Physical properties of electron-beam irradiated corneas stored in recombinant Human Serum Albumin

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**Background**

Corneal transplantation is a highly effective procedure to treat blindness caused by corneal diseases. The availability of sterile, irradiated corneal tissue may offer solutions to several problems surrounding corneal transplantation such as: limited tissue availability, potential transmission of disease or pathogens, immune rejection, and lack of long-term preserved tissues for emergent procedures.

Electron-beam (e-beam) irradiated tissues have been used with great success in many ophthalmic procedures. With the increase in popularity of sterilized tissues for ophthalmic use, we seek to further our understanding of clinically relevant properties of e-beam treated corneas.

**Purpose**

To compare the physical properties of e-beam treated corneal tissue stored in recombinant Human Serum Albumin (HSA) to that of fresh corneas.

**Methods**

The clarity, structural properties, and surgical handling of e-beam irradiated corneas were examined and compared to fresh donor corneas. Dark field microscopy and computer-aided analysis using Matlab were performed to determine corneal clarity (Center for Ophthalmic Optics and Lasers, COOLLab). Differential scanning calorimetry, tissue histology, and swell ratio were used to examine the corneal collagen matrix organization (Oregon Health and Science University, Johns Hopkins University, Lions VisionGift). The rigidity (elastic modulus) of the cornea was examined using Brillouin optical microscopy (Harvard-MIT). Tissue and suture handling evaluations were performed by a fellowship-trained cornea surgeon who was masked to tissue treatment conditions prior to handling. Statistical analysis was done using SPSS (IBM Analytics) and R (www.r-project.org).

**Results**

A. Histology of Fresh and E-beam Treated Corneas

- **Fresh**
  - H&E staining of fresh (left) and e-beam treated cornea (right).
  - The arrow points to Bowman’s membrane. **Green** arrowheads point to keratocytes, and **red** arrowheads point to keratocyte-debris after e-beam treatment.

- **E-beam**
  - The clarity, structural properties, and surgical handling of e-beam treated corneas were examined and compared to fresh donor corneas.

B. Denaturing Temperature of Fresh and E-beam Treated Corneas

- **Fresh**
  - Average denaturing temperature (measured by differential scanning calorimetry) of fresh (n=2) and e-beam treated corneas (n=3).
  - The results suggest that e-beam treatment induces only minor changes to the organization of the corneal collagen matrix.

- **E-beam**
  - The rigidity (elastic modulus) of the beam treated corneas have a higher cross-linking density than fresh corneas, even after long-term storage.

**Clinical Applications**

A. Lamellar patch gratt at 1-year postoperative using e-beam irradiated sterile corneal tissue.

B. E-beam irradiated corneas used for glaucoma shunt cover.

C. Perforation due to Herpes zoster infection addressed using sterile corneal graft and amniotic membrane.

D. Temporary whole corneal graft used for 4-weeks during treatment of severe endophthalmitis while patient waited for viable tissue.

**Conclusions**

Our analysis revealed only minor differences between the physical properties of fresh and e-beam treated corneal tissue. We found an increase in tissue cross-linking due to e-beam irradiation, and this may be advantageous in certain ophthalmic applications. Overall, these results suggest that e-beam treated corneas are suitable alternatives for fresh tissue for planned and emergent procedures.

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