endothelial cell failure has been frequently associated with ocular trauma after intraocular lens implantation and endothelial corneal dystrophies.2,3 At present, surgical treatment of corneal endothelial decompensation is limited to penetrating keratoplasty. Penetrating keratoplasty is a safe and effective method for restoring corneal transparency in patients with disabling corneal opacities.4-6 However, recovery is prolonged, and visual rehabilitation is often hampered by high-degree astigmatism.7,8 Some authors have attempted endothelial cell transplantation,9,10 and present clinical applications appear to be feasible only using a posterior stromal lamellar carrier (posterior lamellar keratoplasty [PLK]). In this approach, replacement of the posterior stroma, Descemet membrane, and endothelial cell layer is accomplished through a scleral pocket.11-14 The technique has shown promising results. However, it is laborious and requires a highly skilled surgeon.

Instruments used for laser-assisted in situ keratomileusis can also be used to perform posterior lamellar transplantation using a corneal flap technique.15 Several recent studies have shown promising results using these procedures in human subjects.16-18 Advantages as compared with penetrating keratoplasty include preservation of the original central corneal surface, avoidance of extensive superficial suturing, and a decrease in the thickness of the tissue transplanted.

In this experimental model, we attempt to develop a modified PLK using a manually guided microkeratome and an artificial anterior chamber. The purpose of the study was to compare the graft stability and astigmatic change using 2 types of wound closure techniques: standard suturing vs a novel chondroitin-sulfate–based corneal adhesive.
DONOR TISSUE

After receiving approval by the institutional review board of the Johns Hopkins University, Baltimore, Md, we obtained donor corneoscleral rims (n=8) not suitable for transplantation from the Central Florida Lions Eye and Tissue Bank, Tampa. Corneas were preserved under standard eye bank conditions and kept hydrated in Optisol-GS medium (Bausch & Lomb Surgical, Inc, San Dimas, Calif) at 4°C. The procedure was performed no longer than 10 days after death. Demographic data are shown in Table 1.

EXPERIMENTAL SETTING

A manual microkeratome (LSK One; Moria USA, Doylestown, Pa) was used to perform a hinged-flap keratectomy just past the central opening of the chamber in a way that created a large hinge. This opening is similar to an artificial nondilated pupil, which could be the reference point in a clinical setting. A 300-µm flap stromal bed was used in all corneas. The artificial anterior chamber (ALTK System; Moria USA) was used to support the corneoscleral rims as described in previous reports.16,19,20 The gearless tracks on the base plate of the artificial anterior chamber were designed to fit into the microkeratome head so that its pass across the cornea maintains the same plane and direction. All discs with posterior stroma, Descemet membrane, and endothelial cell layer were obtained using a 6.25-mm free-hand trephine. Intrachamber pressures were recorded using a digital manometer (Digimano 1000, Netech Corp, Hicksville, NY). The artificial anterior chamber was connected to an infusion system with a Balanced Salt Solution bag (Abbott Laboratories, Chicago, Ill). The height of the bag was adjusted accordingly using a modified pulley system to obtain the desired intrachamber pressure.

SURGICAL TECHNIQUE

An infusion of isotonic sodium chloride was released before the corneoscleral rims were placed on the base of the anterior chamber to clear the residual air from both the infusion line and underneath the cornea. The solution bottle was raised 1.5 m above the level of the chamber to obtain adequate intrachamber pressures (60-70 mm Hg) for the microkeratome pass. Corneas were centered according to circular guides in the base of the chamber. Mechanical epithelial scraping was performed with a new 2.5-mm, straight, rounded-tip crescent knife (Beaver; Beckton Dickinson Surgical Systems, Franklin Lakes, NJ) to avoid surface irregularities due to loose epithelium, which may introduce errors in pachymetric and videokeratographic measurements.

