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Comparisons of Cornea Cold, a New Corneal Storage Medium, and Optisol-GS

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Abstract

Purpose: This study compares the quality of donor corneal tissue stored in Optisol-GS and Cornea Cold.

Methods: Seventeen pairs of donor corneas were obtained from an eye bank. One of each pair was stored in Cornea Cold or Optisol-GS. Endothelial cell loss (ECL), central corneal thickness (CCT), and endothelial cell density (ECD) were measured at 7 and 21 days of storage. Qualitative metrics were evaluated by using a slit lamp.

Results: At days 7 and 21, there were no observed differences in qualitative corneal health of the samples. There were no statistical differences in the mean ECL at 7 and 21 days between the 2 groups ($P = 0.07$ and $P = 0.50$, respectively). At 7 days, the mean CCT was 644 ± 52 μm in the Cornea Cold group and 591 ± 64 μm in the Optisol-GS group ($P = 0.001$). At 21 days, CCT was 714 ± 55 μm in the Cornea Cold group and 708 ± 58 μm in the Optisol-GS group ($P = 0.70$). The mean ECD was not statistically different between the groups ($P = 0.56$ at 7 days and $P = 0.14$ at 21 days).

Conclusions: Storage of corneal donor tissue in the Optisol-GS and Cornea Cold storage media resulted in statistically comparable ECL and ECD for up to 21 days. CCT was higher in Cornea Cold at 7 days, but this discrepancy disappeared at 21 days.

Keywords

endothelial viability; endothelial survival; Descemet membrane endothelial keratoplasty; corneal storage solution

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Ideal corneal media for transplantation involve a balance of practical storage of tissue, cellular preservation of the various layers, absence of biologic and nonbiologic contamination, and usable mechanical characteristics for surgical handling. Optisol-GS (Bausch and Lomb, Rochester, NY) remains a commonly used medium for intermediate

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storage for corneal donor tissue in the United States, whereas in other international markets, proprietary and organ culture storage media carry a larger percentage of market share.[1–7]

Common measurable metrics of corneal donor health ex vivo include both quantitative and qualitative measures, such as endothelial cell density (ECD), endothelial cell loss (ECL), epithelial preservation, and stress lines that are recorded during eye banking. These parameters provide critical data on the current quality of the donor cornea and assist in surgical judgment for appropriate live human use during transplantation. An additional physical property that can be easily measured is central corneal thickness (CCT) as a marker of the physiologic status of the cornea and how it may handle mechanically during surgery (ie, swollen vs. compact corneas and secondary osmotic medium effects).[8,9]

Cornea Cold (GenBio, San Diego, CA) is a storage medium recently approved by the Food and Drug Administration (FDA) which is the subject of evaluation in comparison to Optisol GS using the above-described ex vivo measures to determine the comparable viability for corneal tissues. Components of the 2 media demonstrate common components necessary for safe storage (Table 1).

MATERIALS AND METHODS

Seventeen pairs of donor corneas (34 total corneas) were obtained from the Sight Life Eye Bank (Seattle, WA). This sample size was determined based on previous similar studies and designed to detect at least a 20% difference in ECL (assuming a marginal error of 27% with 80% power).[10,11] The inclusion criteria were Washington state donors between the ages of 2 to 80 years, no history of eye surgery, and death-to-preservation time of 18 hours or less, with the slit-lamp microscopy protocol completed within 4 hours of death. One of each pair was stored in either the Optisol-GS or the Cornea Cold corneal preservation medium in a 33°C incubator before evaluation. At 7 and 21 days of storage, the samples underwent the following assessments: corneal health evaluated by a backlit slit-lamp microscopy approach performed by a trained eye bank tissue evaluator, cell viability measured by calcein AM (CAM) vital dye (which selectively fluoresces viable cells), CCT measured by anterior segment optical coherence tomography, and ECD measured by specular microscopy. Slit-lamp microscopy was performed by eye bank technicians after the standardized Cornea Health–Qualitative Slit-Lamp Observation of epithelium, endothelium, and folds.[12] Because CAM staining cannot be performed consecutively on the same sample, 10 of the samples (5 from each group) were randomly chosen to undergo CAM staining at 7 days, and the remaining 24 tissues were stained at 21 days. Statistical analysis for all outcomes except for corneal health was performed using 3-way analysis of variance. A P value less than 0.05 was considered statistically significant.

RESULTS

All 34 samples underwent slit-lamp examination at 7 and 21 days. Between the 2 groups, there were no differences in the subjective grading of stress lines, Descemet folds, epithelial defects, and stromal scars. At 7 days of storage, ECL was 0.87% in the Cornea Cold group and 0.51% in the Optisol-GS group ($P = 0.07$). At 21 days, endothelial loss was1.10% and 1.20% in the Cornea Cold and Optisol GS groups, respectively ($P = 0.50$) (Table 2).

