Dynamic Analysis of Hydrofluoric Acid penetration and decontamination on The Eye using high resolution Optical Coherence Tomography

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Purpose

For chemical burns a considerable lack of methods exists for defining penetration kinetics and effects of decontamination within biological structures. We demonstrate that high-resolution optical coherence tomography (HR-OCT) can close this gap. This medical imaging technique was employed to evaluate the penetration dynamics and decontamination of hydrofluoric acid (HF) within the ex vivo eye irritation test (EVEIT).

Methods

Rabbit corneas ex vivo were exposed to 25µl of 2.5% HF solution for 20 sec. Post-burn the corneas were rinsed in triplicate with each 15 minutes of water, Hexafluorine® and 1% calcium gluconate solution. Data were left untreated. The changes of the microstructure induced by the corrosive resulting in corneal opacity and the propagation within the corneal layers during and after decontamination by rinsing were monitored by OCT imaging.

Results

Application and penetration of HF resulted in a shrinking of the corneal thickness to be interpreted as result of osmolaric changes and of loss of water binding capacity. A substantial increase in OCT signal amplitudes was observed, showing full penetration in the untreated corneas within 240 seconds.

Rinsing the burned cornea with tap water and calcium gluconate (1%), the deep corneal stroma was found to remain clear until the end of the rinsing period but became opaque later. When using Hexafluorine® the cornea still remained clear for 60 min after rinsing was stopped.

Conclusions

The use of OCT as an additional diagnostic tool within the EVEIT system is capable to essentially enhance the information available by this test method. The direct access to the diffusion process of HF into the cornea provided new and valuable informations on its penetration kinetic. It allows the quantification of the efficiency of new emergency substances like Hexafluorine® in comparison to established rinsing solutions like calcium gluconate and water with a reduced number of tests.

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Fig. 1 Corneal thickness after different treatments with rinsing solutions without corneal burn and with rinsing solutions after HF burn. Each rinsing was performed for 15 minutes; HF burn was done with 2.5% HF with 25 µl in Machery-Nagel filter paper of 10 mm diameter.

Fig. 2 Untreated rabbit cornea ex vivo

Fig. 3 Rabbit cornea 15 min after burn with 2.5% HF. No change in appearance of the untreated burned eye until the end of the experiment (75 min after application).

Fig. 4 Rabbit cornea 15 min after burn with 2.5% HF rinsed with tap water

Fig. 5 Rabbit cornea 75 min after burn with 2.5% HF rinsed with tap water

Fig. 6 Rabbit cornea 15 min after burn with 2.5% HF rinsed with calcium gluconate 1%

Fig. 7 Rabbit cornea 75 min after burn with 2.5% HF rinsed with calcium gluconate 1%

Fig. 8 Rabbit cornea 15 min after burn with 2.5% HF rinsed with Hexafluorine

Fig. 9 Rabbit cornea 75 min after burn with 2.5% HF rinsed with Hexafluorine