Influence of patient setup in the context of EPID-based *in vivo* dosimetry

F. Oliva [1], S. Celi [1,2], F. Husson PhD [1] & J-C. Diaz [1]

[1] DOSIsoft, Cachan, France, [2] Medical Physics Department, Institut Curie, Paris, France

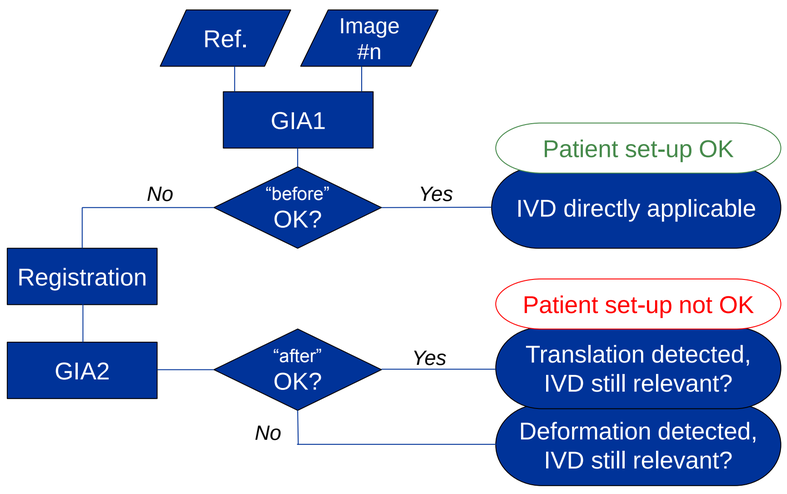
Introduction

At present, the available commercial solutions for *in vivo* transit dosimetry reconstruct point dose values in the patient by applying back projection algorithms on portal images acquired during the whole treatment fraction. These solutions provide the means to compare the predicted dose to the measured dose at each point inside the patient, assuming the beams are aligned with the patient anatomy as planned. Therefore if the actual setup is not tested, reconstructed dose values may be erroneous in case of patient setup errors or breast deformation during treatment, even when the actually delivered dose is correct. The aim of this work is to analyze the possibility of using treatment portal images to assess *a posteriori* the actual patient setup to validate the reconstructed dose values in the patient or to adjust measured dose deviations by correcting the beam-patient alignment.

Methods and Material

1 Fraction to fraction comparison strategy

- **First fraction: Patient set-up validated and reference portal image acquired**
- **Following fraction: Fraction portal image #n and *in vivo* dose results by EPID-based transit dosimetry (IVD)**
- **Fraction portal image #n *vs* Reference portal image**
  - 2D-Gamma Index Agreement (GIA):
    - map and cumulative histogram "*before/after*" image registration
    - tolerance criteria: 3% [local pixel value] - 3mm
  - Rigid registration using an adapted Powell's method
  - "*before/after*" GIA test for:
    - patient alignment default detection
    - IVD validation/correction by beam-patient-image virtual re-alignment in the EPID-based *in vivo* dosimetry system



2 Conventional tangential breast beams

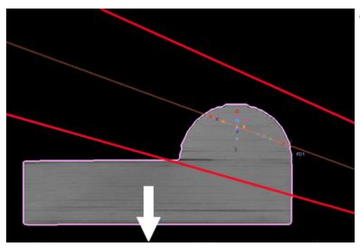
- **Treatment planning and delivery**
  - Eclipse Treatment Planning System (Varian, v. 10)
  - Clinac X6 + EPID aS1000 (Varian Medical Systems, Palo Alto, CA)
- **EPID-based *in vivo* dosimetry system**
  - **EPIgray** (DOSIsoft, France)
  - Dosimetric deviations computed on 23 points within the beam

Study cases

- **Breast-shaped phantom**
  - with gradual setup shifts of 0, 3, 5 and 10mm in the posterior direction
- **Clinical cases**
  - with simple translation of patient setup predominant
  - with extra non-rigid transformations

Results

1 Phantom study



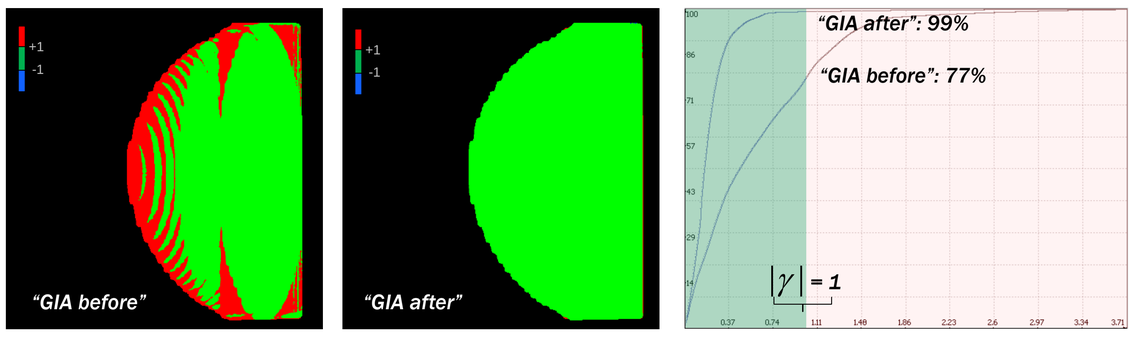
Reference beam-phantom alignment + phantom offset direction

Translations computed by image registration -values projected on the EPID plane at level 150cm- according to the actual offset given at SAD

Notice: beam obliquity from the EPID plan must be taken into account.