Anterior segment optical coherence tomography showed no difference in the mean CCT at baseline ($P = 0.17$). At 7 days, the mean thickness was 644 μm in the Cornea Cold group and 591 μm in the Optisol GS group ($P = 0.001$). By 21 days of storage, the mean thickness was 714 μm in the Cornea Cold group and 708 μm in the Optisol GS group ($P = 0.70$) (Table 2).

The ECD by specular microscopy was not statistically different between the 2 groups at baseline ($P = 0.64$). At 7 days of storage, the mean ECD was 2693 cells/mm^2 in the Cornea Cold group and 2728 cells/mm^2 in the Optisol GS group ($P = 0.56$). At 21 days, the mean endothelial cell densities were 2452 and 2651 cells/mm^2 in the Cornea Cold and Optisol GS groups, respectively ($P = 0.14$) (Table 2).

DISCUSSION

Optisol-GS remains the most commonly used corneal preservation medium in the United States. Ex vivo studies of the medium stored at 4°C found significant increases in epithelial damage after 7 to 10 days. Epithelial damage was as high as 40% to 50% at 11 to 15 days and 60% to 70% at 15 to 34 days. However, more than 80% of the corneal endothelium was viable after 3 weeks of storage.[13,14] In our study, we chose to focus on endothelial cell viability. The medium is FDA approved for storage of corneal tissues for 14 days. Cornea Cold is a medium approved for up to 21 days of storage in Europe. Dextran is the main colloidal osmotic agent in both media, but Cornea Cold contains a T-500 high-molecular-weight dextran versus the T-40 in Optisol-GS. The cost of Optisol-GS at our local eye bank is $40 per bottle and Cornea Cold is $15 per bottle.

Corneal tissue stored in another alternative storage medium, Life4°C (Numedis, Inc, Minneapolis, MN), was studied after transplantation in patients with Fuchs dystrophy and showed comparable 6 months postoperative ECL.[6] However, Life4°C is also FDA approved for only 14 days of storage. The Chen medium (Chen Laboratories, Phoenix, MD) also received FDA approval for corneal storage. However, its investigating group was unable to obtain specular microscopic images for endothelial analysis from corneas stored in the medium for 21 days. They concluded that corneal tissue storage in the Chen medium resulted in minimal endothelial damage for up to 14 days.[11]

In this ex vivo model study, our initial results suggest comparable ECL between storage of cornea in the Optisol GS and Cornea Cold media up to 21 days. Of note, CCT was higher in Cornea Cold at 7 days, but this discrepancy disappeared at 21 days. Given ECL and ECD were not significantly different at 21 days between the 2 groups, the significantly higher CCT in the Cornea Cold group at 7 days could represent increased cellular size because of swelling, but not actual cell loss. A slightly thicker cornea at 7 days could still be suitable for Descemet stripping automated endothelial keratoplasty preparation, but the surgeon or eye bank technician performing the preparation must be aware of the CCT to achieve the desired postcut thickness goal.

In addition, Cornea Cold could provide a less costly alternative with comparable tissue preservation to Optisol-GS for up to 21 days. The fact that Cornea Cold has received the approval in Europe for storage up to 21 days in addition to its lower cost could immensely expand the pool of potential donor tissue for developing countries.

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TABLE 1.

Components of Optisol-GS and Cornea Cold

Optisol GS	Cornea Cold
MEM	T-199 and MEM-Earle
HEPES	HEPES
T-40 dextran	T-500 dextran
Streptomycin sulfate	Streptomycin sulfate
Phenol red	Phenol red
Glucose	Glucose
Pyruvate	Pyruvate
Mixture of amino acids	Mixture of amino acids
NaCl	NaCl
KCl	KCl
NaH_2PO_4	NaH_2PO_4
Glutamine	Glutamine
$MgSO_4$	$MgSO_4$
$CaCl_2$	$CaCl_2$
$NaHCO_3$	$NaHCO_3$
Gentamycin	Penicillin G sodium
Chondroitin sulfate	KNO_3
Mixture of Optisol base powder	D-biotin
β-Mercaptoethanol	D-Calcium pantothenate
	Choline chloride
	Myo-inositol
	Nicotinamide

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TABLE 2.

Differences Between Tissues Stored in Cornea Cold and Optisol-GS

	Cornea Cold	Optisol GS		
	Mean	**Mean**	***P***	**95% CI**
Cell viability (% cell loss)				
7 d (n = 5)	0.87 ± 0.34	0.51 ± 0.19	0.07	−0.06, 0.77
21 d (n = 12)	1.10 ± 0.88	1.20 ± 0.80	0.50	−0.42, 0.22
CCT (μm)				
0 d	555 ± 36	550 ± 36	0.17	−3, 13
7 d	644 ± 52	591 ± 64	0.001 *	25, 82
21 d	714 ± 55	708 ± 58	0.70	−31, 44
ECD (cells/mm^2)				
0 d	2711 ± 361	2746 ± 498	0.64	−190, 119
7 d	2693 ± 329	2728 ± 432	0.56	−161, 90
21 d	2452 ± 425	2651 ± 263	0.14	−493, 94

* *P*-values < 0.05.