Comparative Experimental Decontamination of Concentrated Hydrofluoric Acid (HF) in New Ex Vivo Eye and Human Skin Models

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BIO-EC who performed the skin experiments

Comparative Experimental Decontamination of Concentrated Hydrofluoric Acid (HF) in New Ex Vivo Human Eye and Skin Models

- Introduction
  - HF: production and uses,
  - HF: properties and health hazards
- Eye exposure
  - Knowledge of HF eye burns
  - Decontamination study
- Skin exposure
  - Knowledge of HF cutaneous burns
  - Decontamination study
- Conclusion

Hydrofluoric Acid

- Production:
  - Production is still increasing (> 3 million metric tons/year)
  - European production in 2001: 260 000 t
  - US production in 2002: 434 000 t
  - Chinese production in 2008: 870 000 t

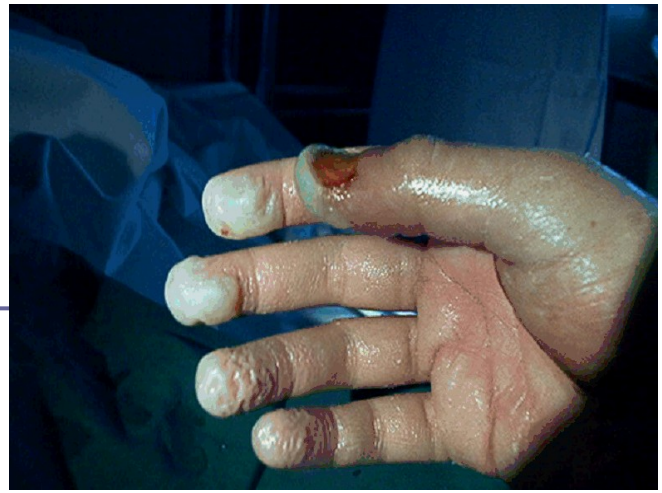
- Uses:
  - Manufactured of fluorinated compounds (organic and inorganic)
  - Metallurgy (etching, aluminium, steel treatment…)
  - Glass and crystal industry
  - Oil refinery industry (alkylation)
  - Electronics
  - Uranium treatment
  - Photovoltaic industry
  - Chemical industry

HF properties and Health hazards

- HF properties:
  - Pure state (Hydrogen fluoride) = liquid under pressure
  - In aqueous solution: 70 % maximum strength
  - Acid with fluoride ion in solution

- Health Hazards:
  - Corrosive, due to the acidic ion H^+
  - Toxic, due to fluoride ion F^- (Ca and Mg binding)

HF health Hazards



Lethal risk exists also with non concentrated solutions, depending on the TBSA involved.

Time of contact	Total Body Surface Area	HF Concentration
Skin	1 %	Anhydrous
	5 %	> 70 %
	7 %	50-70 %
	10 %	20-50 %
	20 %	< 20 %
Ingestion		> 5 %
Inhalation		

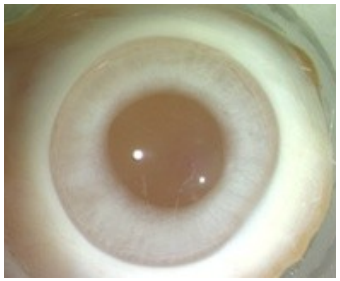
📖 *Dünser MW, Ohlbauer M, Rieder J, & al. Burns, 2004*

HF health Hazards

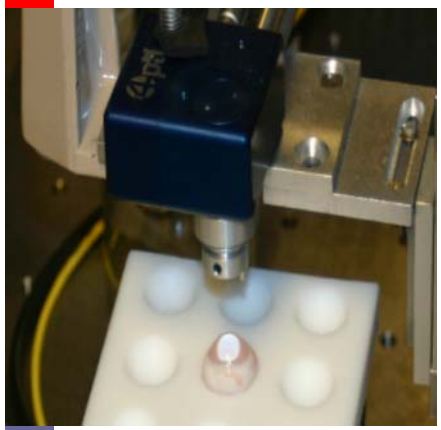
Concentration	Pain
50 % and more	Immediate and associated with a quickly visible destruction of tissues
From 20 to 50 %	Delayed by 1 to 8 hours after exposure (with erythema developing within the same amount of time)
Less than 20 %	Delayed by 24 hours or more (with erythema developing within the same amount of time)

Characteristic of HF: the pain and symptoms can be delayed. This can lead to delayed washing and then complicated secondary care. The result can be fatal.