The artificial anterior chamber was set to achieve a maximal flap diameter in all cases using the diameter setting lens (ALTK System). The maneuver was intended to leave as much area in the stromal bed as possible for performing the trephination and suturing of the flap. The surgeries were all performed by the same experienced surgeon using a surgical microscope to avoid variability related to different surgeons (Ophthalmic 900S; Moeller-Wedel, Hamburg, Germany).

Several drops of 0.5% proparacaine hydrochloride were applied to the corneal surface prior to the microkeratome pass to approximate clinical conditions. A partial flap keratectomy was performed by passing the microkeratome head with its oscillating blade at a relatively constant speed across the plate, stopping just past the central opening of the chamber. A new blade was used to perform each surgery. Differing from previously published techniques, this approach attempts to obtain a wide flap hinge with a relatively less likelihood of flap slippage to provide more stability to the corneal flap and reduce the corneal opening (Figure 1).16,19,20 The remaining stroma underneath the flap hinge was severed using a 2-mm-wide Culler iris spatula (Sparta Surgical Corporation, Concord, Calif) to leave adequate space to perform a central trephination. Intrachamber pressure was returned to 18 to 20 mm Hg by lowering the height of the isotonic sodium chloride solution bottle to 25 cm above the cornea level, and the trephine was centered according to the keratectomy and “pupillary” edge provided artificially by the central opening of the chamber. A hand trephine of 6.25 mm in diameter was used to perform a circular cut of the stromal bed. The trephine blade was carefully rotated until perforation and the remaining circular cut completed with corneal scissors. Donor buttons were placed in the recipient beds and left unsutured, and the flap was repositioned.

STUDY GROUPS

The experiment consisted of 2 groups of 4 corneas each. In group 1 (group 1), the flap was secured with 5 interrupted 10-0 nylon sutures (Sharpoint Surgical Specialties Corporation, Reading, Pa) (Figure 2). The suturing technique was the same in all corneas to ensure consistency. In the second group (group 2), the flap was secured using an experimental tissue adhesive based on chondroitin sulfate. The chemical basis of this adhesive is available elsewhere.21 In both groups, the transplanted disc was left without sutures or glue because it tends to stay in place by surface tension after the intrachamber pressure reaches 15 to 18 mm Hg.

MEASUREMENTS

After epithelium removal, the isotonic sodium chloride infusion was closed, and corneal thickness was measured using an ultrasound pachymeter (Pach IV; Accutome Inc, Malvern, Pa). The ultrasound probe was lightly opposed to the center of each cornea, obtaining an average of 5 different readings. A second measurement was made after the hinged flap was created and reflected from the stromal bed. Central flap thickness was then calculated.

For surface curvature analysis, we used a commercial videokeratoscope (EyeSys Laboratories, Inc, Houston, Tex). The Placido disc was placed in a vertical position and the chamber centered according to the monitor control. This setting was adopted from a previous study to obtain reproducible measurements.19 Care was taken to preserve the orientation in preoperative and postoperative recordings. Three measurements were performed preoperatively and postoperatively for each cornea.

To assess graft stability, intrachamber pressure was raised progressively by changing stepwise the height of the bottle, as previously reported.22 Under visual control with the surgical

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microscope at ×12 magnification, presence of leakage was monitored and pressure recorded by digital manometry as described earlier in the article.

STATISTICAL ANALYSIS

Calculations were made using StatsDirect, version 1.9.0, for Windows (CamCode, Ashwell, England). Mean, standard deviation, minimum, and maximum values were described. Comparisons between groups were performed using the nonparametric Mann-Whitney U test for unpaired samples and the Wilcoxon signed rank test for paired samples. A Spearman rank correlation test was performed to assess the dependence of resisted pressure on donor size. A P value of .05 was considered statistically significant.

RESULTS

The surgical procedure was simple and similar to a combination of a corneal flap technique and penetrating keratoplasty. The mean (SD) flap thickness was 317.25 (51.65) µm in group 1 and 263.25 (67.73) µm in group 2 (P = .25).

