Advance Optical Guidance

Part III. Clinical Aspects of Stereovision (3D Vision) -Guidance

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Temple University Health System

I. Why Stereovision Guidance (SG)?

- ✓ most efficient 3D imaging (taking as snapshot)
- ✓ most accurate in monitoring patient's motion even during beam-on time
- ✓ no ionization, no body contact
- ✓ Intuitive for users
- ✓ and easy to use

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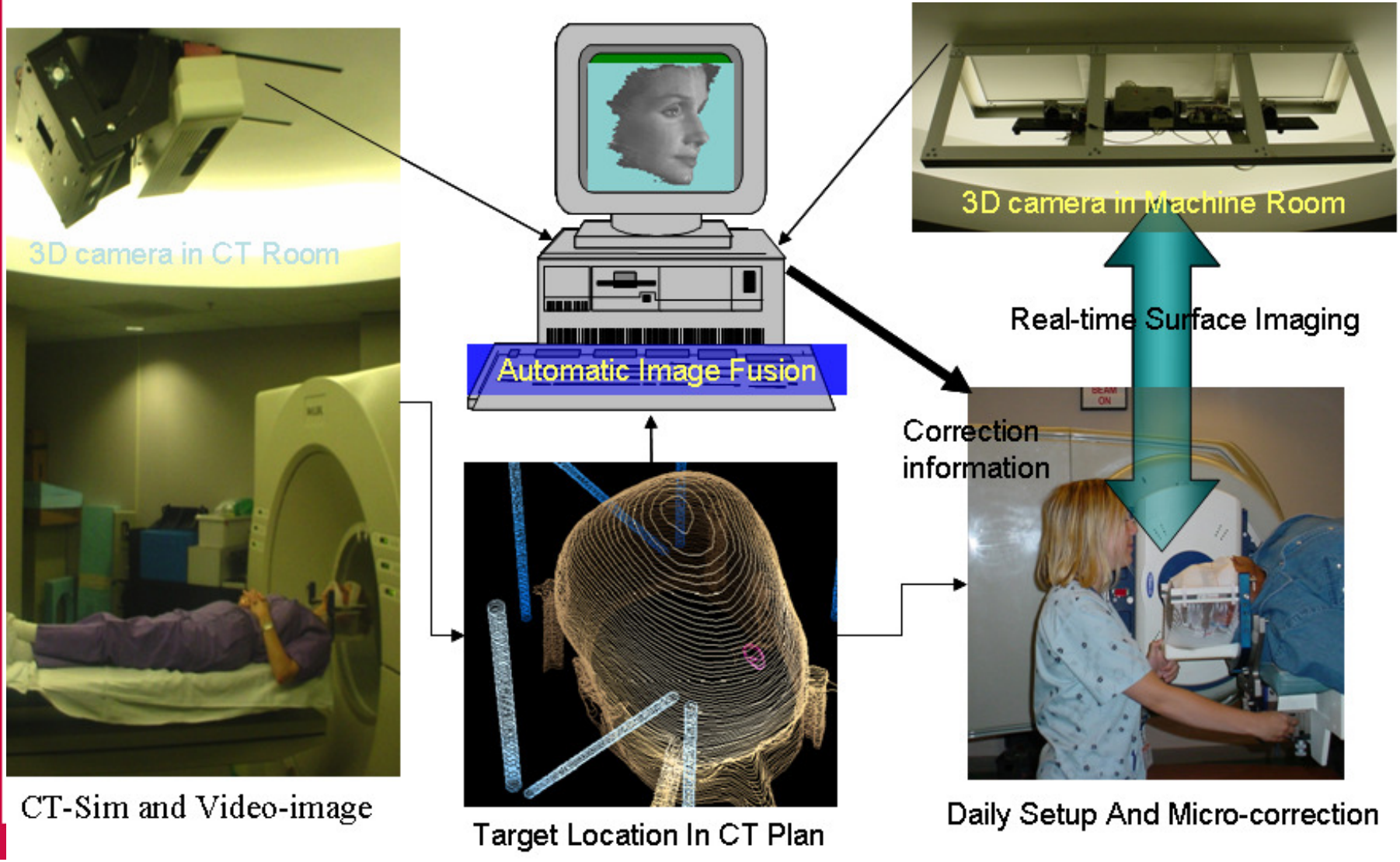
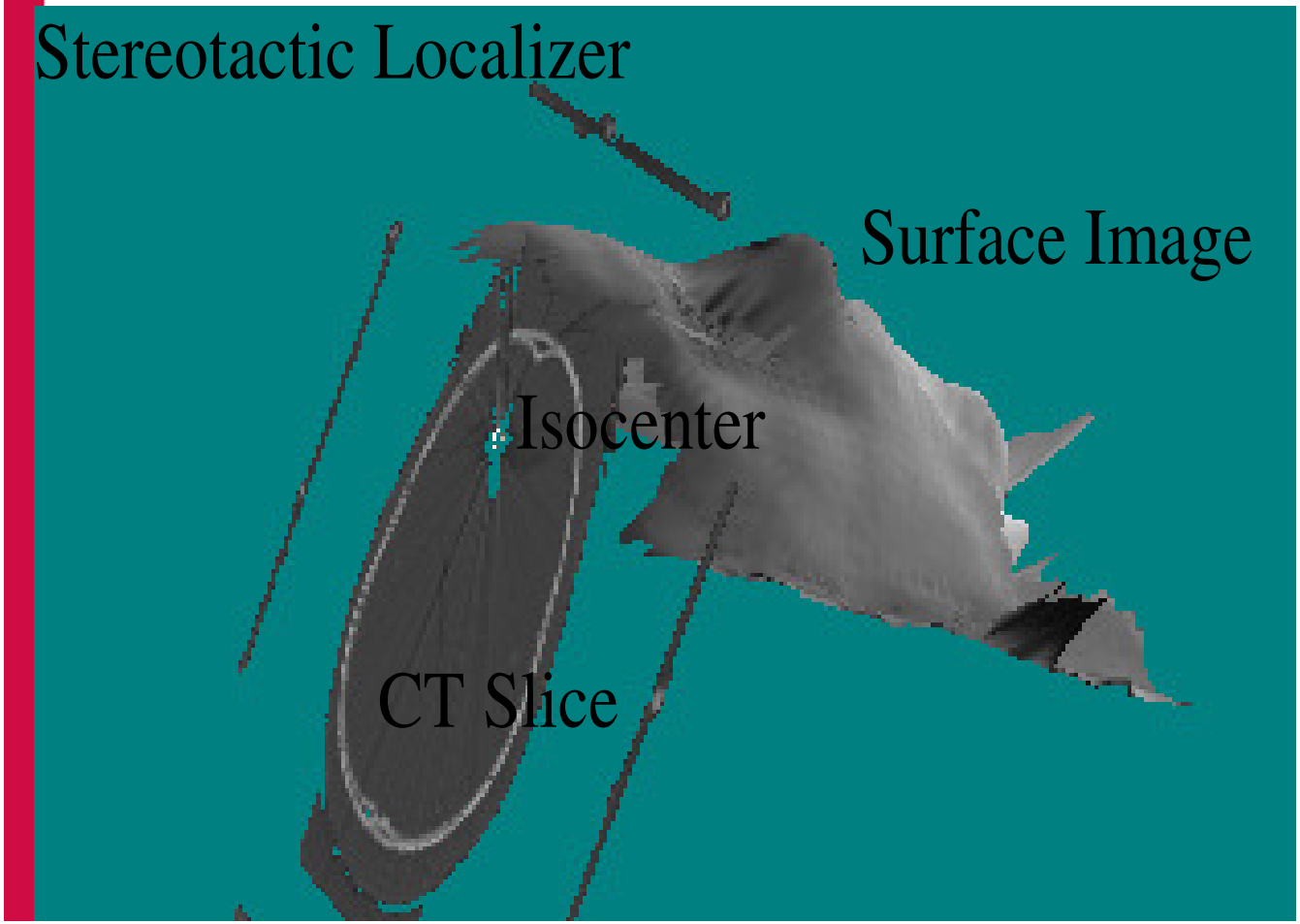
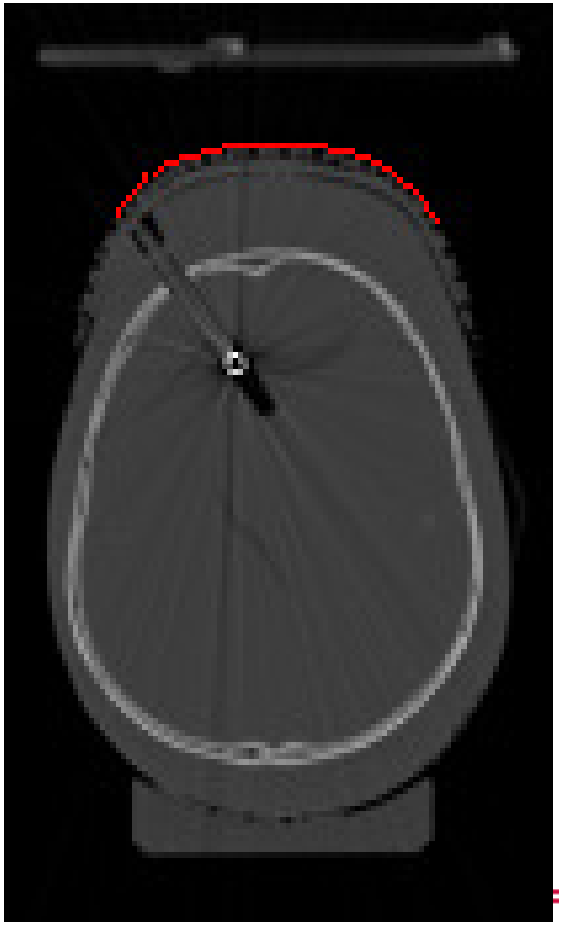
II. Issues in clinical application