Knowledge of HF eye burns



- Eye models and methods
  - Acute-EVEIT
    - An ex vivo model
    - Cornea of enucleated slaughtered rabbits preserved at 4°C in a specific chamber
    - reacts very similar to living eye tissue concerning the behaviour during chemical eye burn

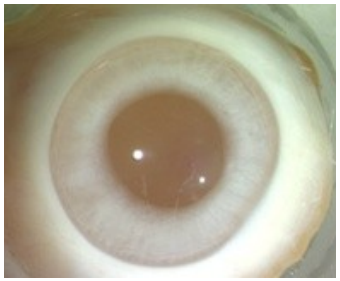


  - HR-OCT
    - OCT: Apparatus use in ophthalmology
    - Non-invasive
    - High Resolution = to be very precise

📖 *Spöler F, Frentz M, Först M, Kurz H , Schrage F. JBO, 2007*

Eye experiments

- Methods
  - 2.5 % HF (1.25 M)
  - 25 µl soaked on filter paper
  - 20 s exposure
  - Observation of HF penetration with OCT

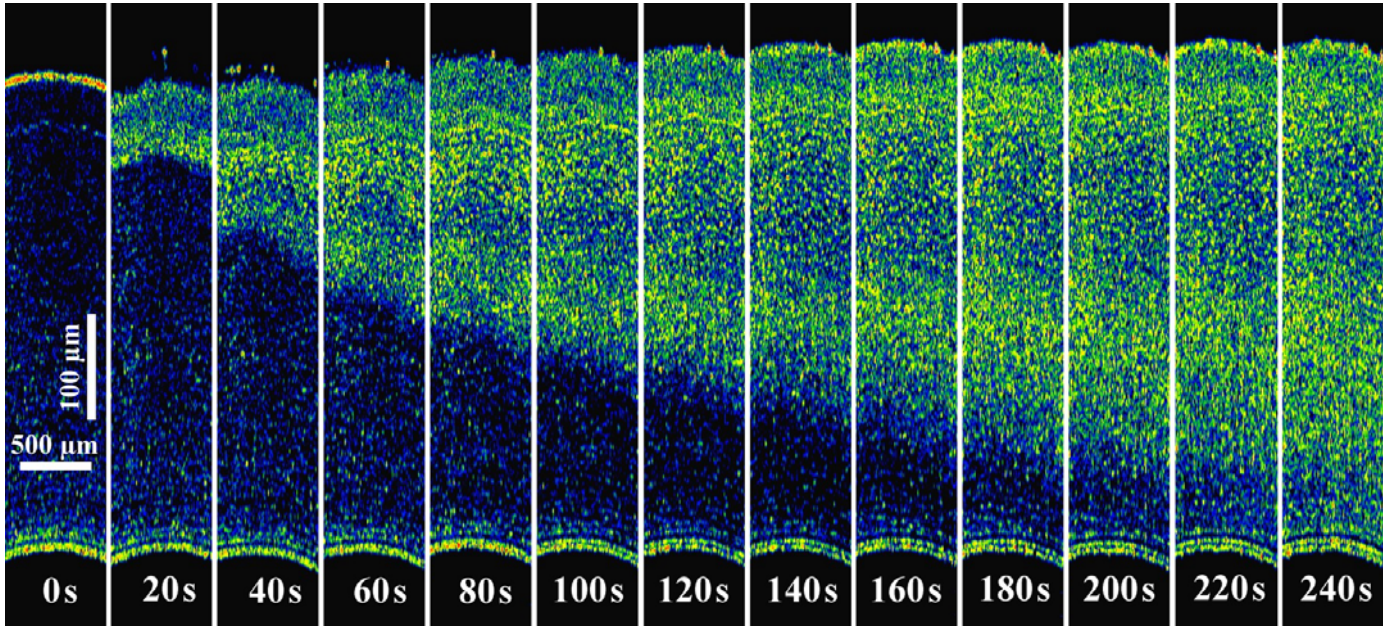


For the decontamination study:

- A group : no rinsing
- A group : with 15 minutes of tap water washing
- A group with 15 minutes of washing with 1 % calcium gluconate solution
- A group with 15 minutes of Hexafluorine® washing
- Observation until 75 min (60 min after the end of the washing)

Eye experiment: HF alone

Diffusion of 2.5% hydrofluoric acid in the rabbit cornea

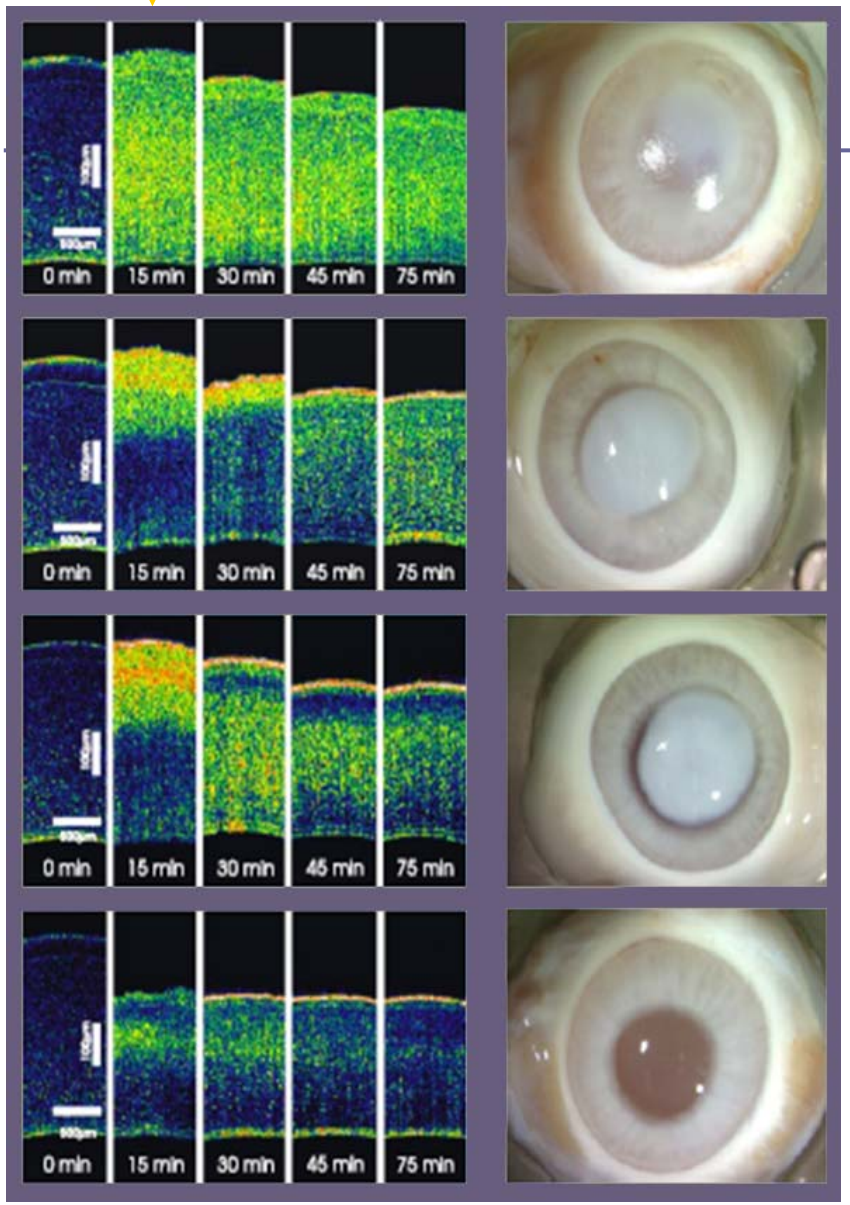


The diffusion of HF through the cornea is achieved within 4 minutes

HF penetration velocity decreases with time because of the dilution

📖 *Spöler F, Frentz M, Först M, Kurz H , Schrage F. Burns, 2008*
27th annual Conference AIOH, December 2009, Canberra

Washing end



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Eye experiment: decontamination study

