EOS:
Low Dose Imaging

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Disclaimers:

• None
Discussion Points

- What is EOS?
- Components
- Positioning
- Dose
- Spine and Lower Extremity Imaging
- Surgical Planning Recons
- Conclusion
“X-ray in a box”

Sometimes the simplest of things have the most significant impact!
What is EOS?
What is EOS?

EOS is an imaging unit that utilizes ALARA principals (As Low As Reasonably Achievable) while capturing patients in their normal weight bearing state.
EOS systems have 2D and 3D imaging capability which support evaluation, diagnosis and treatment in musculoskeletal abnormalities.

Whole body imaging
Specific anatomical regions
  * Spine
  * Lower Extremity
  * Recons off of 2D images
EOS Components
EOS Workstation

- Technical workstations are intuitive, straightforward and user friendly
- 3 window application
  - Patient demographic screens
  - Post processing
  - Review past history
EOS Workstation

Workstation selections directly impacting patient dose:

- Patient habitus
- Technical factors
- Detector selection - biplane imaging simultaneously
  **lessens overall time**
- Speed of acquisition (detectors)
  **caution too fast or slow increases motion artifacts**
- Implant device compensation
- **Micro dose**
EOS Unit

- Marked floor base and walls
- Step (removable)
- Marked elevated floor (removable)
- Hand rail
- Head rest
- Lasers for positioning
  - Midline (red)
  - Superior/inferior ranges (green)
Patient Positioning

Standing:

- Feet firmly planted, slightly apart
  - recon-one foot minimally forward
- Standing straight
  - *no leaning
- Arms at 90 degree angle or straight out
  - AP and/or Sagittal planes unobstructed
Patient Positioning

- No shoes
- Must be able to stand 5-8 minutes unassisted
- Able to follow verbal queues
- Capable to hold completely still for approx. 8-16 seconds during acquisition phases
**EOS Patient Positioning**

**EOS Chair**

Non-weight bearing/non-ambulatory patients are secured in chair via:

- Chest & lap harnesses
- Adjustable head supports
- Additional leg & body Velcro straps
- Hand rail
  
  *for patients if both views are possible.

The introduction of this chair has increased the number of patients who were previously not candidates for EOS.
Chair restrictions:

- Must < 5’5”
- Weight restriction < 220lbs
- Small to medium body habitus due to narrow width of chair
- For most patients, only an AP view is obtainable
- Holding assistance is limited
DOSE
CHOP RADIOLOGY DEPARTMENT’S MISSION AND PRIMARY FUNCTION:

The Department of Radiology of The Children’s Hospital of Philadelphia, *provides specialized imaging* for infants and children, which covers all available modalities, in an *environment that is safe for children* and pleasant for the patients and their families. We also *strive for accurate and prompt diagnostic interpretation*, expert therapeutic intervention, high quality teaching, *the development of new and better techniques*, and advances in research.
CHOP’s mission directly aligns with those of Image Gently.

**Image Gently Mission Statement**

The mission of the Image Gently Alliance is, through advocacy, to improve safe and effective imaging care of children worldwide.
EOS is equipped with a DAP meter which captures the accumulated dose per detector.

**Dose Area Product (DAP)** is defined as the entrance surface dose (mGy) times the total patient area irradiated (cm²).

DAP for a radiograph or complete examination is denoted by (Gy cm², mGy cm² or dGy cm²).
EOS DOSE

- EOS dose is about $\frac{1}{2}$ the dose compared to a conventional x-ray units
- EOS uses a fixed dose
  - age ranges
  - size of patients
- Conventional x-ray uses modulated MAS techniques - EOS MAS is adjusted automatically
- Initial assessments or pre-surgical exams require full dose EOS techniques
Micro dose

- Micro dose allows us to reduce exposure but with an obvious visible reduction to image quality.
- Micro dose decreases EOS dose approximately 1/5 of a full EOS dose.
- Used for patients for follow up on surgical patients or patients who require ongoing assessments.
  - exclusions pre-surgical imaging & initial assessments.
Dose Area Product (mGycm²) and Entrance Dose (mGy) for the long-axis protocols