Actual offset (mm)	Computed translation (mm)
0	reference
3	2.23
5	3.41
10	6.27

10mm offset case



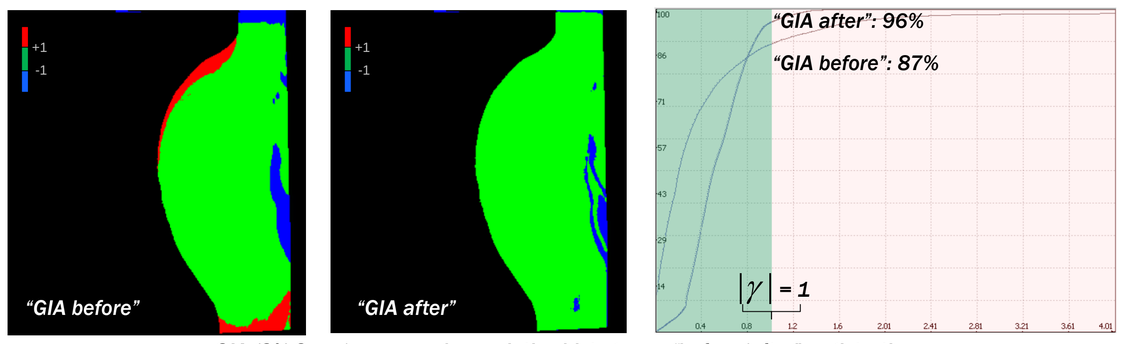
GIA (3%-3mm) maps and cumulative histograms "before/after" registration (6,27mm)

Dosimetric deviations: "*before/after*" phantom *re*-alignment in Epigray

	Initial plan reference image (R)	Fraction offset 10mm acquired image (A)	Corrected alignment translation 6.3mm	*Modified plan actual fraction setup*
Portal image + external contour projection	R	A	A	A
Dose computation mode	TPS Planned dose	Back projection dose "before"	Back projection dose "after"	*TPS True delivered dose*
Reconstructed mean dose (cGy)	105.1	113.5	105.7	*105.4*

2 Clinical cases

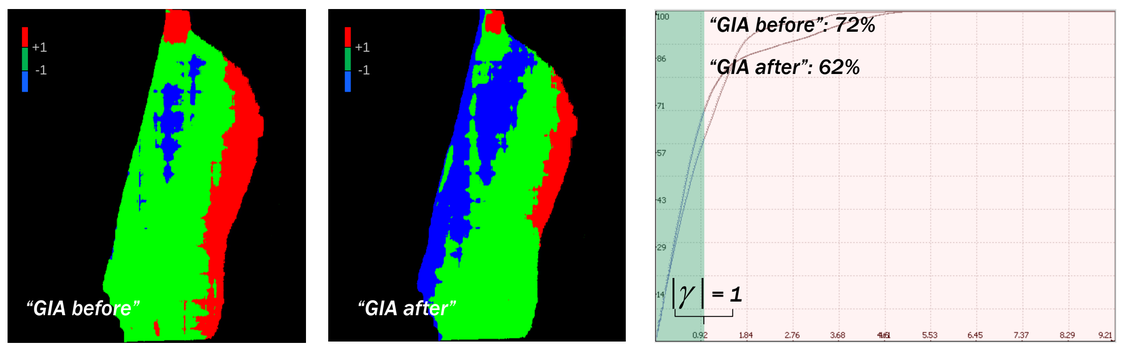
Case 1: translation default between Fraction #2 and REFERENCE Fraction



GIA (3%-3mm) maps and cumulative histograms "before/after" registration

- Patient positioning slightly "out-of-tolerance"
- Computed translation: 3.5mm "ALERT"
- No major extra transformation (GIA2 = 96%)
- Computed translation can be applied on the beam-patient-image alignment for re-computing "true" *in vivo* doses for Fraction #2

Case 2: non-rigid transformation default between Fraction #2 and REFERENCE. Fraction



GIA (3%-3mm) maps and cumulative histograms "before/after" registration

- Patient positioning "out-of-tolerance"
- Computed translation: 7.6mm "ALERT"
- Extra transformation uncovered (GIA2 = 62%)
- No simple rigid transformation between REF and Fraction #2 images: extra deformations occurred, the patient setup model is unsuitable for dose back projection from the portal image

Conclusion

Image registration analysis and impact on EPID-based *in vivo* dosimetry

The "*before/after*" gamma-index test allows to identify the type of deformation in case of patient misalignment:

☞ If the GAI improves significantly after registration, the patient misalignment results from a major translation issue. Considering the computed translation, the early *in vivo* dose deviations have to be *re*-evaluated by reconstructing a more realistic back projection from the portal image.

☞ Else, a rigid transformation may not be the only reason why the points would not coincide. *In vivo* dose reconstructions must be interpreted with caution. The origin of the treatment reproducibility issue must be investigated – if large anatomical deformations are highlighted, the initial plan may be no longer valid.

With a suitable and automatic geometric processing, it is possible to improve the confidence in *in vivo* dosimetry results for tangential breast beams by reducing the effect of setup error during the course of treatment.

References

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Corresponding author: husson@dosisoft.com

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