There was a significant difference regarding the preoperative and postoperative change in average keratometry values between both groups. The mean (SD) change in average keratometry value for group 1 was 3.08 (0.84) diopters (D), whereas for group 2 that change was 1.13 (0.55) D (P = .008) (Table 2) (Figure 3).

In terms of stability of the graft, we observed great variability in both groups. A higher resistance was observed in group 1. The mean (SD) calculated resisted pressure was 95.67 (27.37) mm Hg (range, 56.2-119.9 mm Hg).

Group 2 had a lower leaking pressure of 82.45 (18.40) mm Hg (range, 57.9-102.1 mm Hg). However, this difference was not statistically significant (P = .97).

COMMENT

Penetrating keratoplasty has been the only treatment of visual impairment resulting from corneal endothelial cell decompensation for many years. Recovery of vision can be delayed by corneal distortion resulting from the presence of sutures because of the degree of tension necessary to obtain a watertight wound.

Barraquer first reported the transplantation of posterior corneal tissue underneath an anterior lamellar flap. Melles et al and Van Dooren et al reported a technique of PLK through a limbal incision creating a stromal pocket. Terry and Ousley have described a similar technique, also using a limbal incision and deep stromal dissection. Lamellar corneal surgery has become more popular recently with the use of microkeratome instrumentation, achieving a remarkable cut quality with the latest systems. The smoothness of the cut surface may lead to a better surgical outcome with a clearer interface, which is essential to obtaining a good optical result. Posterior lamellar keratoplasty is emerging as an alternative to penetrating keratoplasty in patients with endothelial cell dysfunction.

We previously reported on 2 different techniques of PLK using an artificial anterior chamber and microkeratome. In the first report, we used 8 interrupted sutures (10-0 nylon) in the stromal bed to secure the graft.
In our second study, we used a running graft suture to secure the graft. However, we have observed that the transplanted corneal disc tends to remain attached to the flap stroma, without sutures, when the pressure is within physiologic limits. Now we believe that the stromal surface tension at the donor-recipient interface, together with a physiologic intraocular pressure, contributes to keep the disc in the right place. With the additional pump of endothelial cells, these adherent forces may be stronger.

Compared with penetrating keratoplasty, PLK may have several advantages, including less surgical time, less risk of intraoperative complications, less risk of high astigmatism, faster visual recovery, less frequent follow-up visits for selective suture removal, decreased risk of suture-induced neovascularization toward the graft, and less risk of wound dehiscence. Donor tissue may be used more efficiently, as with the use of corneas that might otherwise be discarded after photorefractive keratectomy.

The resultant astigmatism after penetrating keratoplasty is variable. With standard trephination methods, the mean astigmatism fluctuates between 3 and 6 D. With excimer laser trephination, the mean keratometric astigmatism fluctuates between 3 and 3.5 D. In endokeratoplasty, the mean refractive astigmatism in the small series reported was 2.9 D, whereas in our reported series using interrupted sutures for securing graft, the mean astigmatism was 3.3 D. In our last report, using a running graft suture and a sutureless hinged flap, the mean astigmatism was 1.47 D.

The use of tissue adhesive in this study produced less astigmatism than other reports of microkeratome-assisted PLK. Furthermore, the absence of sutures made the technique simpler and considerably less time-consuming. However, one of the major concerns of this technique is the stability of the graft because of the reduced support of the sutureless disc in the posterior stroma and the wide anterior opening with the flap. It is possible that in time, there could be slippage of the glued interface, which could lead to induced astigmatism. Although videokeratographic data showed a smaller degree of astigmatic change, further studies are needed to verify this in a clinical setting.

With the particular modifications added in this study, more stability is provided to the flap with a large hinge of almost 2 quadrants of extension. The anterior opening is therefore reduced and easily sealed with sutures or corneal adhesive. Hence, sutureless microkeratome-assisted PLK with the use of tissue glue may become a new alternative in the surgical treatment of corneal endothelial disorders. Further clinical experience is required before the widespread use of this approach in patients.

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