1. How to correlate SG with plan images?

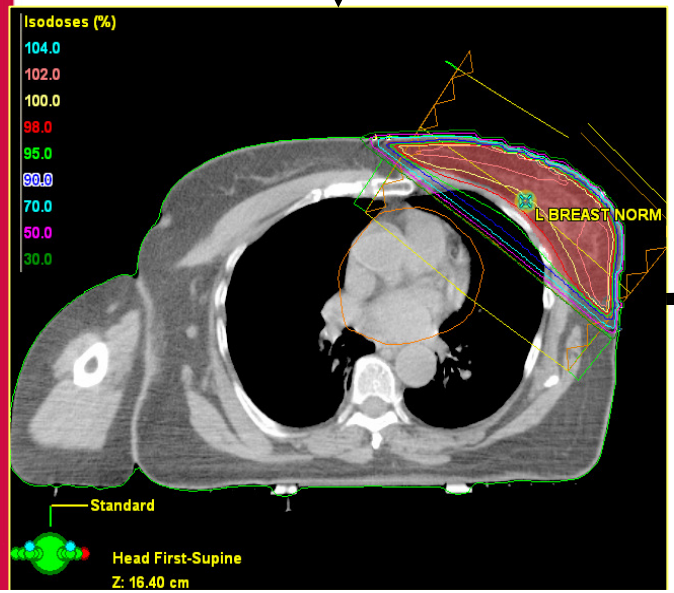


Verify the accuracy of the SG with 3D (left) & 2D (right) displays

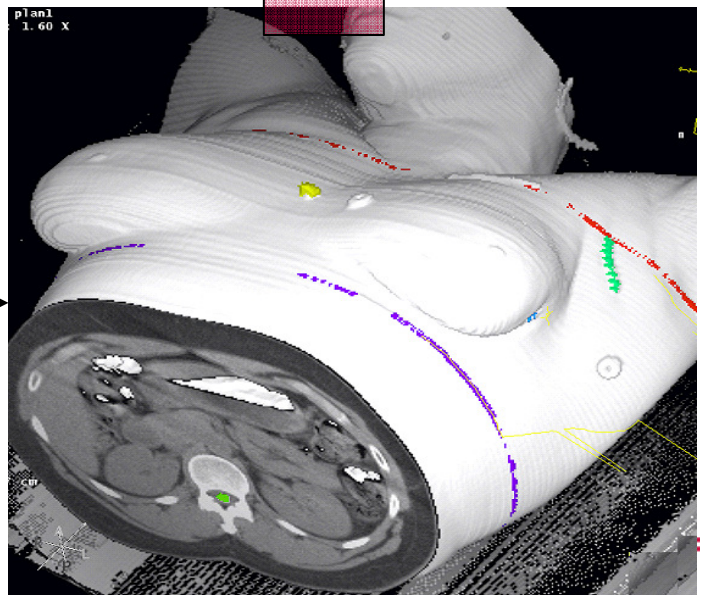




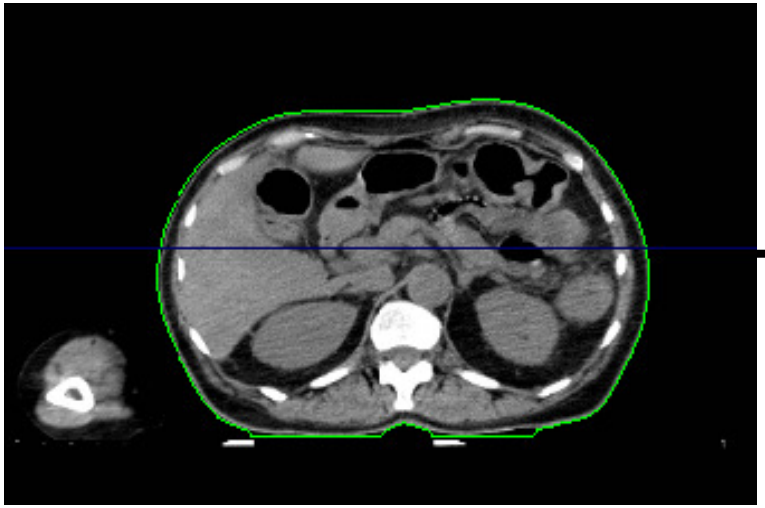
Simulation Surface



Real-time Surface

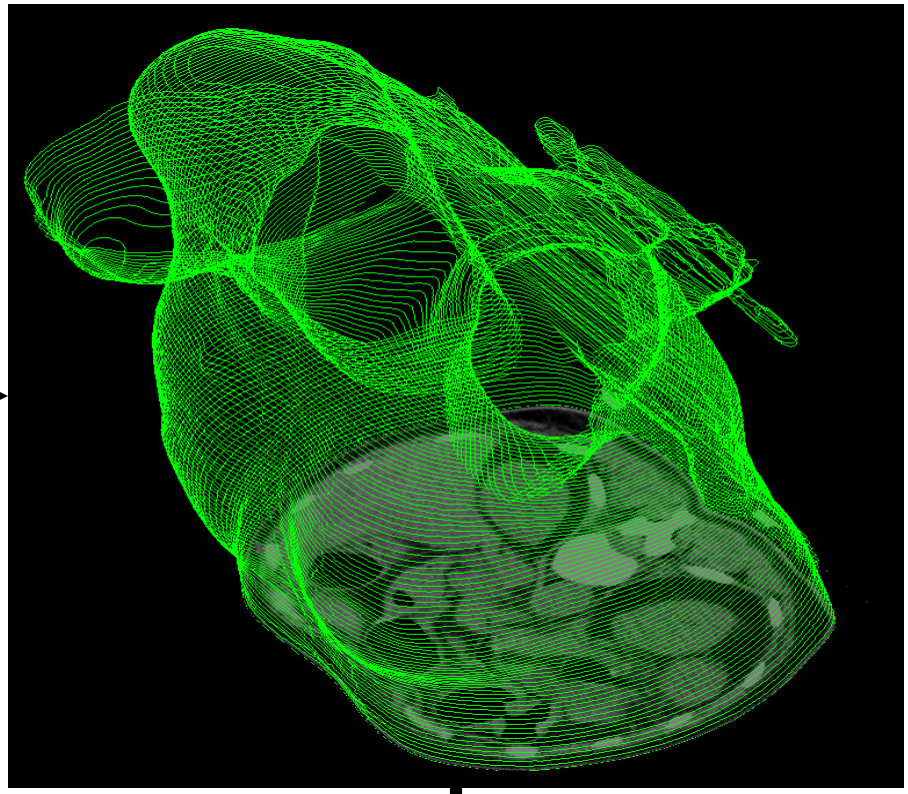


CT plan
Ref. Surface



A CT-plan skin contour

A Stack of CT-based External Contours



Easily converted to a stereovision with optic surface format images

Liu and Li at Henry Ford Hospital

2. How to register stereovision in a Linac Coordinate (LC)

- Setup Cal. phantom with marks and lines aligned with LC
- Capture and transform the phantom surface image lines to the axes of LC, keep the transformation matrix for future captured images.
- Verify phantom with portal or CBCT images

Liu and Li, Med Phys. 2006, 4379-83

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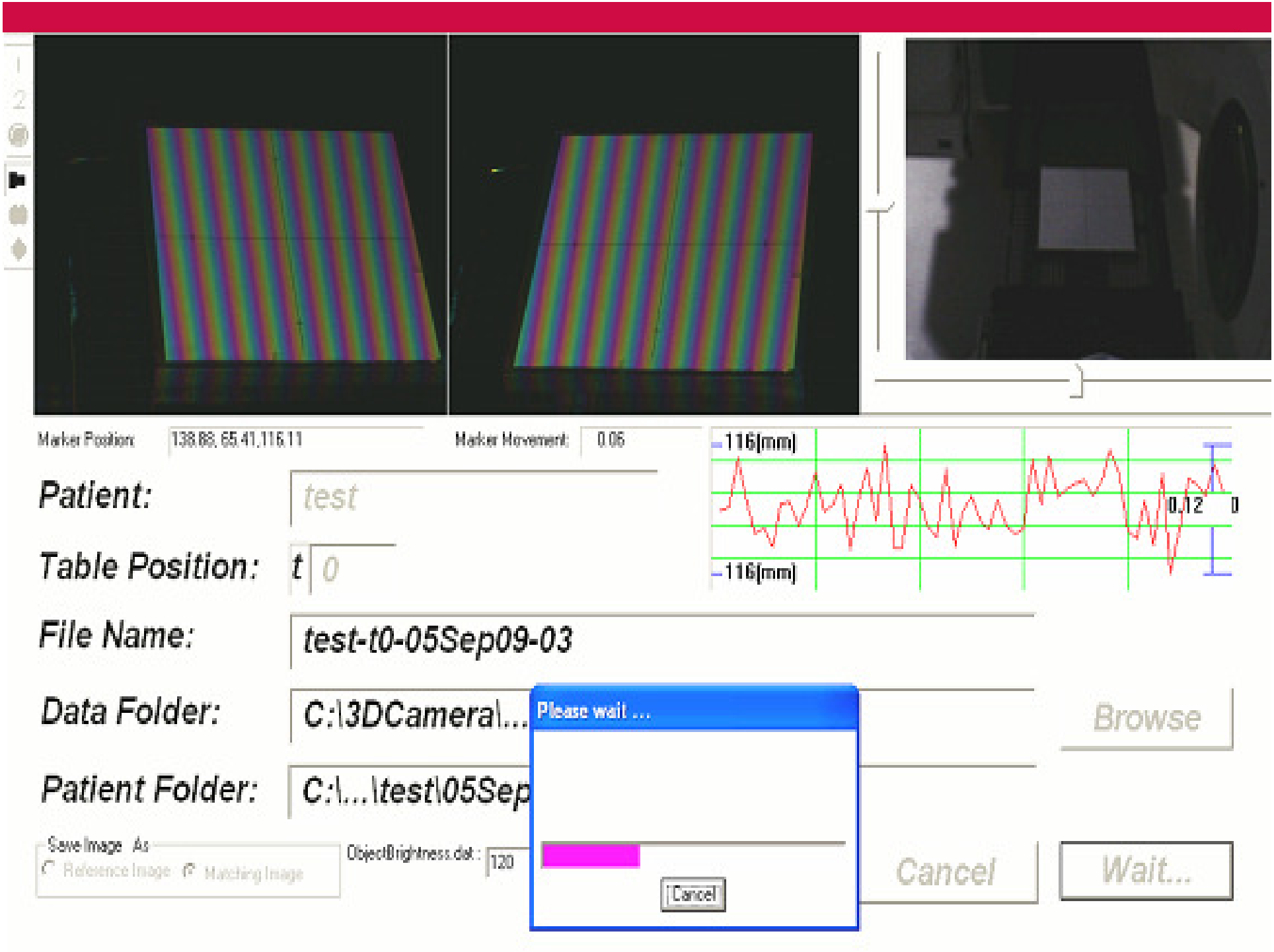
Marker Position:
138.88, 65.41,116.11
Marker Movement:
0.06
116[mm]
0.12
0
-116[mm]
Patient:
test
Table Position:
t
0
File Name:
test-t0-05Sep09-03
Data Folder:
C:\3DCamera\...
Browse
Patient Folder:
C:\...\test\05Sep
Save Image As
Reference Image
Matching Image
ObjectBrightness.dat :
120
Please wait ...
Cancel
Cancel
Wait...

3. Special features of 3D camera?

- ✓ Speed of Imaging (< 1 sec)
- ✓ Spatial Resolution at the Focus Distance (0.2 to 4 mm)
- ✓ FOV and Depth of View
- ✓ Projector Power or Light Intensity Range
- ✓ Stability of Camera System

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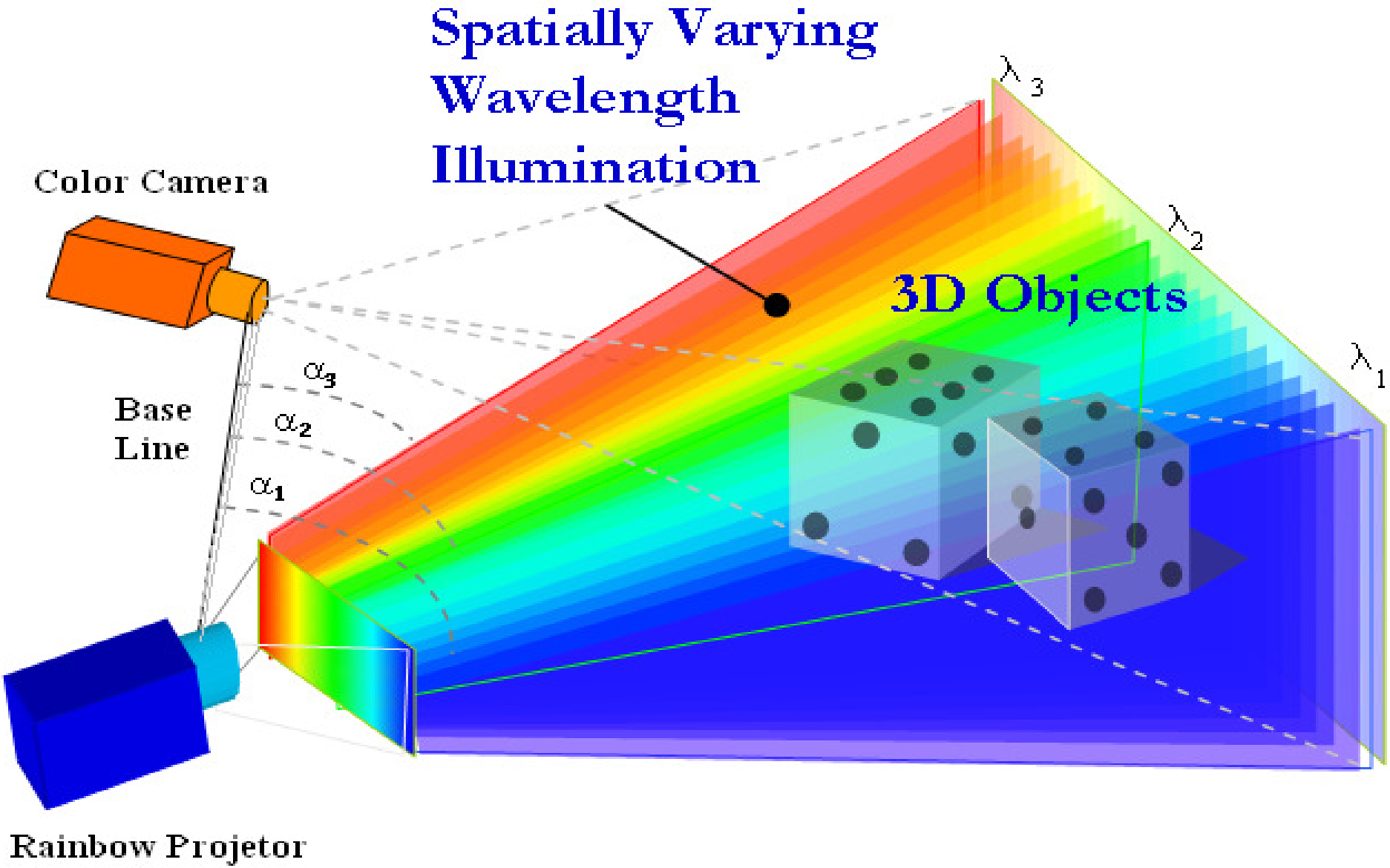
Rainbow Camera (Geng, Opt. Eng, 1996): Resolution: 0.5 – 1 mm at 1.8 m focus distance, >40x40 FOV and >40 cm DOV, less light and skin tone effect, projector power at 20% to 250%

