Retrospective dosimetry on human nails using X-band EPR spectroscopy

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Outline

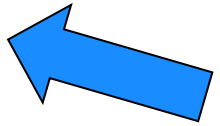
- Background
- Performance
- Results
- Conclusion
- Further investigations

Retrospective dosimetry

- For triage
- For individual dose assessment after nuclear accidents
- For dose reconstructions after radiological and nuclear accidents
- For epidemiology after exposure of many people

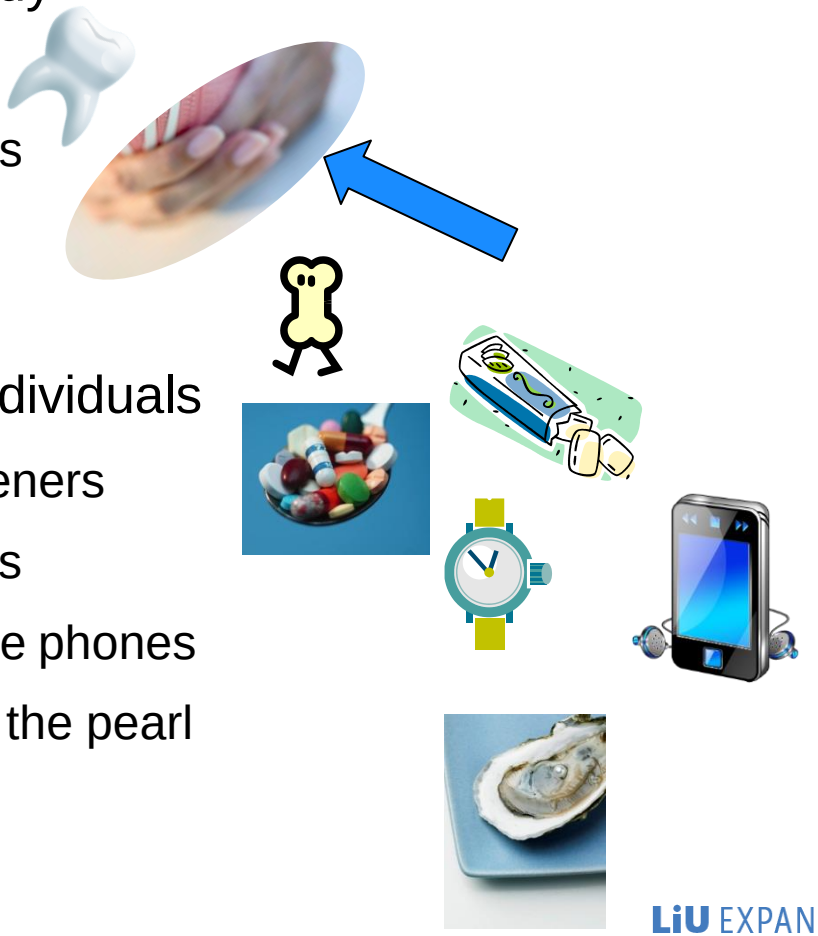
Methods for retrospective dosimetry

- Electron paramagnetic resonance EPR
- Optically stimulated luminescence, OSL
- Thermo luminescence, TL
- Biodosimetry
  - Cytogenic, transcriptomic and proteomic technologies.



What can be used for dose determinations by means of EPR?

- From the human body
  - Tooth enamel
  - Finger and toe nails
  - Bone biopsies
- Things carried by individuals
  - Sugars and sweeteners
  - Glass from watches
  - LED glass in mobile phones
  - Buttons, mother of the pearl



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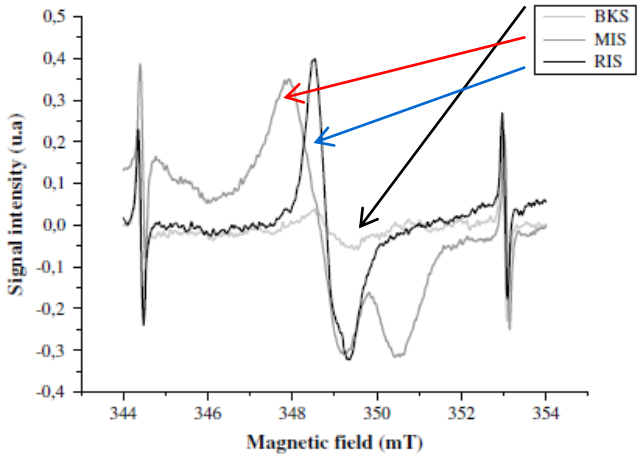
Finger and toe nails

