Vernier Picket Fence Test Using 2D Detector Array

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Outline

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How well can you set up MapCheck?
## How well can you set up MapCheck?

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<th>Accuracy</th>
<th>Aligned With?</th>
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<td>Crosshair</td>
<td>0.1-0.5 mm</td>
<td>Mechanical Isocenter</td>
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<td>ExacTrac</td>
<td>~0.2 mm</td>
<td>Imaging Isocenter</td>
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<td>OBI/CBCT</td>
<td>~0.2 mm for OBI</td>
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<td>~0.5 mm for CBCT</td>
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<td>Vernier Picket Fence</td>
<td>&lt;0.02 mm</td>
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Overview

• Vernier Picket Fence (VPF) test is a tool to:
  – Identify the radiation isocenter
  – NOT for MLC leaf QA

• By delivering 2-3 extra radiation fields, the user can identify the radiation isocenter, up to 0.02 mm accuracy
Vernier Scale in a Caliper

- Moving arm has a vernier scale spaced at nine tenths of the main scale on the fixed arm
- Measure up to 0.1 mm precision
Vernier Scale

- Best match between two marked lines
- 0.1 mm offset will move the matched lines from one pair to the next
- Magnification Factor N=10
MapCheck QA Device

5 mm
Location of Maximum Signal

- Relative position between MapCheck and VPF

5.25 mm

5 mm
0.25 mm Offset Moves Measurement Curve by 5 mm Magnification Factor = 20
Methods

• VPF tests are read by finding the maximum signal, which give a 0.25 mm accuracy

Can we do better?

• VPF tests can also be read by computers
• Detector signals are fit with a Gaussian curve to determine the peak position
MLC Offset Test

- A sequence of VPF fields were delivered with different MLC offsets for every 0.05 mm step size
- We tested how accurately our algorithm can detect the offset
VPF Accuracy = 0.02 mm
ExacTrac Cross Validation & Couch Hysteresis

- Couch was programmed to move along one direction and back to the starting position.
- 0° gantry angle with 0° and 90° collimator angles to determine the lateral and longitudinal shifts.
- Results from the VPF tests were compared with optical tracking (OPT) of the ExacTrac system.
Lateral Shift Results

- Both methods detect couch hysteresis (up to 0.3 mm)
- VPF agreed with optical tracking ($\sigma = 0.055$ mm)
Longitudinal Shift Results

- Couch hysteresis is large for longitudinal direction (up to 0.5 mm)
- VPF agreed with optical tracking (σ = 0.041 mm)
Conclusions

- VPF tests can be used to identify the radiation isocenter with sub-millimeter accuracy.
- MLC offset test shows that VPF is accurate up to 0.02 mm.
- Cross validation shows that VPF agrees with optical tracking within 0.05 mm.
Potential Applications

• A useful tool to identify the radiation isocenter:
  1. IMRT/VMAT QA setup: especially for small SRS fields
  2. Winston-Lutz QA setup
  3. Check crosshair or laser: mechanical isocenter
  4. Check CBCT: imaging isocenter
Future Work

• Measure the VPF for the vertical direction to implement a 3D correction
  – Gantry angle = 45°

• Apply VPF tests to other QA phantoms such as the Delta4
Question?