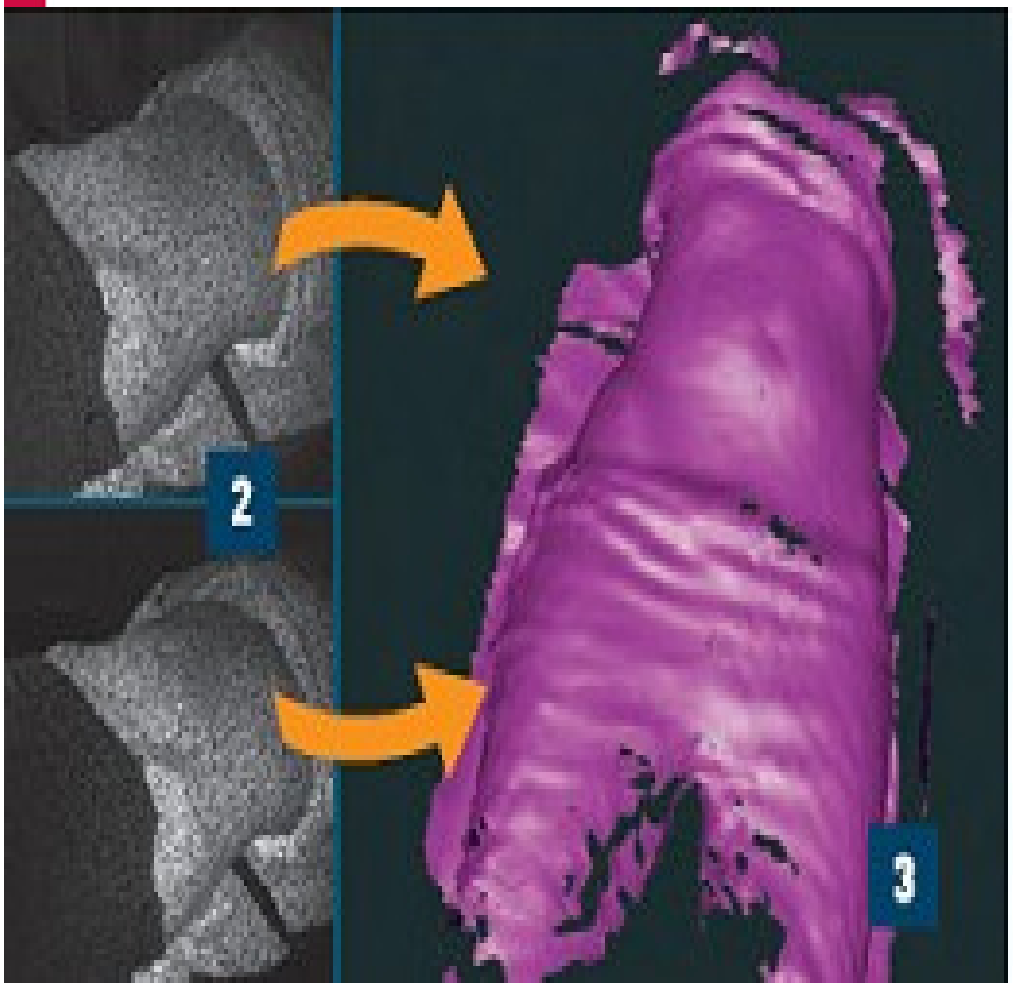


AlignRT (VisionRT Ltd, London, United Kingdom)

Bert et al. Med. Phys. 2005, Schöffel et al. Physics in Med. and Biol. 2007

Resolution ~ speckle size, room-light < projector light intensity, commercially available

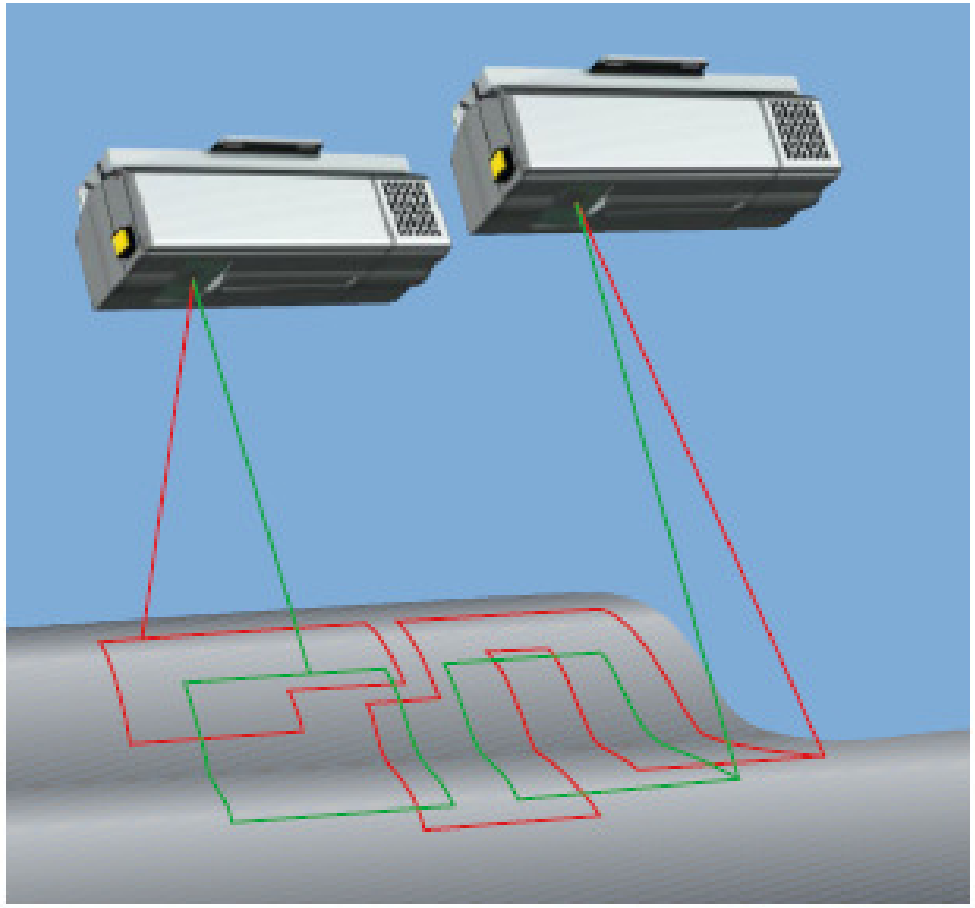
AlignRt with Two VisionRT cameras increase the view of patient's body



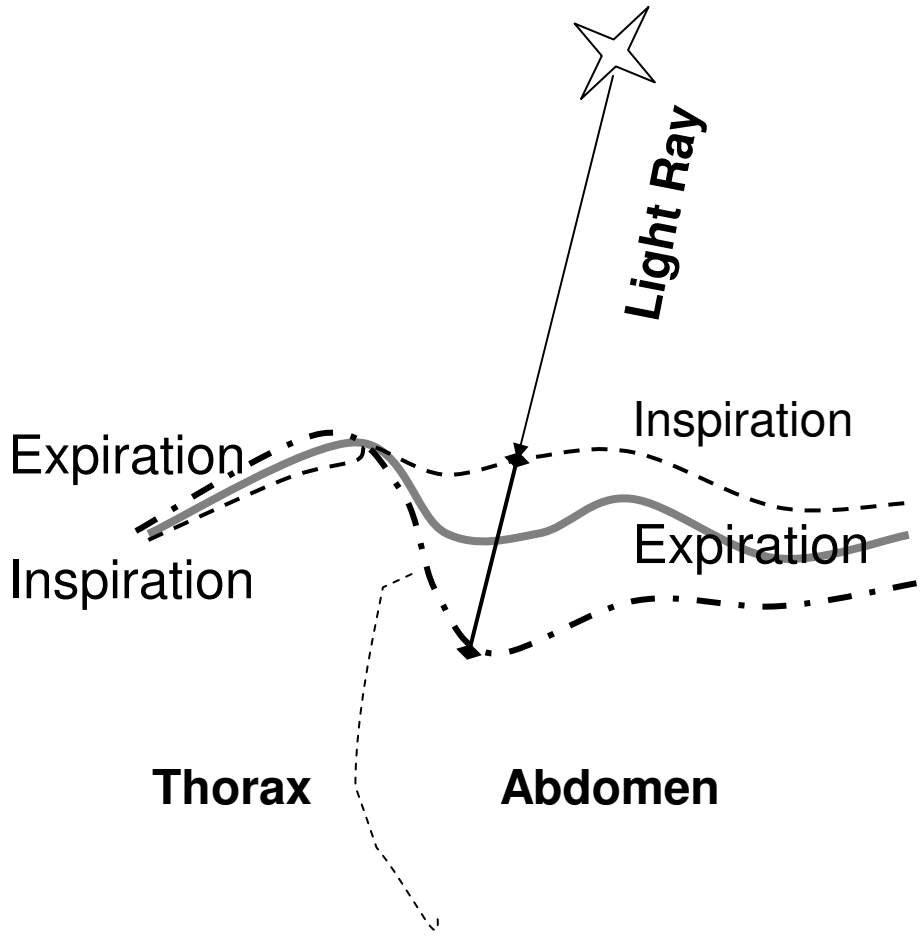
3D Laser scanners, e.g. LAP, GmbH

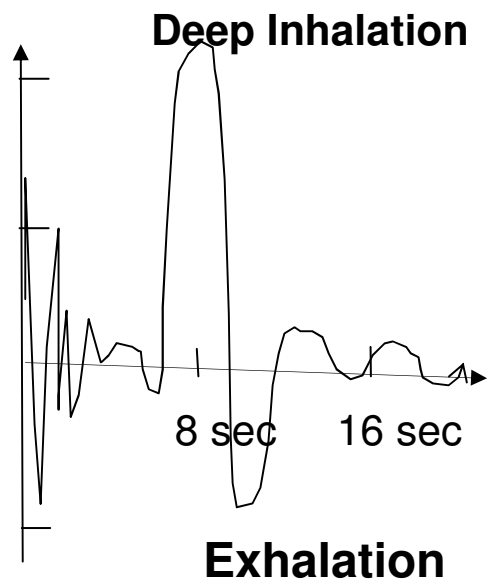
Laser Application L.C., Lueneburg, Germany