- Main radio sensitive component; alpha keratin, a protein of alpha helical peptid chains, coiled and strengthened by S-S bridges.
- Chandra and Symons found that radicals were formed not only from ionising radiation but also from cutting the nails. Nature 328,1987
- Symons et al evaluated the possible mechanisms in radical formation, and summerized; “promising but difficult”.
  - Radiation Protection Dosimetry 58,1995
- Since then significant progress in nail dosimetry has been achieved.
- Romanyukha et al. , Radiation Measurements 42, 2007,
- Reyes et al. Radiation Environment Biophysics 48, 2009
- Trompier et al. Radiation Measurements, 44, 2009

The composed EPR spectrum

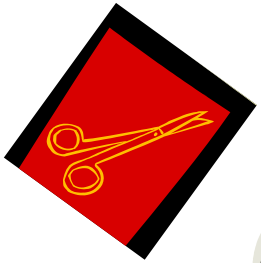
- Three types of EPR signals can be identified in the EPR spectrum
  - The background signal BKS
  - The mechanically induced signal MIS
  - The radiation induced signal RIS



From: Trompier F, Romanyukha, A, Kornak L, Calas C, LeBlanc B, Mitchell C A, Schwarz H M and Clairand I, 2009, Electron paramagnetic resonance radiation dosimetry in fingernails, Radiation Measurements, 44, pp 6-10.

Sample preparation and irradiation

- Nails are gently cut
- cleaned and dried (in open air)
- or treated in water for 10 minutes.
- Irradiated with 6 MV photons,
- cut into pieces
- placed in a 3-5 mm diam. quartz tube
- and analysed in the EPR spectrometer.



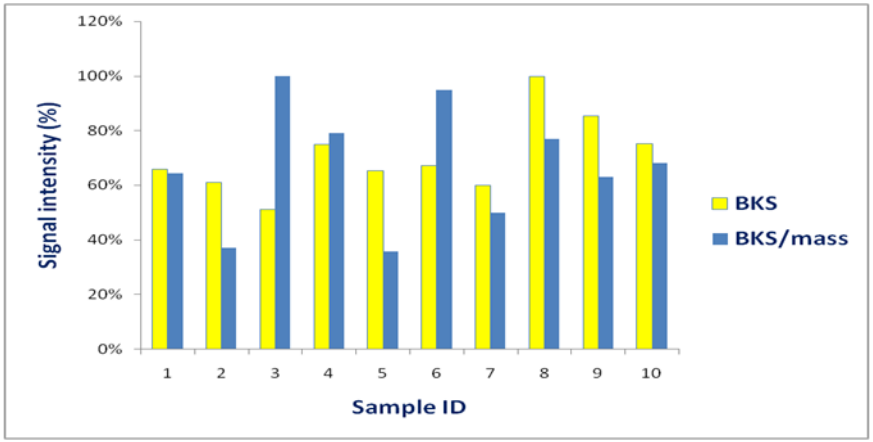
The JES-FR30EX EPR spectrometer (JEOL)

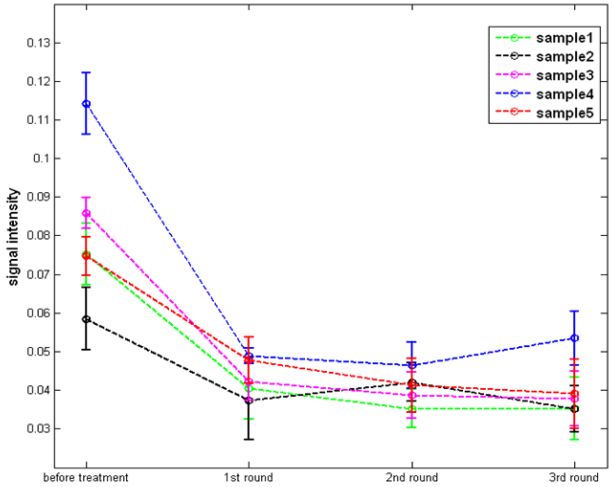
- Spectrometer settings for different experiments, spectra are always normalised to the Mn^{2+}/MgO reference

Settings	For BKS and dose response	For MIS	Comparison toe and finger nails
Microwave power	4mW	4 mW	4 mW
Sweep time	20 s	20 s	20s
Modulation amplitude	0,63 mT	0,79 mT	0,63 mT
Amp gain	200	500	400
No of sweeps	10	10	80
Reference sample position	530 a. u.	450 a. u.	430 a.u.

