Clinical Uses and Potential Future Applications of SGRT

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Disclosures

• Nothing to disclose
Objectives

• Understand the clinical uses of SGRT
• Understand the advantages and disadvantages of SGRT for various treatment sites
• Discuss potential future uses of SGRT
Disease sites with published/presented data

- Breast
- H&N
- SRS
- Thorax/abdomen
- Extremities
- Pelvis
Whole Breast Setup

• Shah et al. PRO 2013
• Evaluated SGRT vs skin marks for setup
• Performed dosimetric evaluation

Table 1 Mean setup errors detected by the surface-based imaging system relative to alignment based on skin marks and lasers for all patients (n = 50)

<table>
<thead>
<tr>
<th>No. of treatment fractions</th>
<th>Vertical (mm)</th>
<th>Longitudinal (mm)</th>
<th>Lateral (mm)</th>
<th>3D vector (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average displacement (including nature of displacements)</td>
<td>1258</td>
<td>0.08</td>
<td>-0.20</td>
<td>-0.62</td>
</tr>
<tr>
<td>Average displacement (absolute value)</td>
<td>1258</td>
<td>4.09</td>
<td>6.88</td>
<td>2.59</td>
</tr>
<tr>
<td>Maximum individual average (absolute value)</td>
<td>1258</td>
<td>11.99</td>
<td>6.88</td>
<td>5.31</td>
</tr>
<tr>
<td>Minimum individual average (absolute value)</td>
<td>1258</td>
<td>0.91</td>
<td>0.82</td>
<td>0.80</td>
</tr>
</tbody>
</table>

Average values given as mean of individual means. Maximum and minimum values given as individual means of each patient. 3D, 3-dimensional.
Bert et al. IJROBP 2006

Free breathing

Evaluated SGRT for setup for accelerated partial breast irradiation (APBI)

Compared to lasers and port films

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**Table 1. Three-dimensional displacement (in mm) as recommended by the alignment procedure**

<table>
<thead>
<tr>
<th>Surface model</th>
<th>Mean</th>
<th>Standard deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laser</td>
<td>7.3</td>
<td>4.4</td>
<td>1</td>
<td>17.6</td>
</tr>
<tr>
<td>Treatment</td>
<td>7.6</td>
<td>4.2</td>
<td>1.7</td>
<td>19.3</td>
</tr>
<tr>
<td>Virtual 3D alignment</td>
<td>1</td>
<td>1.2</td>
<td>0</td>
<td>4.2</td>
</tr>
</tbody>
</table>

Fig. 7. Mean ± standard deviation with minimum (Δ) and maximum (V) of the couch shift required to bring the corresponding surface model back to reference. Data are from 9 patients, and 44 fractions were analyzed.
DIBH – Clinical Results

- Zagar et al. IJROBP 2017
- Prospective trial evaluating utility of DIBH for preventing cardiac perfusion defects
- 20 patients evaluated

By the use of early imaging changes after RT as a surrogate marker for RT-associated heart injury, the present study suggests that DIBH with conformal cardiac blocking is an effective means to mitigate cardiac injury. At 6 months post RT, none of the patients in this study had a new RT-associated perfusion or wall motion defects on cardiac SPECT. This rate of cardiac perfusion abnormalities after RT is lower than the 27% rate reported by Marks et al. (9) (used as our historical control during protocol design) and is also lower than the rates reported by others (8, 11, 12).
A prospective evaluation of open face masks for head and neck radiation therapy

David Wiart PhD*, Sarah Squire MD, Han Liu PhD, Jacqueline Maurer PhD, T. Lane Hayes MS, Benjamin Sintay PhD

Cone Health Cancer Center, Greensboro, North Carolina

• Wiart et al. PRO 2016
• Prospective evaluation of open face masks for H&N RT
• Monitored intra-fraction motion for open-face masks using SGRT

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Intrafraction motion group mean values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3DVL</td>
</tr>
<tr>
<td>Mean (mm)</td>
<td>0.9</td>
</tr>
<tr>
<td>1 SD (mm)</td>
<td>0.5</td>
</tr>
<tr>
<td>Range (mm)</td>
<td>0.1 to 3.5</td>
</tr>
<tr>
<td>Range of means (mm)</td>
<td>0.6 to 1.3</td>
</tr>
</tbody>
</table>

3DVL, 3-dimensional vector length; SD, standard deviation.
Why use SGRT for SRS and SBRT?