- Resolution and accuracy (~0.5 mm) are good
- Major issues is the speed of laser scanners that cannot capture instant surface image for moving part of body



4. How to capture reliable stereovision ?





A method and results for monitoring an abdomen

Li, Chapter 7 in "IGRT Clinical Aspects" Ed. Mount & Roske, in press

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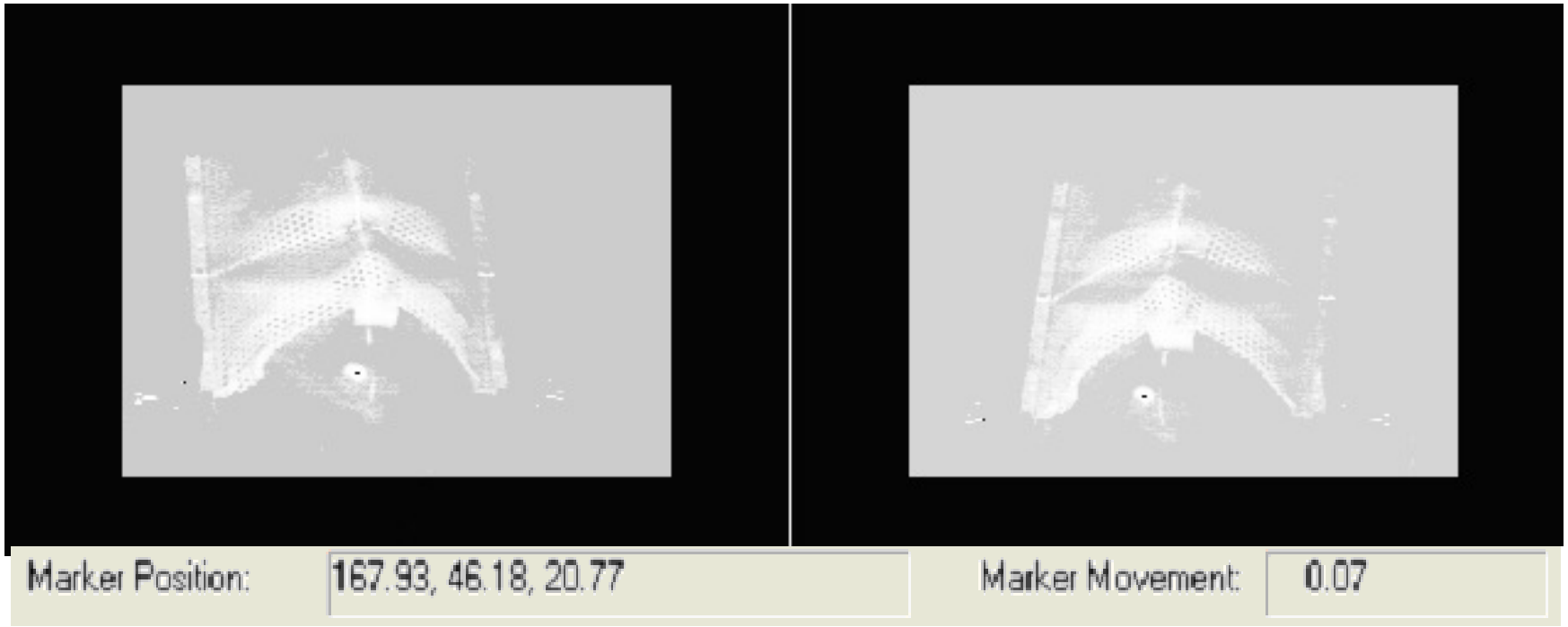
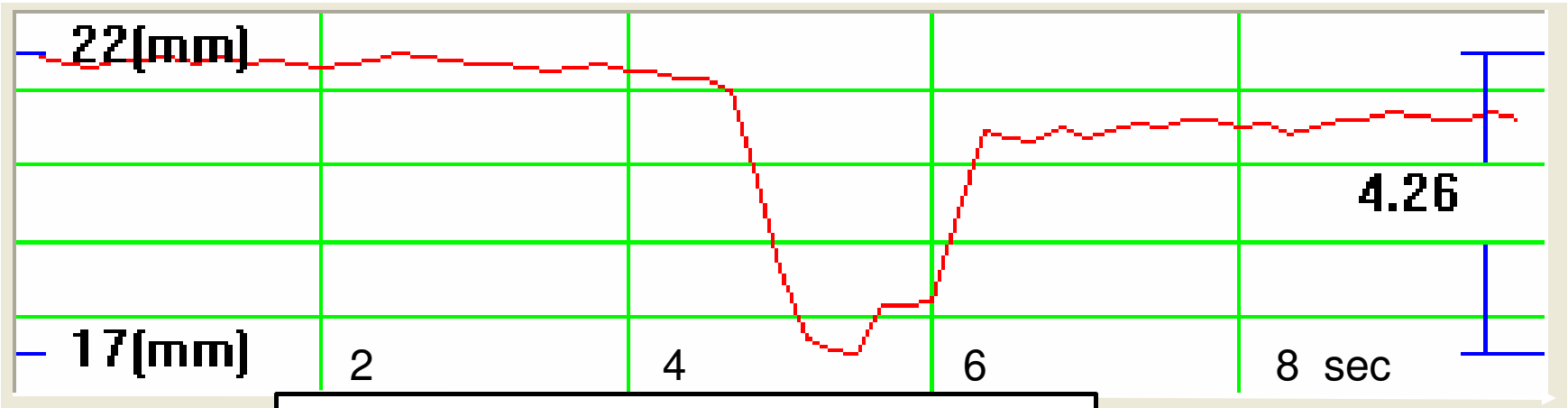
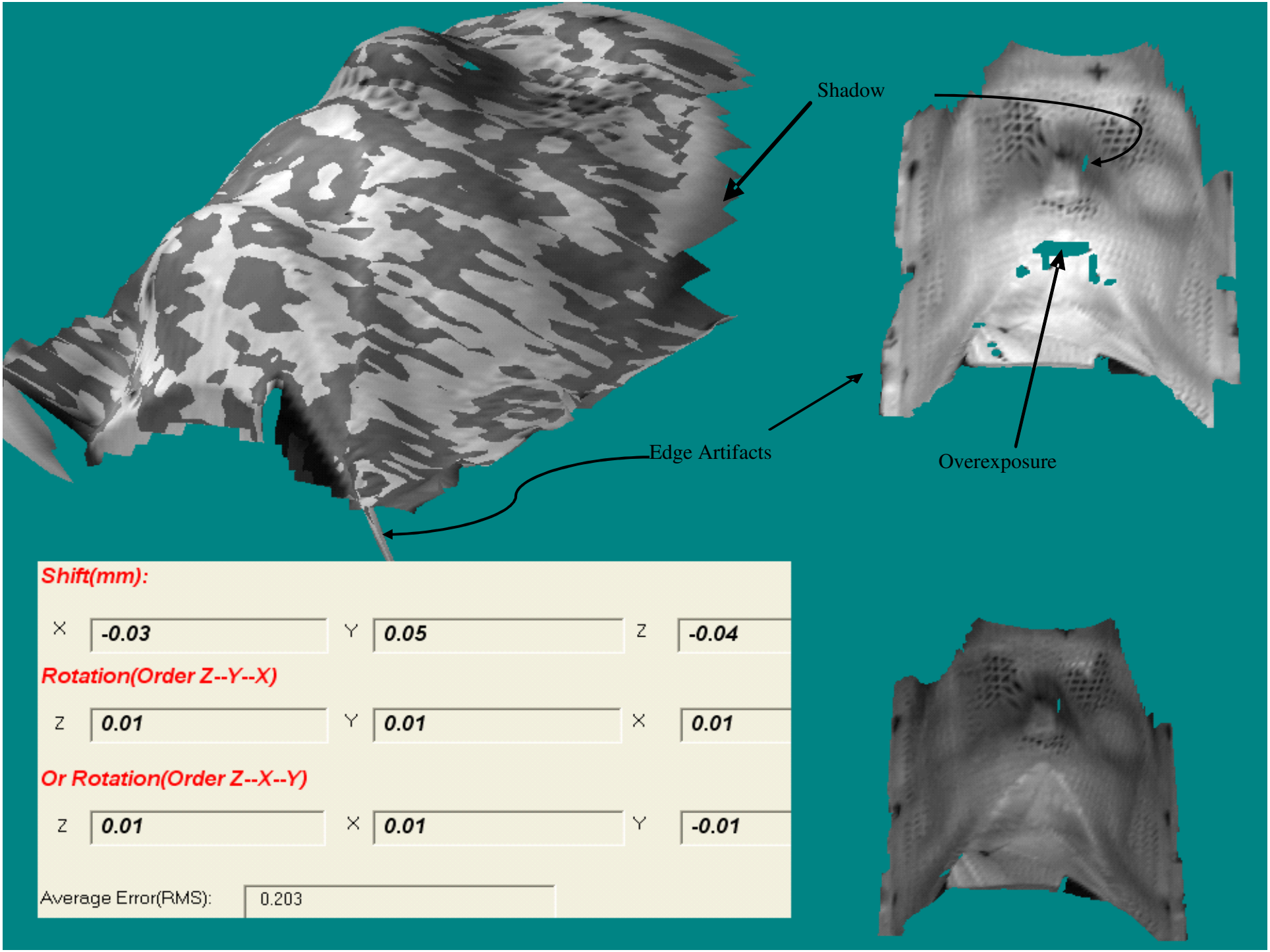
A New Gating/Motion Monitoring



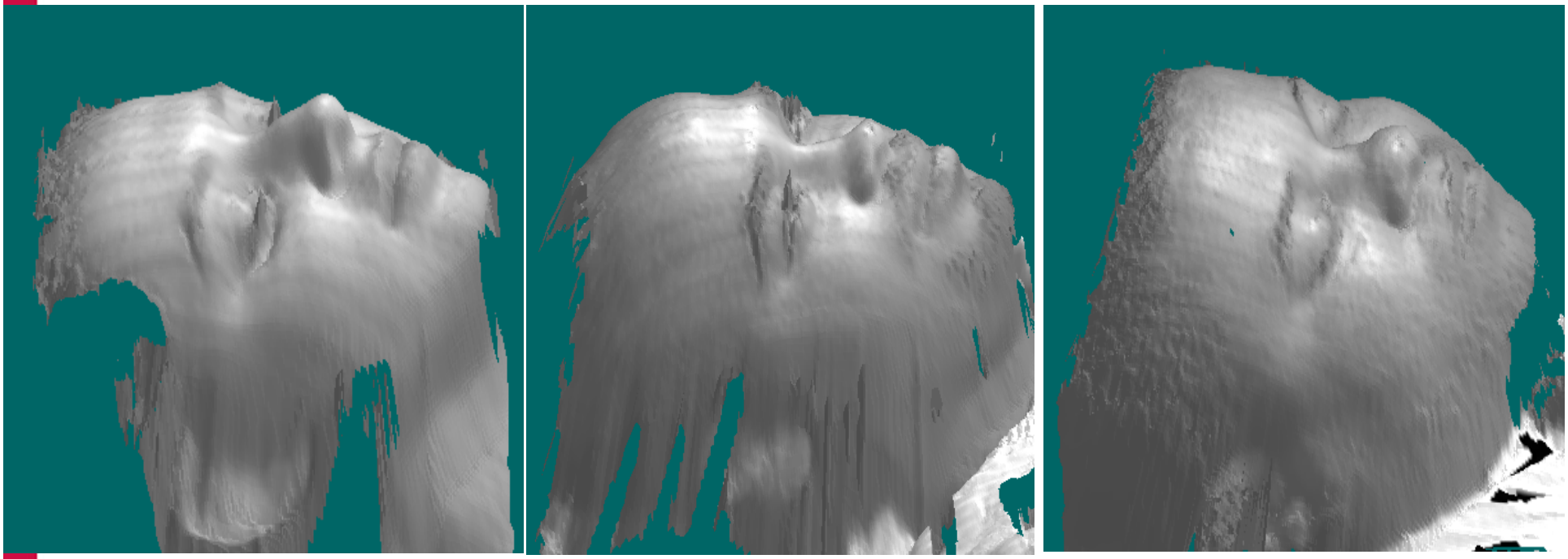


Li, et al. Med. Phys. 2006, 492-503


Shadow
Edge Artifacts
Overexposure
Shift(mm):
X -0.03
Y 0.05
Z -0.04
Rotation(Order Z--Y--X)
Z 0.01
Y 0.01
X 0.01
Or Rotation(Order Z--X--Y)
Z 0.01
X 0.01
Y -0.01
Average Error(RMS): 0.203