The BKS shows a high variation between individuals

For dry nails



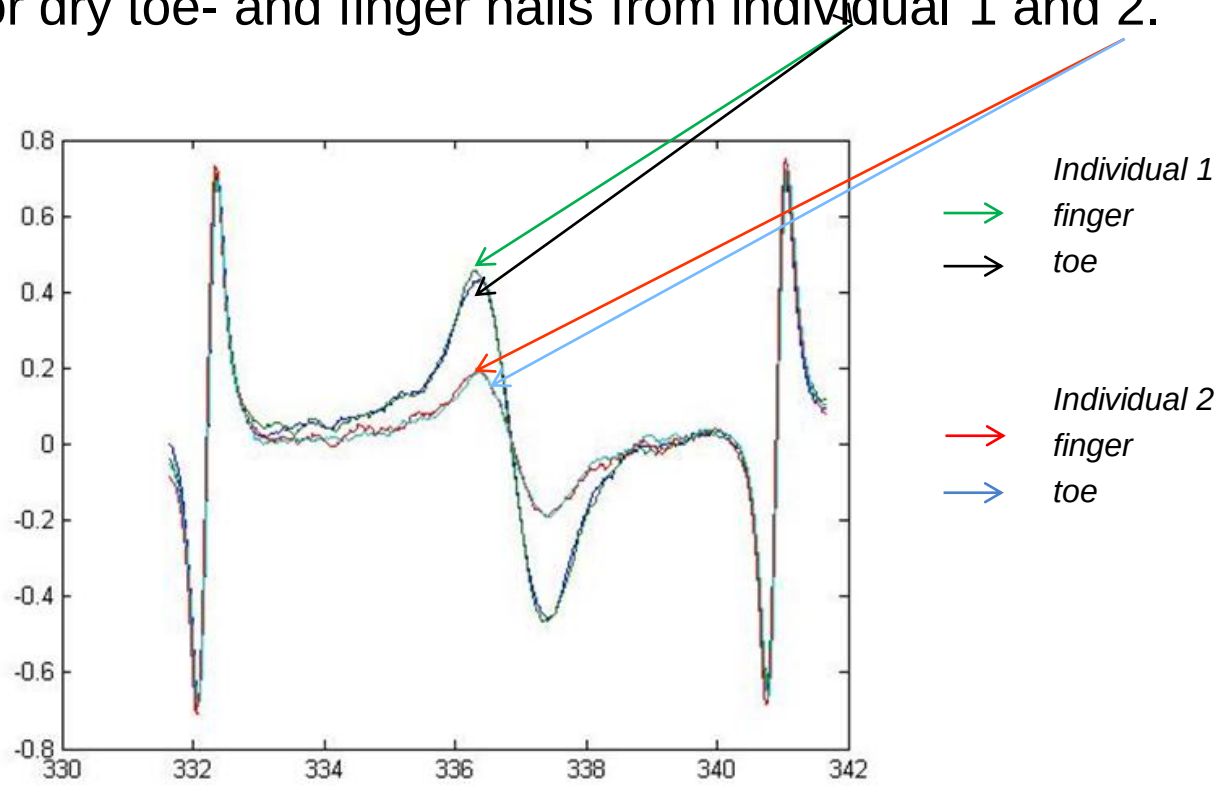


But even after one round of water treatment the BKS decreases and also the difference between individuals. The so called sponge model can give part of the explanation for this.

Ref. Reyes et al Radiat. Environ. Biophysics, 47, 2009

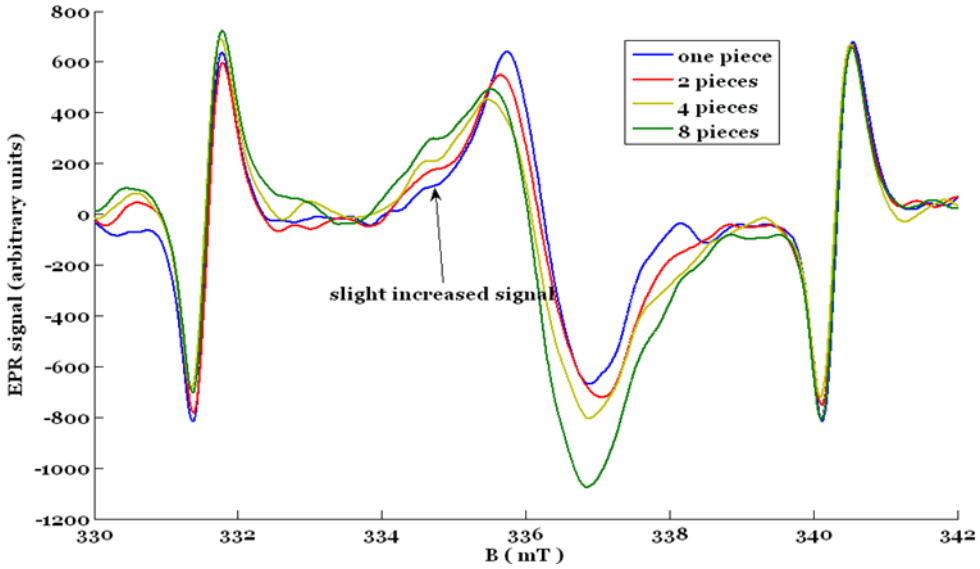
Background signals for toe and finger nails

- BKS for dry toe- and finger nails from individual 1 and 2.