- Treatments with small margins and sharp dose gradients
- Allow smaller margins?
- Benign conditions or pediatric patients – reduce imaging dose
- Pediatrics or non-compliant patients – reduce margins and eliminate need for anesthesia
- Facilitate breath hold lung/abdomen SBRT
• Li et al. Med Phys 2011
• SGRT used to verify setup at treatment angles and for motion monitoring
• CBCT used as standard for IGRT
• Compared frame-based SRS with frameless
SRS

- Cerviño et al. PRO 2012
- Frameless and maskless SRS monitored with SGRT – 23 patients
- Evaluated CBCT – SGRT agreement for setup
- Interrupted treatment if intra-fraction motion exceeded 1 – 2 mm (margin dependent)

Shifts calculated based on CBCT after the initial setup with AlignRT were ~0.8 mm, 1.8 mm, and 0.0 mm in the lateral, anterior-posterior (AP), and superior-inferior (SI) directions, respectively. For our first patient, the shifts beam hold was initiated at least once for 15 patients. In most cases, the patient movement would naturally return back under the movement threshold value. The worst cases were the 2 patients who fell asleep, where the treatment was interrupted 10 and 14 times. Although the average number

Figure 1  An example of a patient-specific head mold made out of expandable foam that conforms to the patient’s head (CDR Systems, Inc, Calgary, Alberta, Canada).
SRS Clinical Outcomes

- Pham et al. Trans Canc Res 2014
- Reported clinical outcomes for frameless SGRT guided SRS
- 163 patients with 490 lesions and 45 post-op cavities

<table>
<thead>
<tr>
<th>Study</th>
<th>Treatment system</th>
<th>Patients, n</th>
<th>Crude LC, %</th>
<th>Actuarial 1-yr LC, %</th>
<th>Actuarial 1-yr OS, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schomas et al. (19)</td>
<td>Frame-based LINAC</td>
<td>80</td>
<td>91</td>
<td>89</td>
<td>33</td>
</tr>
<tr>
<td>Bhattacharjee et al.</td>
<td>Frame-based Gamma Knife</td>
<td>205</td>
<td>***</td>
<td>71</td>
<td>37</td>
</tr>
<tr>
<td>Brennan et al. (6)</td>
<td>Frameless LINAC</td>
<td>53</td>
<td>***</td>
<td>80</td>
<td>44</td>
</tr>
<tr>
<td>Nath et al. (7) [2010]</td>
<td>Frameless LINAC</td>
<td>65</td>
<td>88</td>
<td>76</td>
<td>40</td>
</tr>
<tr>
<td>Pan et al. (17) [2012]</td>
<td>Frameless, surface-imaging guided LINAC</td>
<td>44</td>
<td>85</td>
<td>76</td>
<td>38</td>
</tr>
<tr>
<td>Present series</td>
<td>Frameless, surface-imaging guided LINAC</td>
<td>163</td>
<td>85</td>
<td>79</td>
<td>56</td>
</tr>
</tbody>
</table>

LC indicates local control; LINAC, linear accelerator; ***, not reported; †, estimated from Kaplan-Meier curve.

Frameless, real-time, surface imaging-guided radiosurgery: update on clinical outcomes for brain metastases

Nhat-Long L. Pham, Pranav V. Reddy, James D. Murphy, Parag Sanghvi, Jona A. Hattangadi-GLuth, Grace Gwe-Ya Kim, Laura Cervino, Todd Pavlicki, Kevin T. Murphy

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Correspondence to: Kevin T. Murphy, MD. Department of Radiation Medicine and Applied Science, University of California, San Diego, La Jolla, California, 3960 Health Sciences Dr., MC0861, La Jolla, CA 92039, USA. Email: kevin@ucsd.edu.

Findings that SIG-RS for treating brain metastases can produce clinical outcomes comparable to those for conventional frame-based and frameless SRS techniques. At the same time, SIG-RS setup provides better comfort with an open-faced mask, and allows continuous non-ionizing tracking during the treatment delivery time.
Thorax/Abdomen

- External – Internal Correlation?
- Glide-Hurst et al. Med Phys 2011
- Coupled SGRT with on-board flouro
Thorax/Abdomen

- Heinzerling et al. ASTRO 2017 abstract
- Manuscript under review
- Intra-fraction monitoring of SBRT patients
- 2 mm/2° tolerance – Intra-fraction CBCT
- No significant difference seen in mean 3D vector shifts from SGRT and CBCT
Summary of other treatment sites with published data

- Pelvis – Krengli et al. Radiation Oncology 2016
- Extremities – Gierga et al. PRO 2014
- Setup accuracy – Walter et al. Radiation Oncology 2016, Stanley et al. JACMP 2017
Future Directions

- SGRT only for initial patient set up – eliminate tattoos (some places have done this already)
- Patient identification applications
- Maskless H&N and SRS (claustrophobic patients)
- Use intra-fraction motion data to determine margins
Disadvantages of SGRT

- Require patient surface to be visible – could limit types of immobilization used
- Gantry, imaging arms etc can block the camera’s view of the patient
- Surfaces without much variation can be challenging to track
- Surface is not always a reliable surrogate for internal tumor position
- Potential mismatches in surfaces generated from a CT dataset and that reconstructed by SGRT
Conclusions

• SGRT is an attractive option for patient set-up and intra-fraction monitoring
• Can be used for almost any treatment site
• Uses visible light – no additional dose to the patient
• Sub-millimeter accuracy is achievable
• Surface – internal correlation is still under investigation