5. Eye-Safety & Feasibility

Skin tones and eye-safe tests have been performed with volunteers prior to clinical application with the first Rainbow camera @ JHU

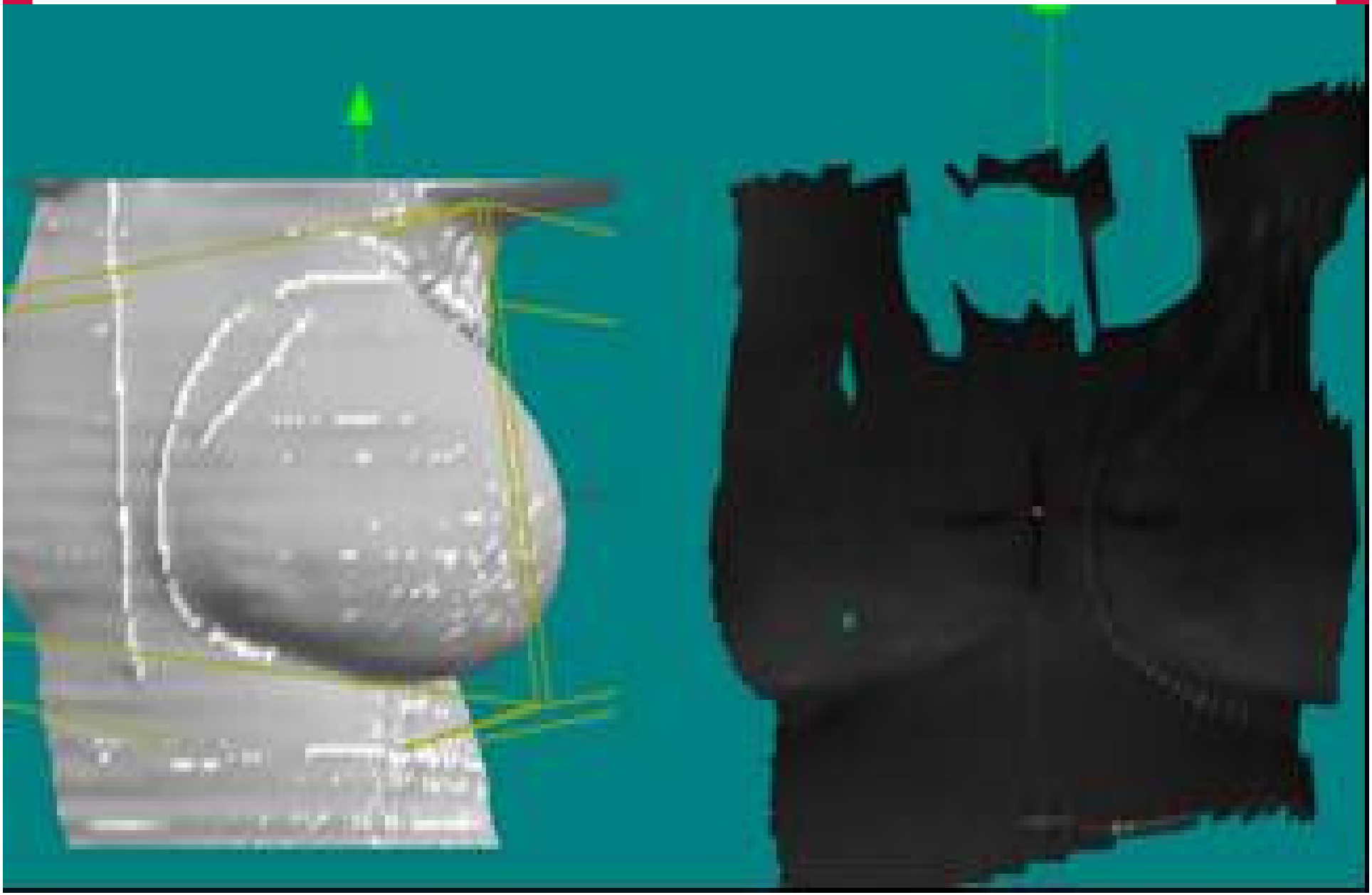


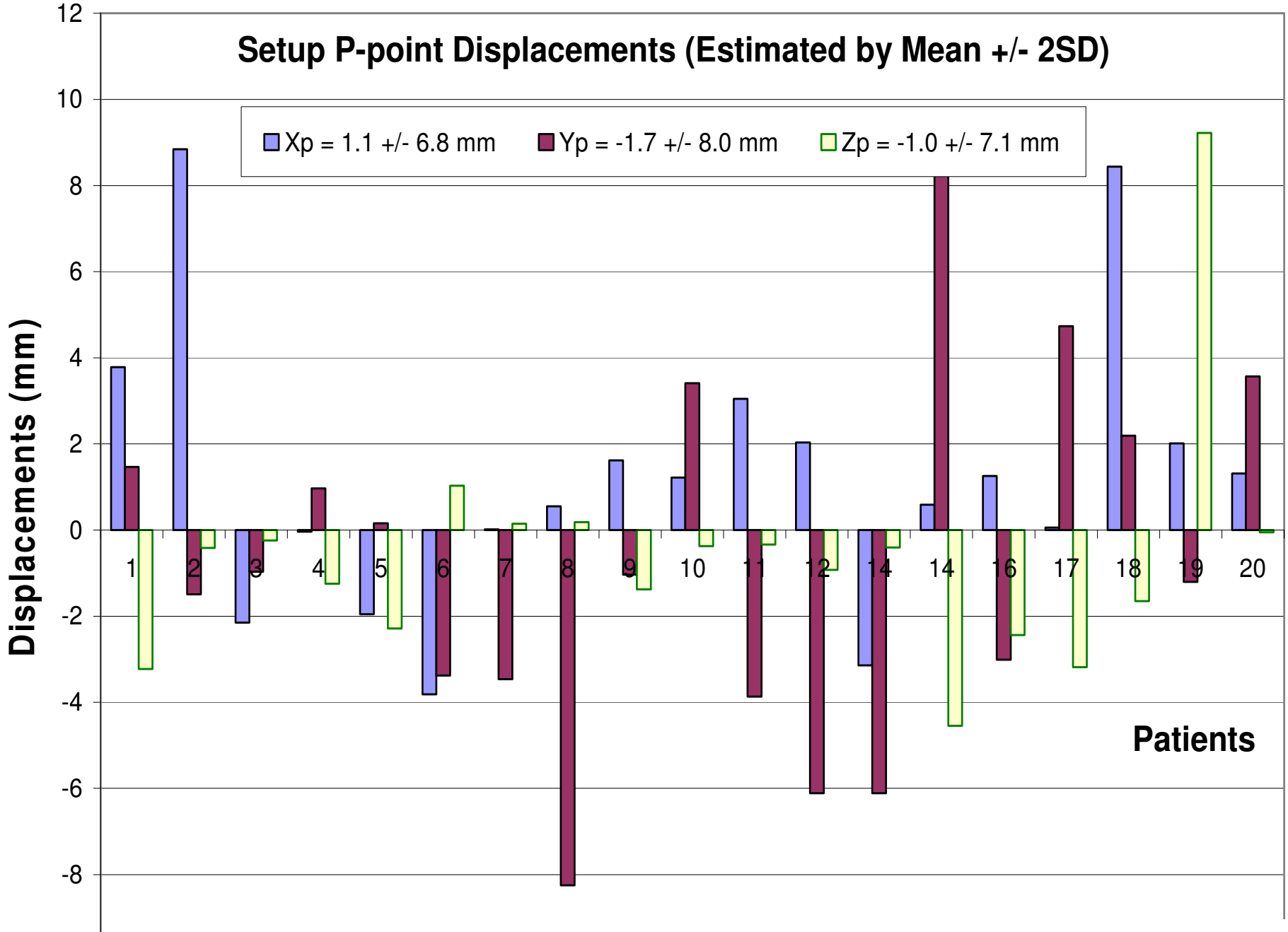
A physician
White (25%PP)

A dosimitrist
Tan (100%PP)

A Therapist
Dark (200%)