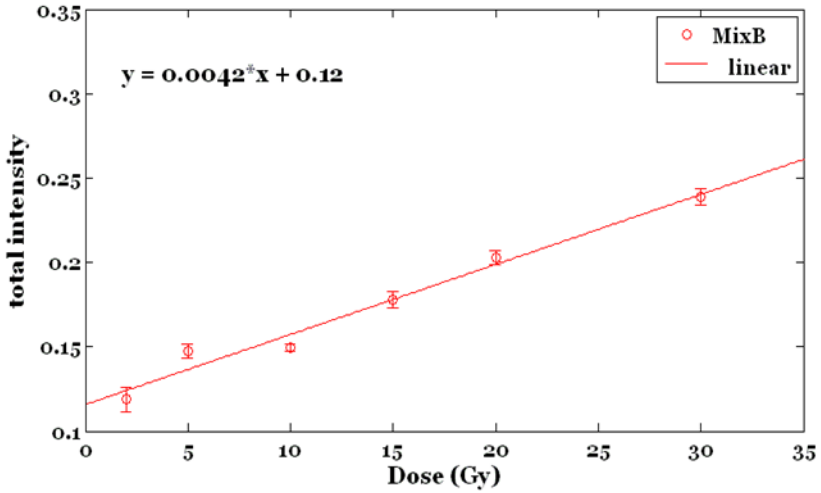


The mechanically induced signal, MIS

- Disappears within 24 hours after cutting
- Decreases after water treatment.
- Increases with repeated cuttings.

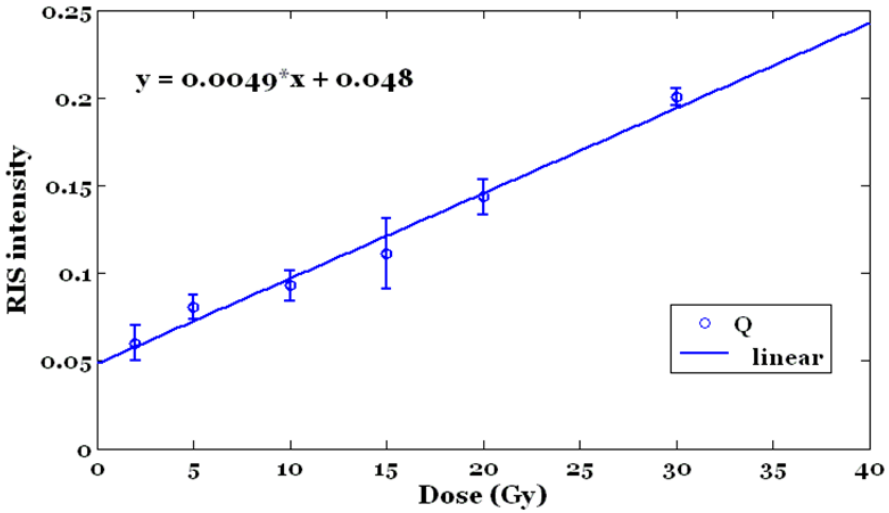


Dose response



Dose response for the total intensity from a mixed sample from different donors. The samples are washed and dried and the MIS has disappeared but some background signal remains.

Dose response for irradiated fingernails from one donor with the BKS determined before irradiation and subtracted. Error bars 1 SD from the combined uncertainty.



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At a real incidence

- The collection of samples and EPR analysis should be made quickly.
- No unirradiated samples for background analysis are available.
  - Unless the exposure is restricted to the hands – then toe nails from the same individual are avaliable.
- To minimize the MIS and BKS the nails should be cut after water treatment.
  - An averaged background from many donors should be available in advance.
  - A dose reponse curve should be obtained for similarily treated nails
- Inserted in this calibration curve the dose can be deduced from the EPR signal.

Conclusions

- EPR retrospective dosimetry of finger and toe nails is promising
- With the advantages
  - of being almost non invasive
  - of being rather sensitive
  - needing a fairly simple sample preparation
- But further investigations are needed
  - for using the background signal from toe nails when possible
  - of the response and fading characteristics of the RIS from nails cut after water treatment.
- For establishment of a protocol for preparations and analysis after nuclear accidents.

Linköping University

expanding reality

Thanks for your attention !

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