*Dose Area Product = 448 mm (image height + detector width)*

<table>
<thead>
<tr>
<th>ANATOMICAL REGIONS</th>
<th>Acquisition height considered</th>
<th>Frontal DAP (mGy.cm²)</th>
<th>Lateral DAP (mGy.cm²)</th>
<th>Frontal Dose @ Isocenter (mGy)</th>
<th>Lateral Dose @ Isocenter (mGy)</th>
<th>Acquisition time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low dose protocols</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Full spine (thin)</td>
<td>66</td>
<td>217.39</td>
<td>343.49</td>
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<td>Full spine (medium)</td>
<td>80</td>
<td>389.97</td>
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<td>512.49</td>
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<td>0.0136</td>
<td>0.0301</td>
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<td>262.73</td>
<td>0.0222</td>
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<td>21.3</td>
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<td>243.97</td>
<td>467.47</td>
<td>0.0443</td>
<td>0.0912</td>
<td>21.3</td>
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</tbody>
</table>

Provided by EOS
Scientific Papers

• Spine radiographs with up to 85% less dose than Computed Radiography (CR) with equivalent or better image quality

• Upright full-length lower limb and whole spine radiography with 50% less dose than Digital Radiography (DR)
Scientific Papers


- Micro Dose allows an average dose reduction of 7.6 vs. low dose for AIS follow up (New EOS imaging protocol allows a substantial reduction in radiation exposure for scoliosis patients (Newton PO, Khandwala Y, Bartley CE, Reighard FG, Bastrom TP, Yaszay B) - Spine Deformity, Volume 4, Issue 2, Pages 138-144)

### EOS vs DR/CR

<table>
<thead>
<tr>
<th></th>
<th>EOS</th>
<th>DR (Philips &amp; Siemens)</th>
<th>CR (Agfa)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Acquisition views</strong></td>
<td>1 or 2 planes * 2 simultaneously</td>
<td>1-2 separate exposures</td>
<td>1-2 separate exposures</td>
</tr>
</tbody>
</table>
| **Acquisition method/timing** | Scanning method  
Less time overall | Tomo method 1-3 swings of tube  
More time x each exposure | One exposure  
Less time x each exposure |
| **Exposure/dose**      | Low dose (1/2 of conventional)  
Micro dose* (1/5 of full EOS) * less detail | Grid technique  
Non grid -lower technique/less detail | Grid technique |
| **Processing method**  | No stitching                                                          | Stitching  
Automatic and manual  
* Accuracy post processing | Stitching  
Automatic  
*Accuracy post processing |
| **Patient type**       | Ambulatory, weight bearing patients  
limited amount of non weight bearing (chair) | Ambulatory and non  
Ambulatory (table/sitting platform)  
*pts with involuntary motion require CR imaging | *Non ambulatory patients who are not EOS or DR candidates (sitting platform) |
| **Motion sensitivity** | Extremely sensitive                                                    | Sensitive                                         | Less Sensitive                                  |
| **Image advantages**   | Captures patients in their normal weight bearing state (erect or sitting) | Captures patients in their normal weight bearing state (erect or sitting w/o assistance)  
Sitting with assistance-possible false representation of normal weight bearing state | Sitting with assistance-possible false representation of normal weight bearing state |
Motion Artifact
Spine Imaging

- Kyphosis
- Idiopathic Scoliosis
- Neuromuscular Scoliosis
- Post Surgical Assessments
- Thoracic Insufficiency (VEPTR)
Spine Imaging
## Spine Exams

<table>
<thead>
<tr>
<th>February 2016-February 2017</th>
<th>EOS Exams</th>
<th>Non EOS exams</th>
</tr>
</thead>
<tbody>
<tr>
<td>1vw AP/PA or Lateral projection</td>
<td>792 exams</td>
<td>352 exams</td>
</tr>
<tr>
<td>2vw AP/PA &amp; Lateral projections</td>
<td>1,611 exams</td>
<td>929 exams</td>
</tr>
<tr>
<td>Total</td>
<td>2,403 exams</td>
<td>1,281 exams</td>
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</tbody>
</table>

Totals reflect Main campus only
Bolster or bending spine exams not included in totals
EOS SPINE IMAGES