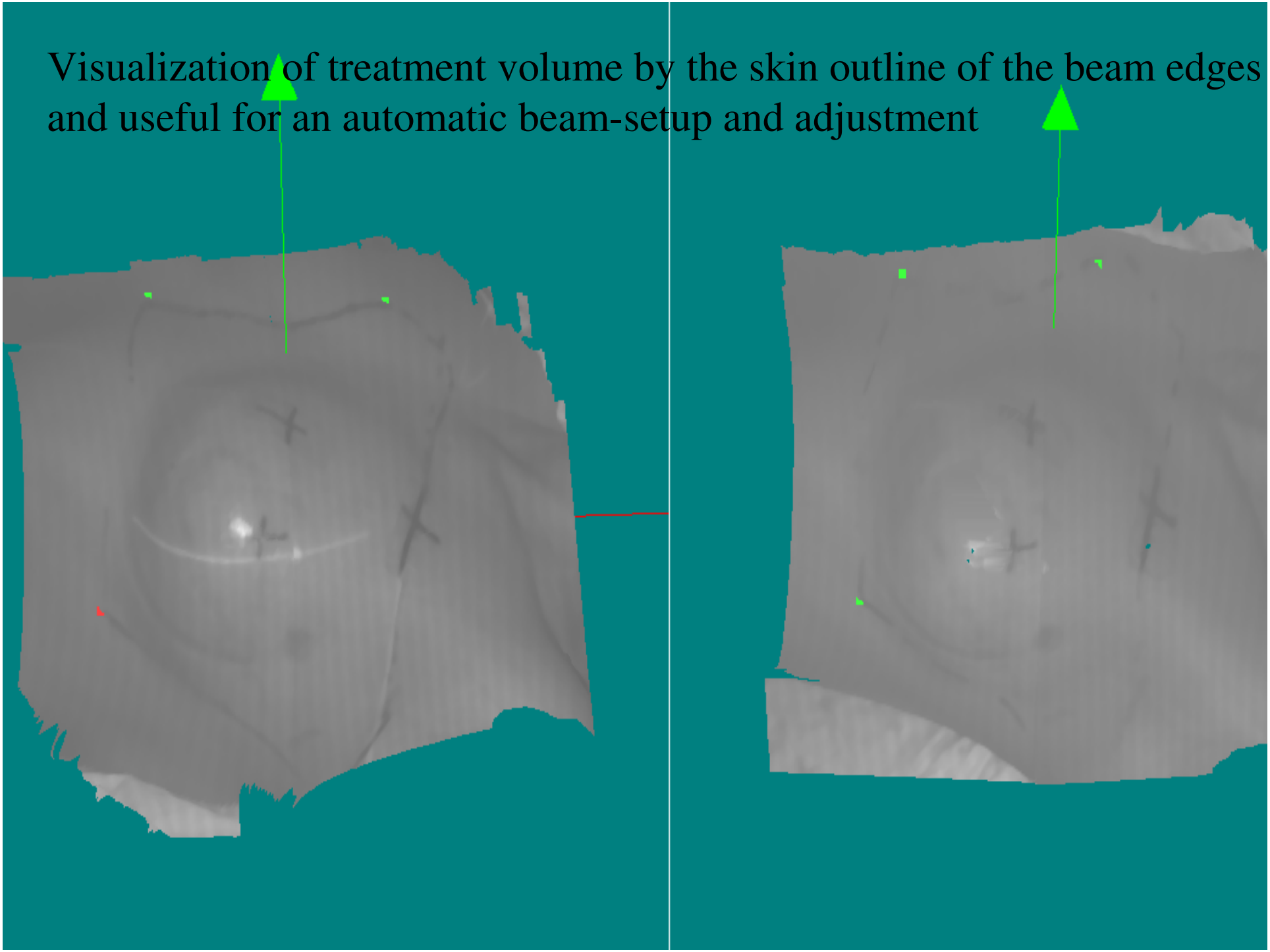
III . Results of Early Clinical Trials





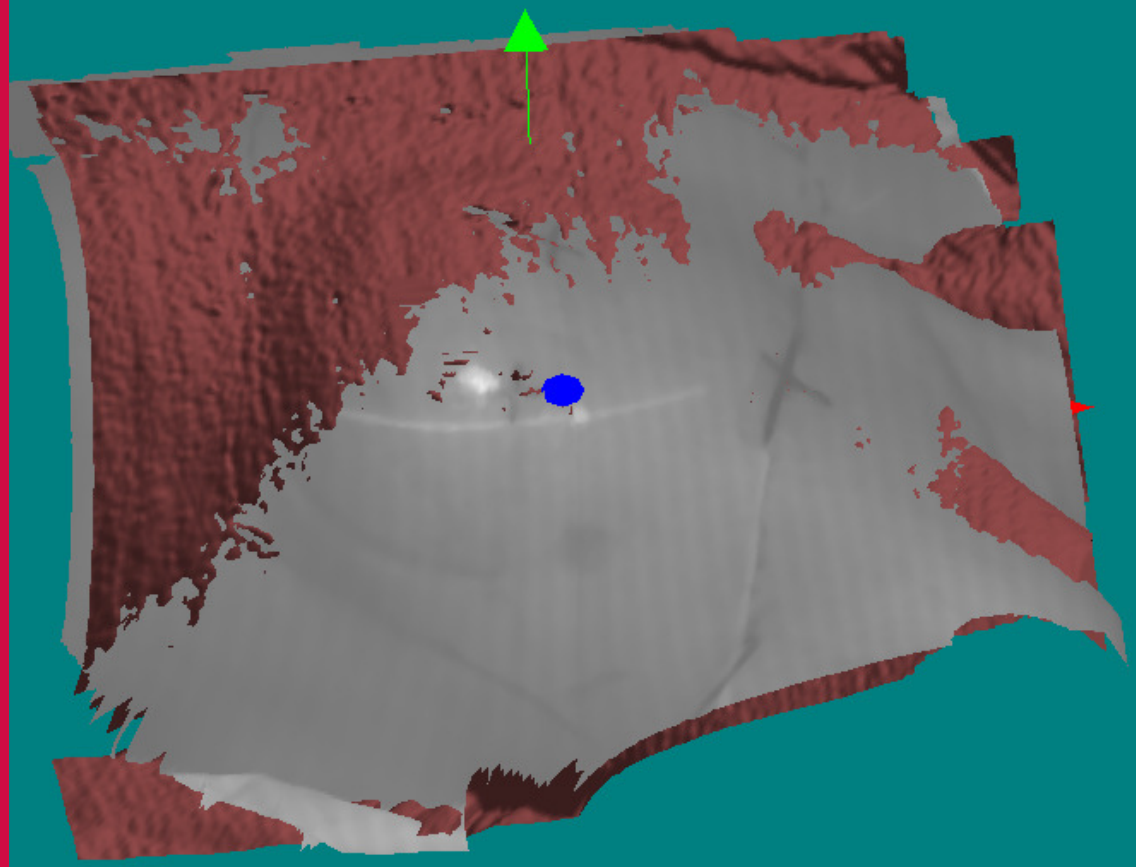
Li, et al, Submitted for publication

Visualization of treatment volume by the skin outline of the beam edges and useful for an automatic beam-setup and adjustment



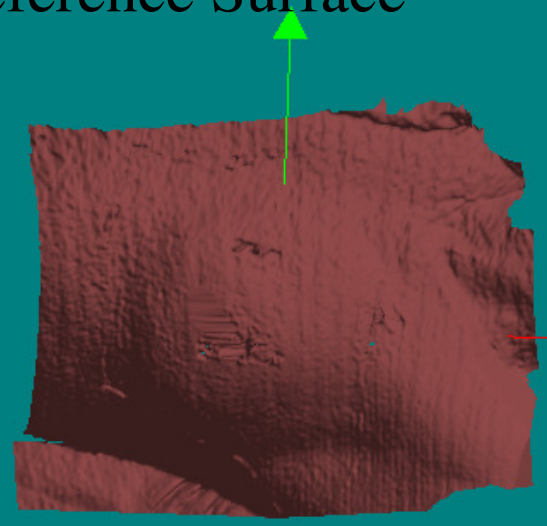
Shape Changes

Overlap of 2nd week surface image on the reference image shown significant shape changes due to the arm position

