A Nomogram for Producing Consistently Thin Posterior Lamellar Microkeratome Cuts for DSAEK

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Abstract:

Objectives: Our goal is to determine what variables influence post-cut thickness, assess our current nomogram's results, and to subsequently manipulate its settings.

Method: 717 donor corneas were prepared between 2010 and 2012. Controlled variables included: precut corneal thickness, microkeratome head size (250, 300, or 350um), IOP during cut (90mmHg), presence or absence of epithelium, and speed of the cut (3-6 sec). Starting in Jan 2014, average cut duration was increased to 20-30 seconds and post-cut thickness was determined.

Results: The median post-cut thickness of the posterior lamellar cornea using the original nomogram was 139um: 60% measured between 100-150um and 95% measured between 100-175um. Upon adjusting the nomogram and increasing cut duration, median post-cut thickness for 91 cuts was 117um: 84% measured between 100-150um and 98% measured between 100-175um.

Conclusion: We hope that this data, combined with the nomogram, will help other eye banks in their manipulation of post-cut thicknesses.

Keywords: Endothelium, Cornea; Eye Banks; Keratoplasty, Lamellar; Nomogram

The cornea community is constantly motivated to refine techniques in the eye bank and the operating room that will improve outcomes. In Descemet's Stripping Automated Endothelial Keratoplasty (DSAEK), graft thickness matters, so we decided to retrospectively analyze three years of eye bank data to see how we measured up.

Consistently producing thin posterior lamellar cornea grafts is enviable as microkeratome cut depth is hinged on multiple variables[1]. Our goal is to determine what variables influence post-cut thickness (PostCT) and to delineate our current nomogram's results. Once with this knowledge in hand, manipulation of PostCT can be pursued.

MATERIALS AND METHODS

Corneas for the study were procured via Upstate New York Transplant Services (UNYTS). All in all, 717 donor corneas were prepared at UNYTS from 2010-2012.

The preparation procedure entails the following general steps: Connect stopcock and infusion line to infusion port of the artificial anterior chamber and flush with balanced salt solution (anterior chamber is primed with Optisol solution to ensure only preservation media is in contact with the endothelium). Center the cornea on top of the piston with the endothelial side down. Seal base locking ring over the cornea. Use the Barraquer tonometer to indirectly measure pressure and adjust to 90 mmHg with flow of solution. Use pachymetry probe to measure PreCT. Use nomogram to determine microkeratome head size based on measured PreCT (Figure 1). Microkeratome blade is mounted. Turbine pedal is pressed while the blade is passed through the cornea with a smooth turn of the wrist (3-6 seconds). Use pachymetry probe to measure PostCT after microkeratome and corneal cap are removed. Package donor cornea for storage/transport.

The nomogram used was developed at Iowa Lions Eye Bank (Figure 1). It gives a microkeratome head size and the need to leave or remove epithelium based on a pre-cut thickness (PreCT). There are other variables involved that are independent of PreCT: IOP during the cut (90 mmHg – measured with Barraquer tonometer) and speed of cut (3-6 sec). Three technicians used this nomogram and process over the course of three years, producing the data points. Data was documented, including PreCT, PostCT, microkeratome head size, presence or absence of epithelium, and age of donor.

Starting in Jan 2014, average cut duration was increased to 20-30 seconds. On top of this, the nomogram was slight-

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ly altered. With a PreCT of 401-450um, we changed the nomogram to remove the epithelium while still using the 250um head. With a PreCT of 451-500, we changed the nomogram to leave the epithelium on and use the 300um head instead of the 250um head. IOP was held at 90 mmHg throughout (Figure 2). We then used the same three technicians and documented the same data points on 91 donor corneas prepared at UNYTS from January to May, 2014.

Thickness (Pre-Cut)	Action	Cutting Head
<400 microns	Not acceptable	N/A
400-450 microns	**Remove epithelium**	250 um
451-500 microns	**Leave epithelium**	**300 um**
501-550 microns	Leave epithelium	300 um
551-575 microns	Remove epithelium	300 um
576-600 microns	Leave epithelium	350 um
601-650 microns	Remove epithelium	350 um
>650 microns	Not acceptable	N/A
IOP = 90 mmHg **Speed of cut = 20-30 sec**		

Figure 1: *Original nomogram — developed at Iowa Lions Eye Bank.*

Thickness (Pre-Cut)	Action	Cutting Head
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601-650 microns	Remove epithelium	350 um
>650 microns	Not acceptable	N/A
IOP = 90 mmHg **Speed of cut = 20-30 sec**		

Figure 2: Altered nomogram — newly defined parameters highlighted in bold.