EOS Micro dose

EOS Micro dose
### Summary

**Performing Physician:** Unknown Performing Physician

**DAP [Gy·cm²]**

<table>
<thead>
<tr>
<th>Description</th>
<th>Exposure Index</th>
<th>DAP [mGy·cm²]</th>
<th>Beam On Time [s]</th>
<th>kVp</th>
<th>mAs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lateral AEC</td>
<td>201</td>
<td>448.2</td>
<td>43</td>
<td>90</td>
<td>38</td>
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<tr>
<td>Lateral AEC</td>
<td>154</td>
<td>703.5</td>
<td>68</td>
<td>90</td>
<td>59</td>
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<tr>
<td>Lateral AEC</td>
<td>132</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>AP AEC</td>
<td>155</td>
<td>199.1</td>
<td>15</td>
<td>85</td>
<td>15</td>
</tr>
<tr>
<td>AP AEC</td>
<td>219</td>
<td>667.9</td>
<td>52</td>
<td>80</td>
<td>49</td>
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<tr>
<td>AP AEC</td>
<td>88</td>
<td>0</td>
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</tbody>
</table>

**Reference Point Dose [mGy]**

| Total | 2.019 |

**AP view =** 867 mGycm² -> 8.67 dGycm²

**Lateral view =** 1151.7 mGycm² -> 11.51 dGycm²

**Total exam =** 2.019 Gycm² -> 20.19 dGycm²
Spine Imaging

EOS micro dose w/ bone age

EOS micro dose
Pre Surgical Assessment
Full dose

Post Surgical Assessment
Micro dose
EOS SPINE IMAGES

Full Dose EOS

Micro Dose EOS w/ bone age
Lower Extremity
Lower Extremity

• Orthoroentgenograms (hips to ankle)
  – Leg length discrepancies
  – Valgus and Varus Alignments
  – Trauma
  – Metastatic and benign disease
  – Post surgical assessments
EOS imaging (full dose)
EOS Recon: Surgical Planning
3D Lab Recons

- AP and Lateral acquisitions must be performed to generate a recon.
- Used for surgical planning or assessments of curvature over time
- Images are sent to the 3D lab EOS workstations
- Each vertebral body is outlined
- Measurements are saved and reprocessed.
- Data via PDF document specifies approximate translations of spine curvatures based on that “reconstructed” data
Pre-surgical Imaging
3D Lab Processing
3D Lab Processing

Spine parameters

<table>
<thead>
<tr>
<th>Scoiotosis parameters (T)</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>C2c (T2-L2-L4)</td>
<td>39°</td>
</tr>
<tr>
<td>Axial rotation of spinal vertebrae L2</td>
<td>50°</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sagittal balance (T)</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1-T12 kyphosis</td>
<td>2°</td>
</tr>
<tr>
<td>T4-T12 kyphosis</td>
<td>12°</td>
</tr>
<tr>
<td>L1-S5 lordosis</td>
<td>42°</td>
</tr>
<tr>
<td>L1-L5 lordosis</td>
<td>41°</td>
</tr>
</tbody>
</table>

Vertebral parameters

Diagram of vertebral axial rotations (calculated in relation to the pelvis)

Pelvic parameters

<table>
<thead>
<tr>
<th>Pelvic parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pelvic incidence</td>
<td>36°</td>
</tr>
<tr>
<td>Lateral pelvic 3B</td>
<td>5°</td>
</tr>
<tr>
<td>Sacral slope</td>
<td>49°</td>
</tr>
<tr>
<td>Pelvic axial rotation</td>
<td>10°</td>
</tr>
<tr>
<td>Right pelvic 4B</td>
<td>5°</td>
</tr>
</tbody>
</table>

1. Parameters calculated in the patient frame: based on a vertical plane passing through the center of the acetabulum, which corrects the effect of potential pelvic rotation of the pelvis during sagittal rotation.
2. Axial vertebral rotations in positive values when the vertebra is rotated towards the patient's left side.
The “X-ray in a box” seems to be quite simple although has a huge benefit in the end!

- Decrease time by imaging both planes simultaneously
- Accurate depiction of normal weight bearing state
- Maintaining diagnostic information despite lower dose techniques
- Decreased dose compared to conventional techniques
  - full dose
  - Micro dose *substantial decrease in dose
Thank you for your time and attention!

Don’t be fooled by the simplistic appearance-it brings a lot of positive things!