- Without washing

Burn

- With water

Burn

-With a solution of calcium gluconate 1%

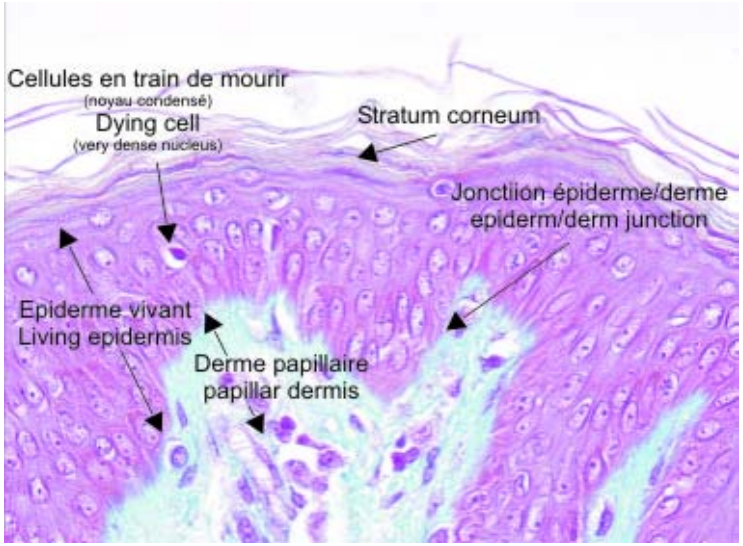
Burn

- With Hexafluorine®

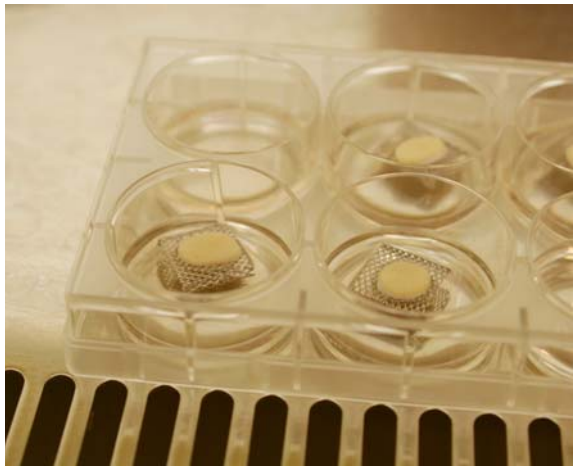
No burn

Skin experiments

- Skin model and methods
  - Ex vivo human skin explants from abdominoplasties
  - *After* obtaining informed consent
  - Explants preserved alive in BEM (BIO-EC's Explant Medium)
    - At 37° C
    - Humidified atmosphere containing 5% CO_2
- Histology results:
  - Observations of cellular structures alterations on 4 main layers of skin
    - Superficial and basal epidermis
    - Papillary and reticular dermis
  - Optical microscopy (40X objective)



