Dosimetry using the materials that can be carried with and separated from a human body

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@5th ARADOS meeting
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  • Fingernail ESR dosimetry

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  • 3D-gel dosimetry

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How to evaluate individual dose?

Simulations
- Air Kerma
- Shielding

Measurements
- Electron Spin Resonance
- Thermo Luminescence
- Personal radiation monitor
- Counting chromosome abnormality

Support
- Environmental radiation measurement / monitoring

Source

distance
How to evaluate individual dose?

Simulations
- Source
- Distance
- Air Kerma
- Shielding

Measurements
- Electron Spin Resonance
- Thermo Luminescence

Unexpected exposure
Local exposure

Support
- Environmental radiation measurement / monitoring
- Counting chromosome abnormality
- Personal radiation monitor
What we should know for retrospective dosimetry?

- Zero-dose distribution
  - Nobody knows how big signal is there before exposure we focus on.

  We can NOT know when is the time of signal generation

- Reproducibility (For destructive measurement)
- Dose-response
- Minimum detectable dose
  - Derived from measurement error (resolution of dose-response)
  - Derived from 0-dose distribution
- Fading
- The factors that make the signal generation and reduction
The Methods for Retrospective Dosimetry 1

- Electron spin resonance (ESR)

  - Irradiation
  - Microwave
  - Electron pair
  - Magnetic field
  - Unpaired electron
  - Reduction of microwave

  - Energy level (middle) ~ μeV

- Measurement of unpaired electron → Radicals, Lattice defect
- Non-destructive measurement
ESR signal

- ESR signal
  - RIS (radiation induced signal)
  - MIS (mechanical induced signal)
- Background
  - Which can not be erased because which is continuously generated by environmental stimulation

→The characteristics of these three components are studied to separate each other.
Fingernail ESR

- Sample Preparation: None. Just cutting.
- Storage condition: Ambient pressure, temperature (20 °C), relative humidity (~15 %), dark

- There are big zero-dose signals. Reference sample should be collected (toenail?) → It is a bottle neck of minimum detectable dose.
- Linear dose-response up to 100 Gy
- Resolution is 1.9 Gy in average
- For X-ray irradiation, no fading for few month.
OSL (Optical stimulated Luminescence)

- Photon emittance induced by being stimulated optically
- Optical light (~THz)
- The wavelength of emitting light is shorter than stimulating light
- The shorter the wave length of stimulating light is, the deeper energy level we can access.
- The mechanism is similar to TL

- Measure the amounts of electrons who are trapped in the meta-stable level
- Destructive measurement
Setup

- TL & OSL measurement
- Violet, Blue, Infra Red stimulating LED
- Beta-ray source: Sr90
- PMT, PMT for ultra violet, CCD camera

@Salzburg Univ.
Dr. Discher supported us
OSL signal from a patient gown

Stimulating light: Violet

Patient gown

(Signal) =
Patient gown (Reproducibility)

- The reproducibility is within ±10% at 8 Gy irradiation.
Patient gown (Dose-response)

- The dose-response may be expressed by the function of $y = a \cdot (1 - b \cdot \exp(-c \cdot x))$
Patient gown (Fading)

- Almost all signal disappear after 30 mins. → It is difficult to use for retrospective dosimetry.
Lab gown (Reproducibility)

- The reproducibility is within ±5% at 8 Gy irradiation.
Lab gown (Dose-response)

- The dose-response may be expressed by the function of $y = a^* (1 - b^* \exp(-c^*x))$
Lab gown (Fading)

- Almost all signal disappear after 30 mins. → It is difficult to use for retrospective dosimetry.
Protection films for smart phones 1

Sample A

Reproducibility (1Gy)

Dose-response (~5Gy)

Fading (1Gy)

Sample B

Sample C

Reproducibility
- fluctuation ±2~6%

Dose-response
- Linear (under 5 Gy)

Error for measurement
- ~0.3Gy

Fading
- 35% for 1 hour in fast decay component
- There is a stable component (60%)

→ Possibility to use
Protection films for smart phones

Sample A

Reproducibility (1Gy) • fluctuation ± 6~9%

Dose-response (~5Gy) • Linear (under 5 Gy)

Fading (1Gy) • Error for measurement • ~0.2Gy

Sample B

• 20~40% for 1 hour in fast decay component
• There is a stable component (50%~80%)
→ Possibility to use

Sample C
Fingernail OSL signal (Blue light)

- Linear dose-response (~20 Gy)
  - Curved line (~100 Gy)
- Resolution (2~5 Gy)
- Reproducibility is within ±10% at 40 Gy
- The fading rate: 20% / hour

- Before cleaning, only 1 sample among 30 samples shows zero-dose signal
- However after cleaning there are signals
- Six mins sunlight exposure reduce 90% of signal.
## Summary and future issues

<table>
<thead>
<tr>
<th>Sample</th>
<th>Method</th>
<th>Zero-dose</th>
<th>Reproducibility</th>
<th>Dose-response</th>
<th>Fading</th>
<th>Other factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fingernail</td>
<td>ESR</td>
<td>30 Gy (std.)</td>
<td>—</td>
<td>Linear up to 100Gy</td>
<td>No (for X-ray)</td>
<td></td>
</tr>
<tr>
<td>Fingernail</td>
<td>OSL</td>
<td>Few % of sample has big signal.</td>
<td>± 10%(40 Gy)</td>
<td>Linear up to 20Gy</td>
<td>20% / h</td>
<td>Sunlight, Cleaning</td>
</tr>
<tr>
<td>Patient gown</td>
<td>OSL</td>
<td>—</td>
<td>± 10% (8 Gy)</td>
<td>1-exp up to 20 Gy</td>
<td>90% / 0.5 h</td>
<td></td>
</tr>
<tr>
<td>Lab gown</td>
<td>OSL</td>
<td>± 10% (8 Gy)</td>
<td>—</td>
<td>1-exp up to 5 Gy</td>
<td>90% / 0.5 h</td>
<td></td>
</tr>
<tr>
<td>Protection Film 1</td>
<td>OSL</td>
<td>—</td>
<td>± 2~6%(1 Gy)</td>
<td>Linear up to 5 Gy</td>
<td>35 % /h</td>
<td>60% is stable?</td>
</tr>
<tr>
<td>Protection Film 2</td>
<td>OSL</td>
<td>—</td>
<td>± 6~9%(1 Gy)</td>
<td>Linear up to 5 Gy</td>
<td>20~40% / h</td>
<td>50~80% stable?</td>
</tr>
</tbody>
</table>

Our conclusions on current status and future issues:
- Fingernail ESR: One of bottle neck is zero-dose distribution. The effect of storage condition and sample preparation on zero-dose should be studied.
- Fingernail OSL: The signal is fragile. We should search more stable signal trapped in deeper energy level.
- Gowns OSL: Fading is very fast. We should search more stable signal trapped in deeper energy level.
- Protection film OSL: We need to study about the behavior of signal from expected stimuli.