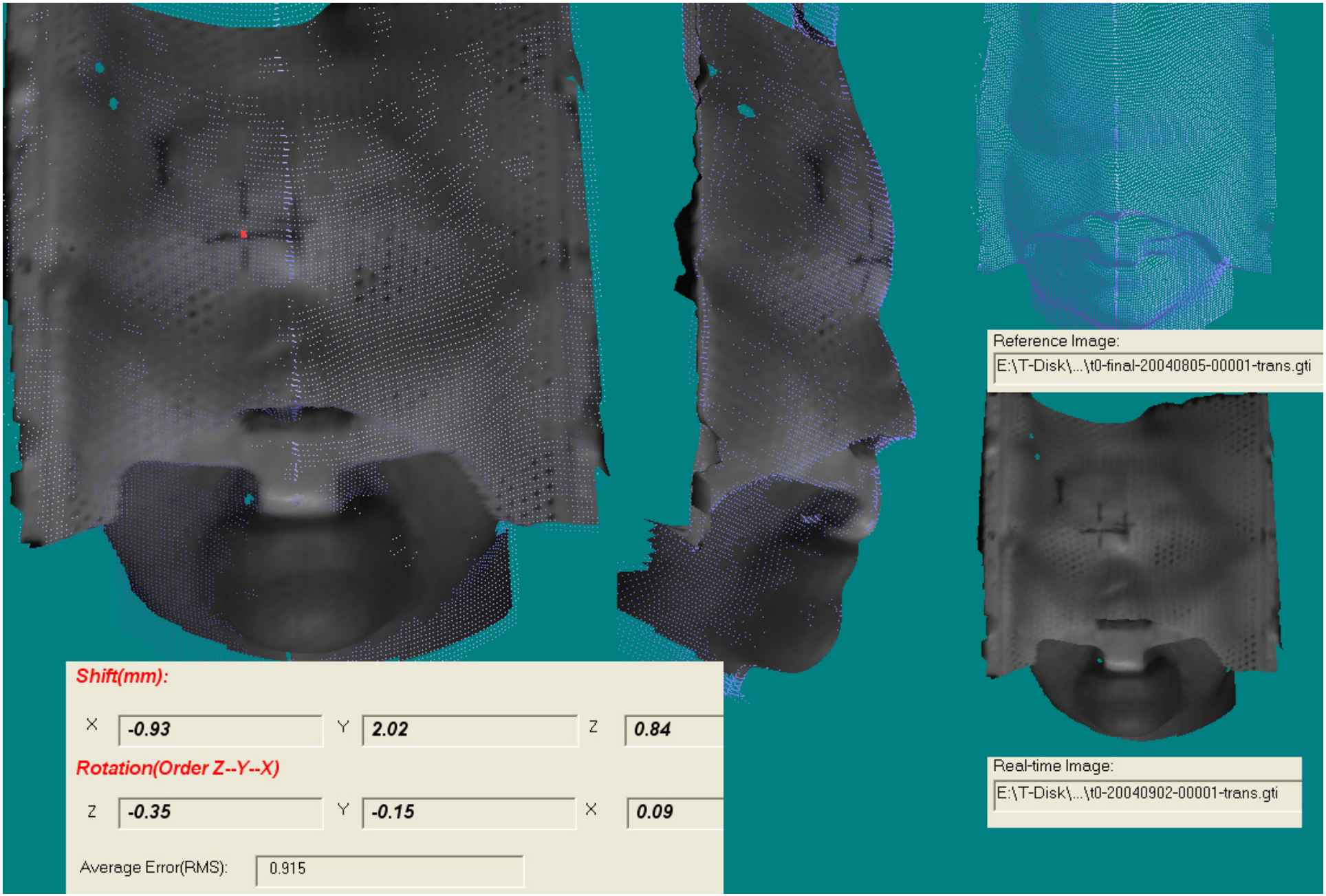


Stereovision at a day in 2nd week

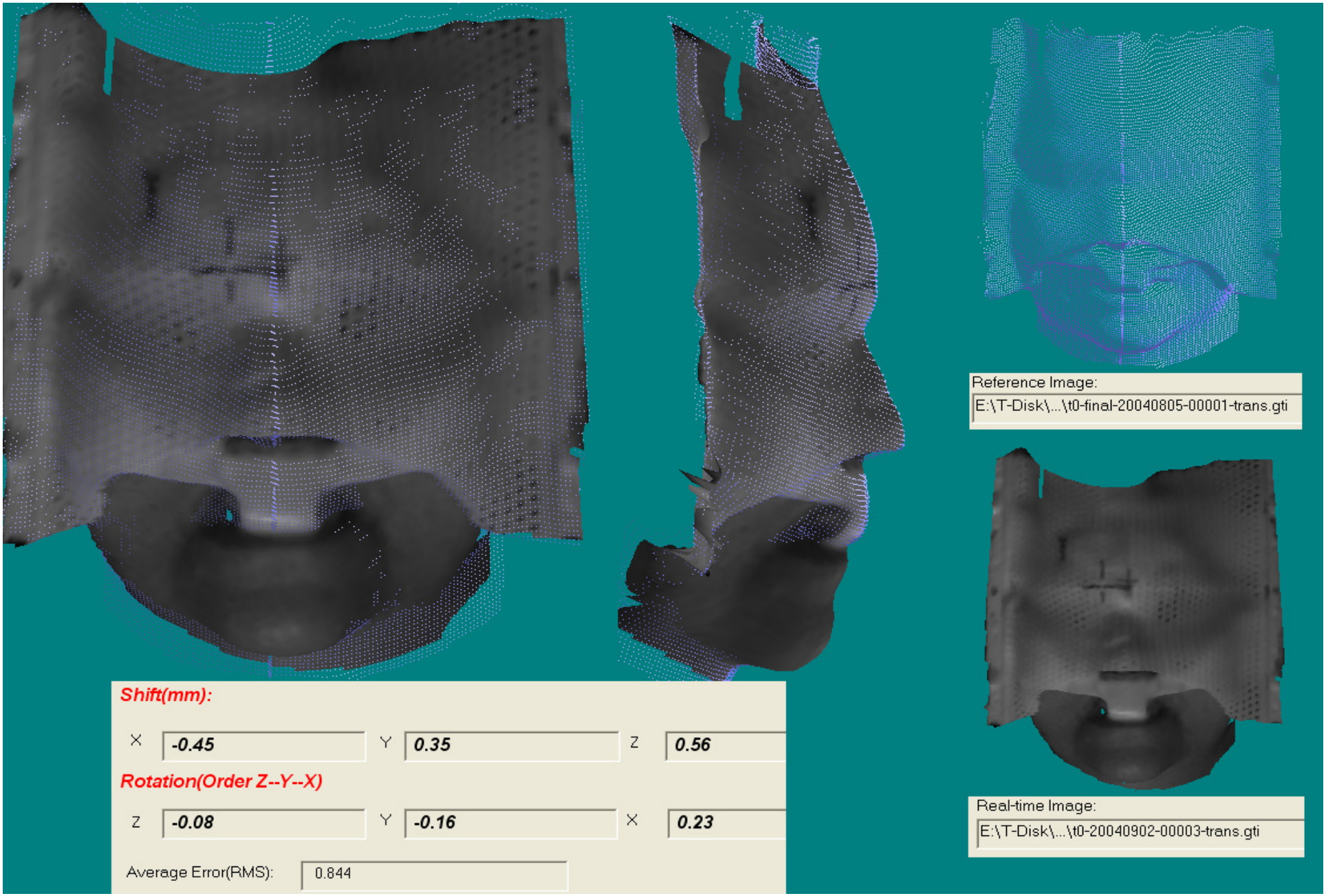
Reference Surface



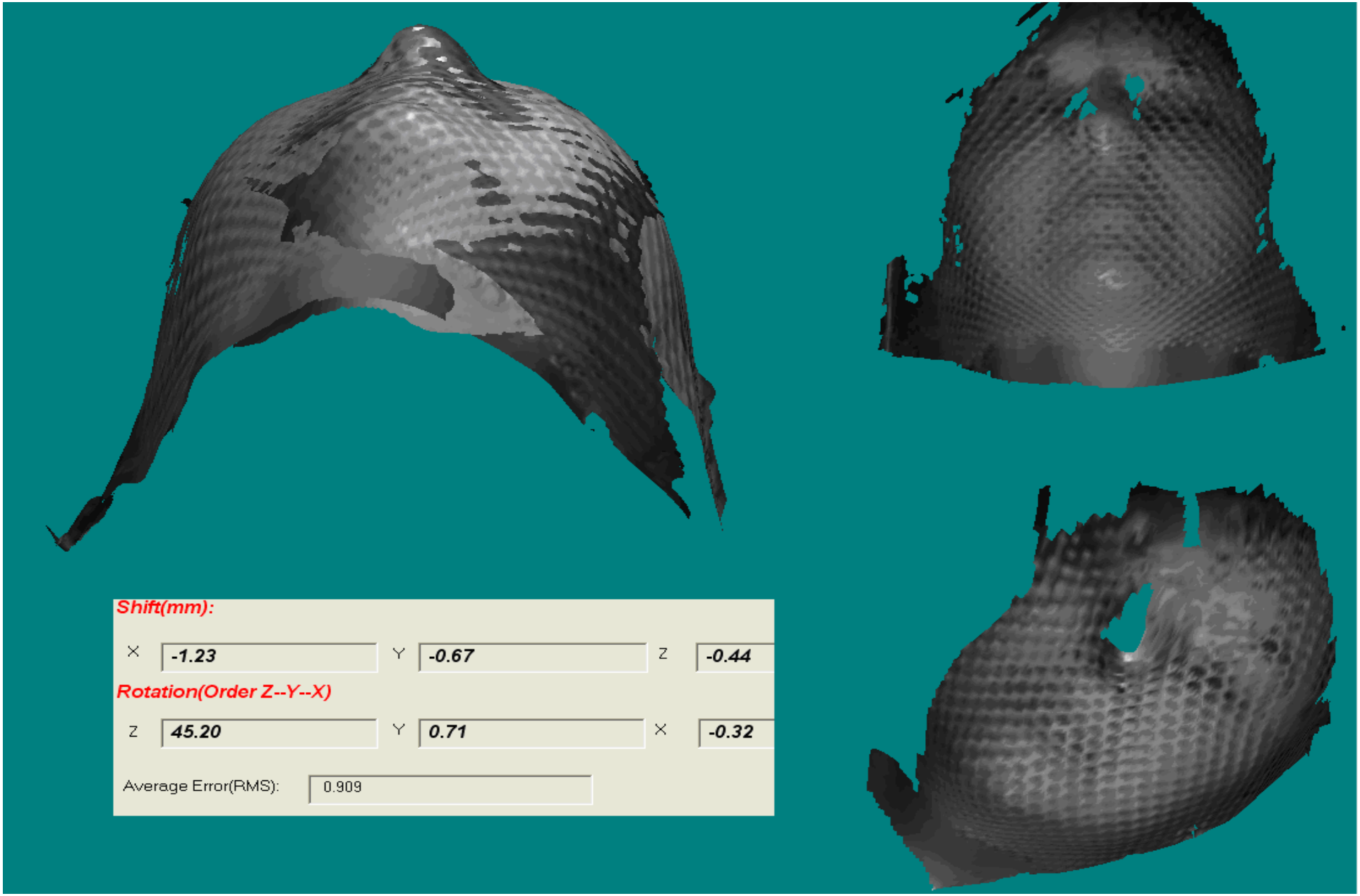
A SRT under SG detects 2 mm setup errors

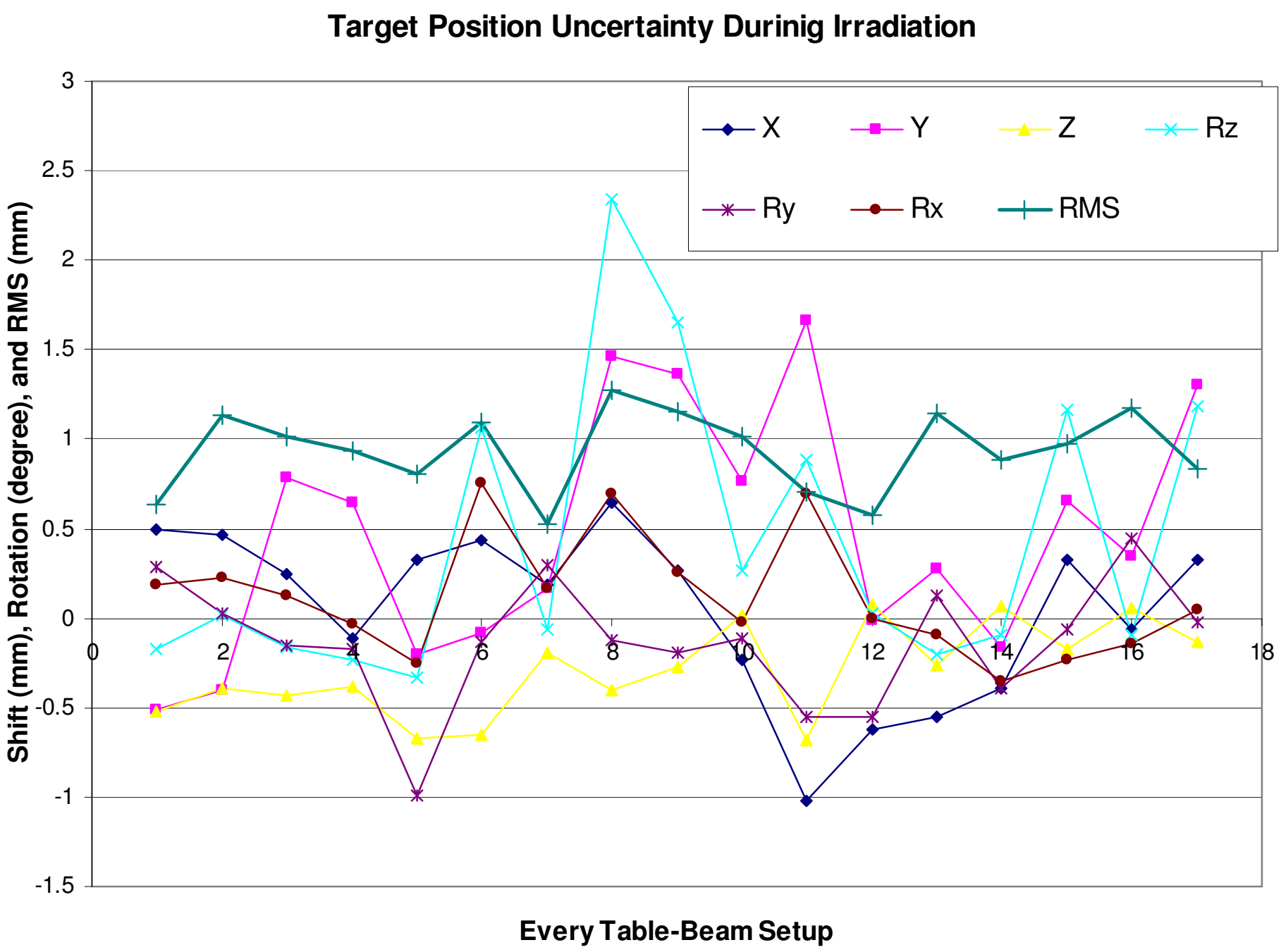


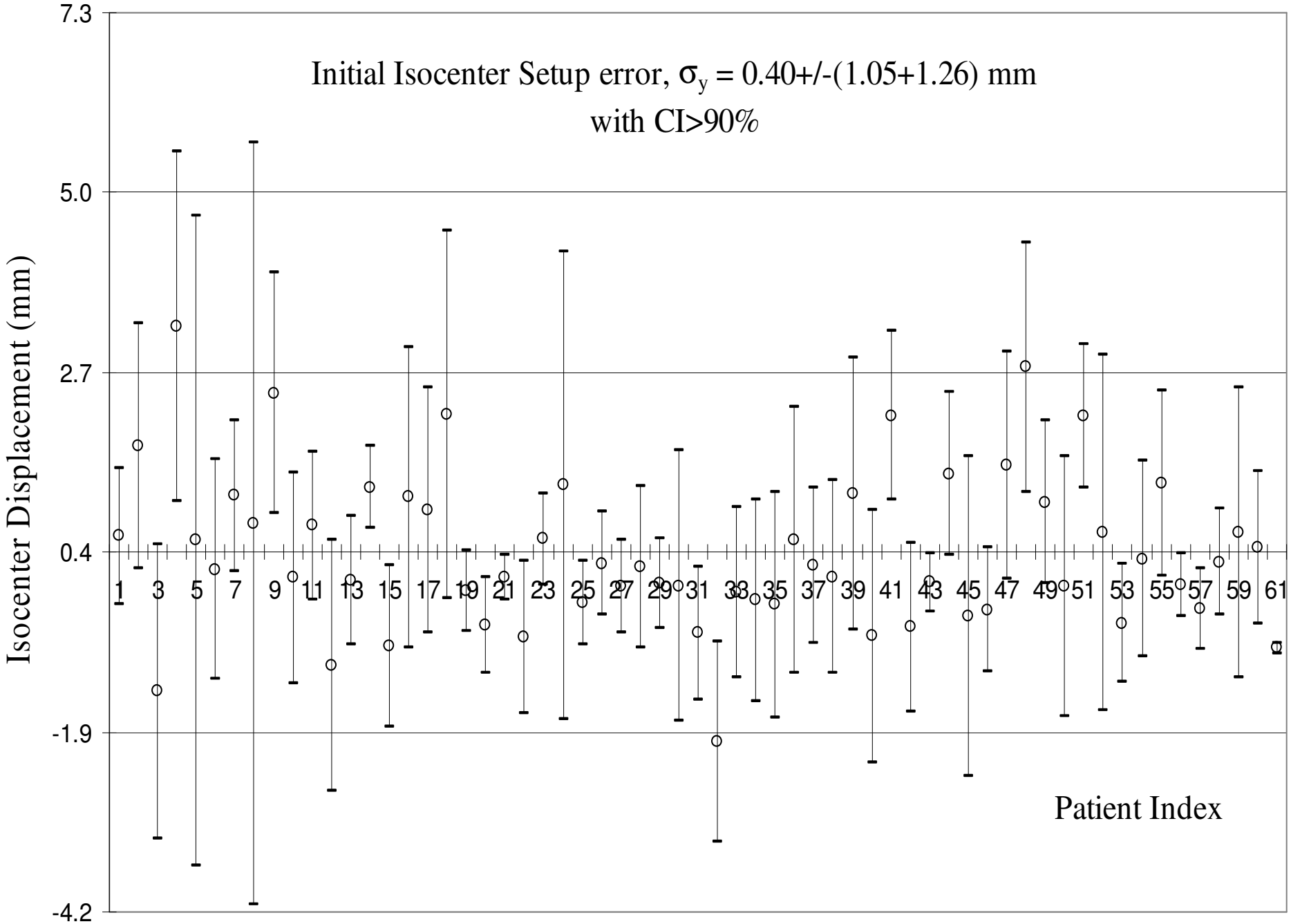
Manual adjusted based on SG <0.6 mm errors

