Application of Dosimetric Methods for obtaining Diagnostic Reference Levels in Panoramic Dental Radiography

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Introduction

Panoramic Dental Radiography (PDR):

- Technique that produces a single tomographic image of the facial structures including the dental arches, maxilla and mandible, and their supporting structures.
Introduction

- PDR equipment consists of a horizontal rotating arm which holds an X-ray source and an image receptor.
Introduction

- The arm moves and its movement may be described as a rotation around an instant centre.
Introduction

- PDR is a complex procedure, where the doses are higher than in the simplest dental procedures.

- In PDR, radiosensitive organs may be irradiated by the primary beam or may receive scattered radiation. Salivary glands were recently introduced as an organ of interest by international bodies such as ICRP.

- Frequently, children are submitted to PDR (orthodontics, ‘wisdom teeth’, etc.)

- In Brazil, reference levels for PDR have not been adopted yet.
The IAEA TRS 457 suggests the use of the quantity kerma-length product ($P_{KL}$) for patient dose measurements in PDR.

Another quantity that can be measured is the kerma-area product ($P_{KA}$).

Some factors make it difficult to measure these values:

- the system moves during the emission of X-rays,
- the irradiation fields are small,
- dose measurement and identification of field size are difficult.

Which method is simple and practical for dose measurements in PDR?
Objectives

- To verify if a $P_{KA}$ meter and a CT ionization chamber can be used to assess $P_{KA}$ and $P_{KL}$ in a panoramic X-ray unit.

- To quantify patient exposure, in order to propose typical values for this type of examination.
Material and Methods

- Panoramic equipment: Rotographic Plus, Villa Sistemi Medicali.
Material and Methods

- Diamentor M4-KDK $P_{KA}$ meter.
- Radcal 9015 dosimetric system:
  - CT ionization chamber (10X5-3CT)
  - thimble chamber (10X5-6).
Material and Methods

- $P_{KA}$ meter calibration procedure:
  - In PDR:
    - Distances are fixed.
    - X-ray tube rotates.
    - Radiation beam is narrow.
    - Collimator is fixed.
  - Calibration in cephalometric mode.
  - Area: A 18cmx24cm radiographic film into an envelope without intensifying screen.
  - $K$: 6cc ionization chamber at the same point where the film had been placed before.
  - $P_{KA}$ ionization chamber in front of the primary collimator (X-ray beam exit).

- $K \times \text{Area} = \alpha \times P_{KA \text{ measured}}$

All values of $P_{KA}$ measured later were corrected by multiplying by $\alpha$. 
Material and Methods

- Measurements with $P_{KA}$ meter and CT chamber:
  - Measurements were performed without the patient in place.
  - $P_{KA}$ ionization chamber in front of the primary collimator.
  - CT chamber in front of the secondary collimator (slit).
  - For different standard exposure factors, panoramic examinations were simulated and dosemeters readings were recorded ($P_{KA}$ and $P_{KL}$).
Material and Methods

- Measurements with $P_{KA}$ meter and CT chamber:
  - The height ($h$) of the radiation beam at the secondary collimator slit was measured on an exposed radiographic film.
  - $P_{KA}$ values were compared with the values calculated from CT chamber data:

$$P_{KA_{\text{calculated}}} = P_{KL} \times h.$$
### Results

Table 1. Measurements performed during the $P_{KA}$ meter calibration. (mA = 10)

<table>
<thead>
<tr>
<th>kVp</th>
<th>t</th>
<th>Air kerma [μGy]</th>
<th>$P_{KA}$ calculated [cGy.cm$^2$]</th>
<th>$P_{KA}$ measured [cGy.cm$^2$]</th>
<th>Calibration Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>70</td>
<td>1.0</td>
<td>46.0</td>
<td>0.37</td>
<td>0.46</td>
<td>0.81</td>
</tr>
<tr>
<td>70</td>
<td>2.5</td>
<td>112.0</td>
<td>0.92</td>
<td>1.12</td>
<td>0.82</td>
</tr>
<tr>
<td>70</td>
<td>3.0</td>
<td>135.0</td>
<td>1.09</td>
<td>1.35</td>
<td>0.81</td>
</tr>
<tr>
<td>75</td>
<td>1.0</td>
<td>59.0</td>
<td>0.48</td>
<td>0.60</td>
<td>0.80</td>
</tr>
<tr>
<td>75</td>
<td>2.5</td>
<td>146.0</td>
<td>1.18</td>
<td>1.48</td>
<td>0.80</td>
</tr>
<tr>
<td>75</td>
<td>3.0</td>
<td>178.0</td>
<td>1.45</td>
<td>1.79</td>
<td>0.81</td>
</tr>
<tr>
<td>80</td>
<td>1.0</td>
<td>70.0</td>
<td>0.57</td>
<td>0.70</td>
<td>0.81</td>
</tr>
<tr>
<td>80</td>
<td>2.5</td>
<td>178.0</td>
<td>1.39</td>
<td>1.78</td>
<td>0.78</td>
</tr>
<tr>
<td>80</td>
<td>3.0</td>
<td>206.0</td>
<td>1.67</td>
<td>2.11</td>
<td>0.79</td>
</tr>
<tr>
<td>85</td>
<td>3.0</td>
<td>247.0</td>
<td>2.00</td>
<td>2.56</td>
<td>0.78</td>
</tr>
</tbody>
</table>