Skin experiments: HF alone

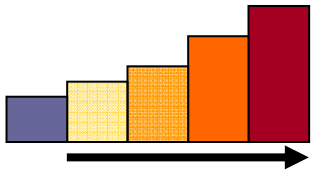


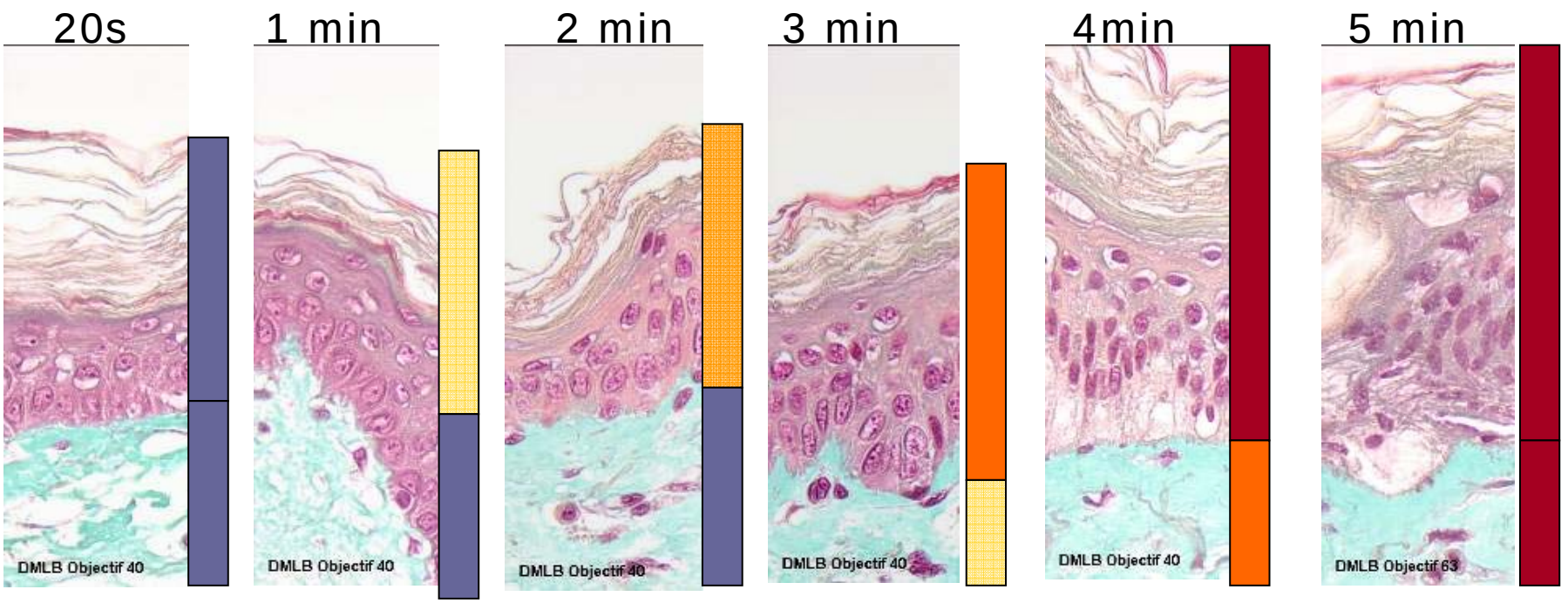
- Methods
  - Explants of 1 cm diameter
  - 70 % HF
  - 30 µl soaked on filter paper
  - Observations at 20 s and 1,2,3,4,5 minutes of exposure
  - Sampling for histology analysis just after each exposure.
  - Experiments in triplicate

Skin experiments: Diffusion of 70% HF

Duration of exposure	Morphology under the microscope
1 minute	Beginning of penetration in the upper part of the epidermis
2 minutes	Deterioration of the deep layer (basal) of the epidermis
3 minutes	Epidermis completely altered. First lesions the surface part of the dermis (papillary dermis)
4 minutes	Completely altered epidermis. Clear deterioration of papillary dermis.
5 minutes	Epidermis completely altered. Beginning of alteration of deep dermis (reticular).

Results





In these experimental conditions, the initial cellular alterations are observed after 1 minute of contact with HF. Alterations are observed more and more deeper with time.

