2386

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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 microbial 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. As the popularity of e-beam sterilized corneal tissues increase, we seek to increase 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 (rHSA) to that of fresh corneas.

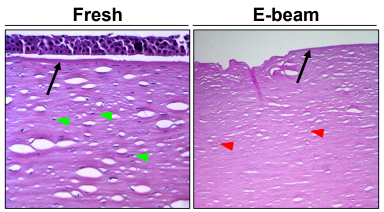
Methods

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 were masked to tissue treatment conditions prior to handling. Statistical analysis was done using SPSS (IBM Analytics) and R (www.r-project.org).

Disclosures - None

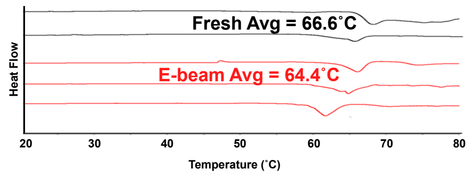
Results

A. Histology of Fresh and E-beam Treated Corneas



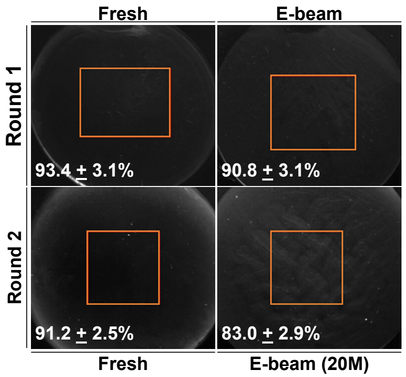
H&E staining of fresh (left) and e-beam treated cornea (right). The arrow points to Bowman's membrane. Green arrowheads point to keratocytes, and red arrowheads point to keratocyte-debris after e-beam treatment.

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



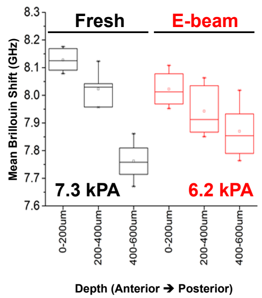
Average denaturing temperature (measured by differential scanning calorimetry) of fresh (n=2) and e-beam treated corneas (n=3). The results suggest that e-beam treatment induces only minor changes to the organization of the corneal collagen matrix.

C. Clarity of Fresh and E-beam Treated Corneas



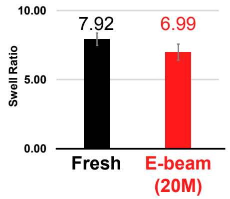
Clarity measurements are shown in each panel. **Top panels:** Clarity of fresh and e-beam treated corneas (n=18). An average of 2.3% reduction in clarity is observed. **Bottom panels**: Clarity measurement of corneas stored in rHSA for 20-months (20M) after e-beam treatment (n=5). An average of 8.2% reduction in clarity is observed.

D. Strength of E-beam Treated Corneas



Mean Brillouin shift of fresh and e-beam treated corneas. The resulting shear modulus (numbers shown inside the graph area) of the full-thickness cornea is not significantly different between the two groups (n=3 in each group).

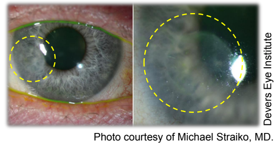
E. Cross-linking Density of E-beam Treated Corneas



The swell ratio of fresh and e-beam treated corneas after 20-months (20M) of storage in rHSA. The lower swell ratio suggests that e-beam treated corneas have a higher cross-linking density than fresh corneas, even after long-term storage.

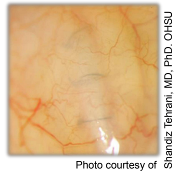
Clinical Applications

A.



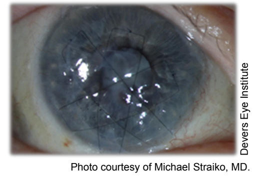
Lamellar patch graft at 1-year postoperative using e-beam irradiated sterile corneal tissue.

B.



E-beam irradiated cornea 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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