Average $P_{KA}$ calibration factor 0.80

Associated uncertainties:

- $K$: 6.4% (10X5-6).
- Area: 1%
- $P_{KL}$: 13% (10X5-3CT)
- $P_{KA}$: 11%

**Calibration factor for Rotographic Plus**

$\alpha = (0.80 \pm 0.13)$
Table 2: Results of $P_{KA}$ and $P_{KL}$ measurements in Rotographic Plus X-ray equipment. [mA = 10, Area = (83.7 ± 1.3) cm$^2$].

<table>
<thead>
<tr>
<th>kVp</th>
<th>Time</th>
<th>$P_{KA}$ (measured)</th>
<th>CL (Pencil chamber measure)</th>
<th>$P_{KL}$ (calculated)</th>
<th>$P_{KA}$ calculated</th>
<th>Δ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(s)</td>
<td>(cGy.cm$^2$)</td>
<td>(µGy)</td>
<td>(µGy.cm)</td>
<td>(cGy.cm$^2$)</td>
<td></td>
</tr>
<tr>
<td>60 (S. child)</td>
<td>14</td>
<td>2.64 ± 0.30</td>
<td>224 ± 29</td>
<td>2240 ± 290</td>
<td>2.64 ± 0.30</td>
<td>0</td>
</tr>
<tr>
<td>65 (M. child)</td>
<td>14</td>
<td>3.36 ± 0.35</td>
<td>290 ± 38</td>
<td>2900 ± 380</td>
<td>3.42 ± 0.45</td>
<td>-2</td>
</tr>
<tr>
<td>70 (S. adult)</td>
<td>17</td>
<td>5.14 ± 0.56</td>
<td>429 ± 55</td>
<td>4296 ± 550</td>
<td>5.07 ± 0.66</td>
<td>1</td>
</tr>
<tr>
<td>75 (M. adult)</td>
<td>17</td>
<td>7.09 ± 0.78</td>
<td>580 ± 75</td>
<td>5802 ± 750</td>
<td>6.85 ± 0.90</td>
<td>3</td>
</tr>
<tr>
<td>80 ⏯</td>
<td>17</td>
<td>8.27 ± 0.90</td>
<td>677 ± 88</td>
<td>6770 ± 880</td>
<td>7.99 ± 1.03</td>
<td>3</td>
</tr>
<tr>
<td>85 (L. adult)</td>
<td>17</td>
<td>10.71 ± 0.95</td>
<td>838 ± 100</td>
<td>8384 ± 1000</td>
<td>9.89 ± 1.30</td>
<td>8</td>
</tr>
</tbody>
</table>

$P_{KAcalculated} = P_{KL} \times h$
Results

- Both methods applied have found similar $P_{KA}$ values when comparing one to another.

- The collected data ($P_{KA}$ and $P_{KL}$) are comparable to and consistent with studies published so far in literature.

- It is important to promote training actions for PDR equipments' operators in order to select the appropriate exposition factors.

- The manufacturer should provide accurate and sufficient technical information to the staff to help in the optimisation of image quality and dose reduction.

Conclusion

- $P_{KA}$ is also an appropriate quantity for dosimetry in PDR. The usage of a $P_{KA}$ meter allows an easy and reliable method to collect the necessary data for standard examinations without the presence of a patient.

- $P_{KA}$ and $P_{KL}$ measurement methods can be employed as a simple and direct way to quantify patient doses in PDR.

- The calculations required are simple, quick and easy, so that they do not introduce many sources of uncertainties in the measurement process.
Relying on dosimetric values in PDR promotes greater control of patients’ exposure.

This methodology is being applied in other panoramic equipment in order to have enough dosimetric information. So, mechanisms for optimization can be proposed and dose reference levels for PDR in Rio de Janeiro and Brazil can be derived.

A similar study is being carried out for cone beam computed tomography.
Obrigada!

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Grupo de pesquisa: Indicadores de Qualidade e Dose em Diagnóstico por Imagem