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Skin experiments: decontamination study

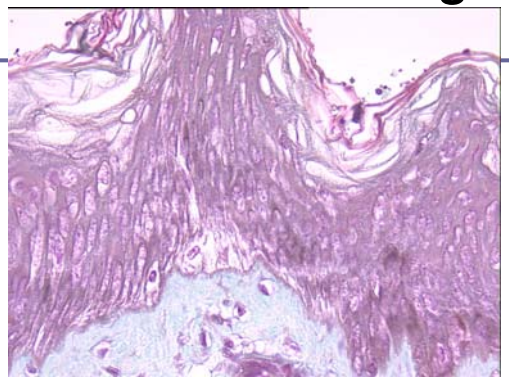
- Methods
  - Explants of 1 cm diameter
  - 70 % HF
  - 30 µl soaked on filter paper
  - 20 s of exposure

Then,

  - No washing
  - Tap water washing (2000 ml/15 min) + local application of calcium gluconate
  - Hexafluorine® washing (400 ml/10 min)
  - Observations at 20 s and up to 24 hours
  - Sampling for histology analysis just after each exposure.
  - Experiments in duplicate

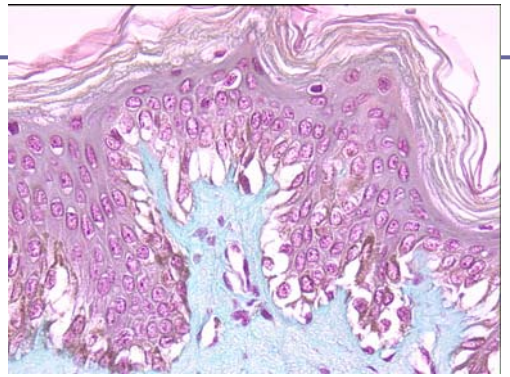
Decontamination study: Results after 24 hours

Without washing



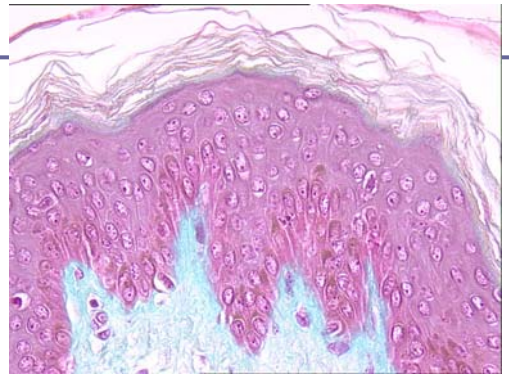
Total necrosis with grey cytoplasm, pyknotic nuclei and acidophilic cytoplasm in papillary and reticular dermis

Water + Ca Glu



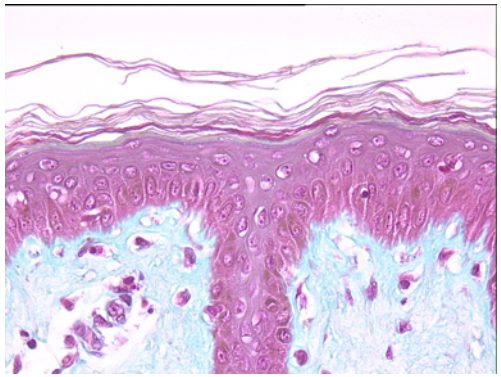
Many edematous cells in basal epidermis with very clear cytoplasm and basal membrane disruption. Pyknotic nuclei and acidophilic cytoplasm in papillary dermis; same lesion but weaker in reticular dermis

Hexafluorine®



Normal morphology in all layers

No contamination, no washing



Conclusion

- experimental burns are reproducible and representative of HF burn evolution.
- In accordance with the results for washing of contaminated workers. Washing must be performed within the first minute, and it could be even more effective within the first 20 seconds according to what has been observed in the experimental burns performed.
- Water rinsing + calcium gluconate ointment decreases and delays HF burns but repeated applications are needed.
- Hexafluorine® prevents HF burns even for concentrated HF exposure