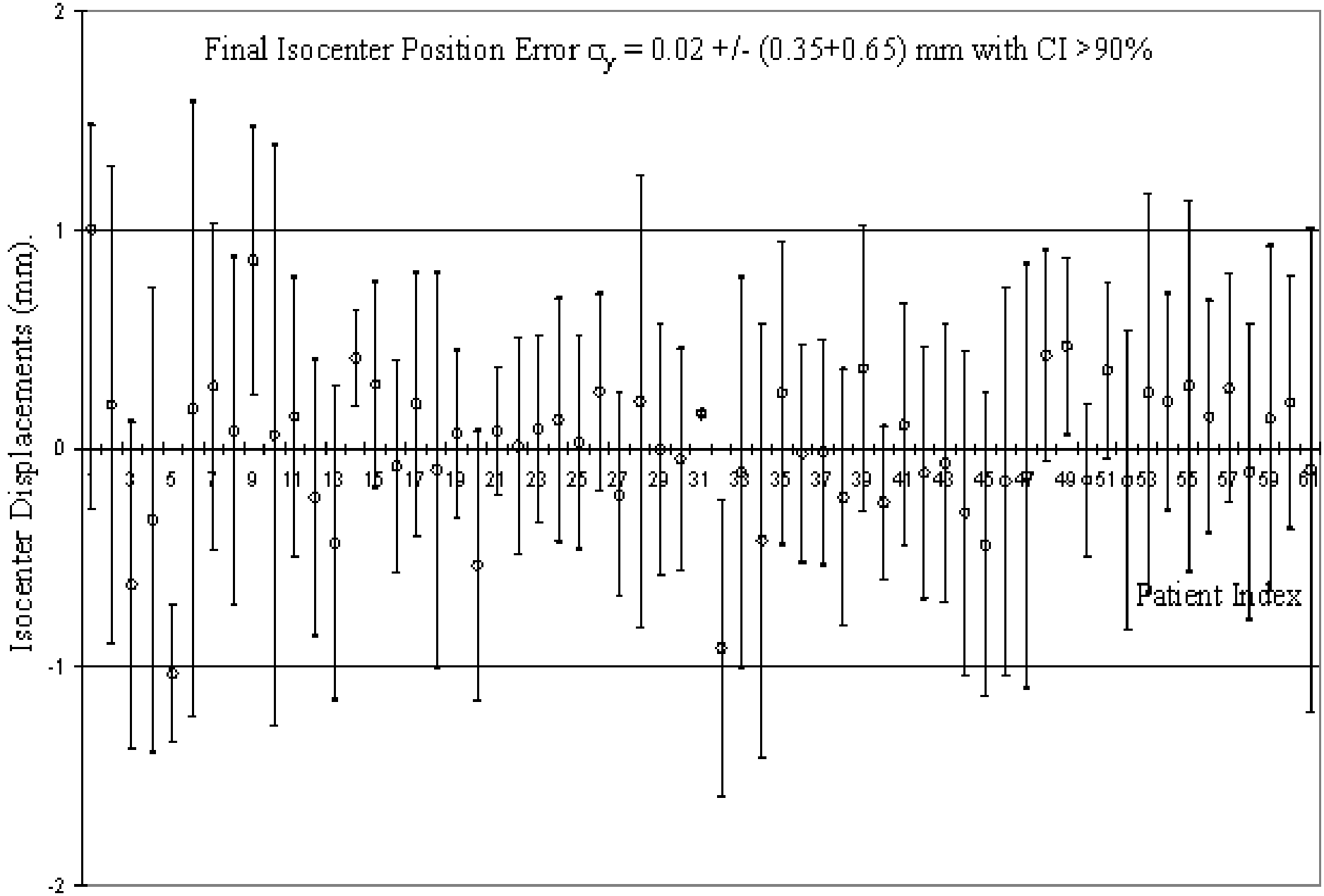


Useful for patients wearing flexible masks

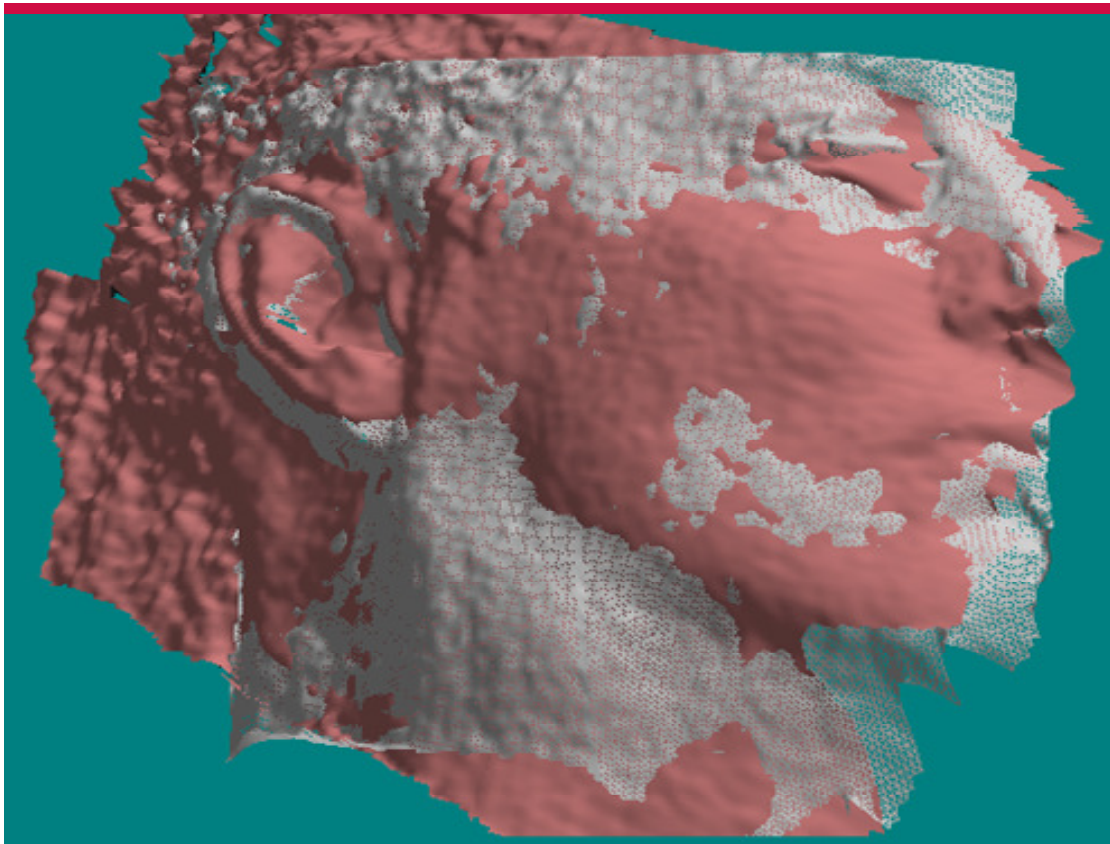



Target Position Uncertainty Durinig Irradiation
Shift (mm), Rotation (degree), and RMS (mm)
Every Table-Beam Setup
X
Y
Z
Rz
Ry
Rx
RMS
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
0
2
4
6
8
10
12
14
16
18

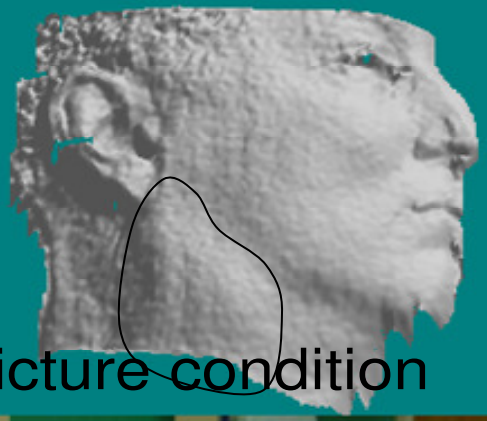

Initial Isocenter Setup error, σ_y = 0.40+/-(1.05+1.26) mm
with CI>90%
Isocenter Displacement (mm)
7.3
5.0
2.7
0.4
-1.9
-4.2
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61
Patient Index



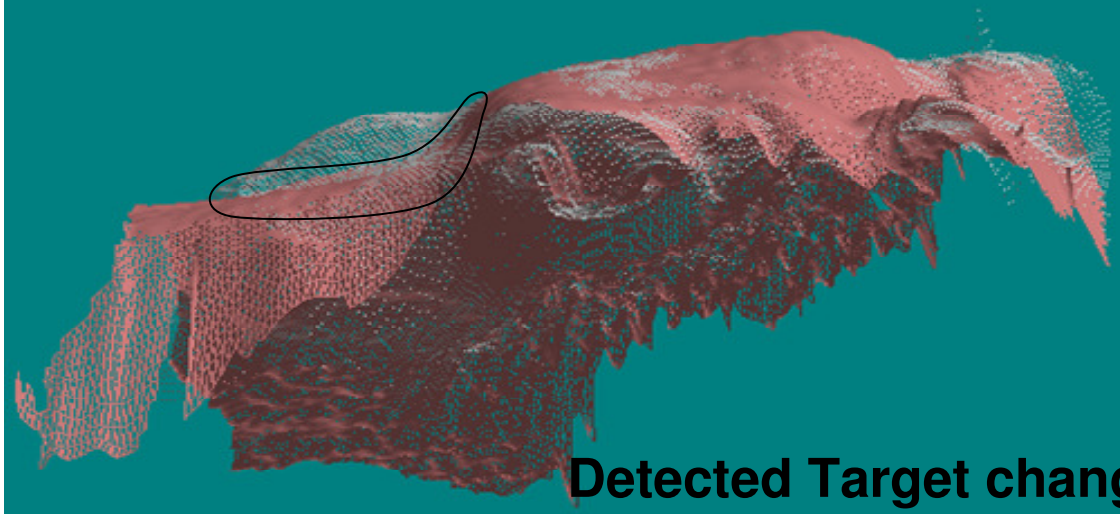
Data of 61 pts out 86 pts at JHU, Accepted for publication by TCRT Journal



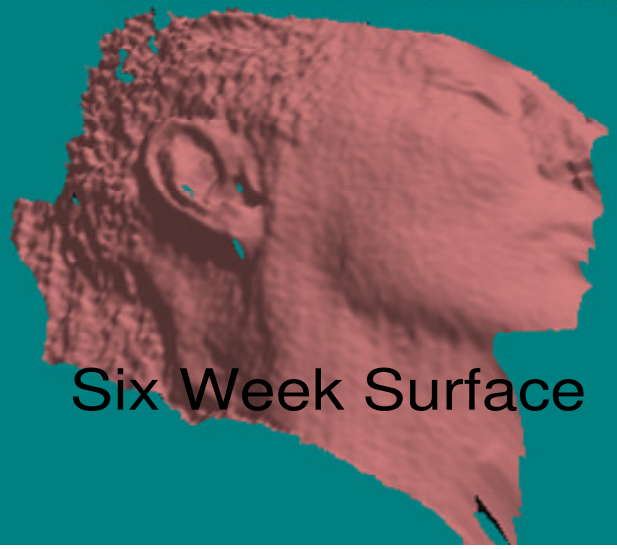
First Day Surface



Picture condition



Detected Target change



Six Week Surface

IV. CONCLUSION

- OG, particular SG, provides an easy and accurate patient positioning and monitoring.
- Early clinical trials and technical developments have demonstrated its usefulness for stereotactic radiotherapy of brain and IMRT of H&N, breast, and other superficial lesions.
- OG combined with CBCT is an ideal approach in IGRT

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