RESULTS

The data obtained from the 717 donor corneas (2010-2012) included PreCT, PostCT, and donor age. The overall median PreCT was 556um with a range of 400-650um. The overall median PostCT was 139um with a range of 100-220um: 60% measured between 100-150um and 95% measured between 100-175um. The overall median donor age was 59 years with a range of 7-75 years. When broken down by microkeratome head size, the results were as follows. In the PreCT range of 400-500um (250um head size), 79 cuts were performed yielding a median PostCT of 154um. In the PreCT range of 501-575um (300um head size), 389 cuts were performed yielding a median PostCT of 148um. In the PreCT range of 576-650um (350um head size), 249 cuts were performed yielding a median PostCT of 121um (Figure 3).

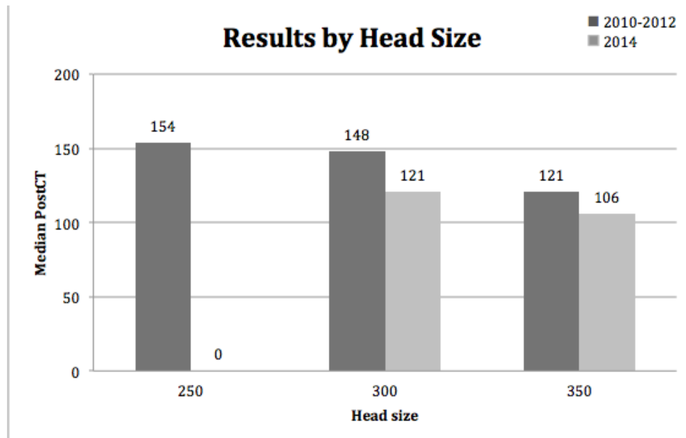

Figure 3: Bar graph — Median PostCT vs Head Size for 2010-2012 and 2014 data sets.

The data obtained from the 91 donor corneas using the edited nomogram (Jan-May, 2014) included PreCT, PostCT, and donor age. The overall median PreCT was 562um with a range of 464-649um. The overall median PostCT was 117um with a range of 99-171um: 84% measured between 100-150um and 98% measured between 100-175um. The overall median donor age was 60 years with a range of 21-72 years. When broken down by microkeratome head size, the results were as follows. In the PreCT range of 451-575um (300um head size), 56 cuts were performed yielding a median PostCT of 121um. In the PreCT range of 576-650um (350um head size), 35 cuts were performed yielding a median PostCT of 106um (Figure 3). Of note, the 250um head size was not needed as no donor cornea PreCT fell in the range of 400-450um during this time. Also of note, the 300um head size was used three times in the new pre-cut range of 451-500um: yielding PostCTs of 99, 101, and 105um.

DISCUSSION

There has been a recent push for thinner grafts to be used in DSAEK in attempt to attain better visual outcomes.

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However, this connection is not clear. Neff et al[2] found thin grafts (<132um) to result in statistically significant improvement in BSCVA. Recently, Acar et al[3] found thin grafts (<150um) to result in statistically significant improvement in BSCVA as well. On the other hand, Terry et al[4] showed that there was no difference in BSCVA in the range of 100-200um; only to find worsening in BSCVA at the extremes of thickness (<100um and >200um). Contrary to this finding, Busin and Albé[5] have shown that Ultrathin-DSAEK (<100um, using a double cut method) has superior results; three times as many patients achieved 20/20 or better vision as compared with conventional DSAEK.

In a study of Descemet's membrane endothelial keratoplasty (DMEK), the technique utilizing the thinnest of grafts for endothelial keratoplasty, superior BSCVA was found in the DMEK eye compared to the DSAEK performed in the contralateral eye of ten patients[6]. DMEK's consistently impressive results with regard to BSCVA have influenced the current push for thinner DSAEK grafts. However, Villarrubia and Cano-Ortiz[7] found similar visual outcomes between their lamella of <120um (using automated microkeratome for DSAEK) and DMEK. It is important to note that as graft thickness decreases in posterior lamellar keratoplasty, preparation and intraoperative handling becomes more difficult. This is something each surgeon has to evaluate based on his or her own abilities.

Among the parameters leading to PostCT, cut speed is obviously important. Through drastic changes in cut speed and only minimal changes to the head sizes used, we reduced our overall median post-cut thickness by 15.8%. While slower cut speeds have proven an effective tool, one potential concern is its effect on interface apposition between host and graft. The stromal interface integrity may be a source of light scatter that ultimately degrades image quality and limits final visual acuity in any DSAEK procedure. At least one study with slower cut speeds has shown impressive BSCVA after DSAEK[8]. On top of this, Bhogal and Allan[9] found that graft asymmetry using microkeratome dissection is an inherent flaw not influenced by microkeratome pass speed.

Overall, the relationship between microkeratome head size and ultimate PostCT is not easy to predict. The same head size used on the same PreCT grafts can have differing PostCTs[1]. Our data shows that this is partially due to cut speed, providing another variable to manipulate in the search for desirable PostCTs. We hope that the simple change in cut speed and the delineation of nomograms used will help other eye banks in their pursuits.

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