**Title**: **Evaluation of a b-spline deformable image registration algorithm using numerical phantoms and physical phantom (“Phydeform”) for dose warping**

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**Introduction:** Adaptive Radiotherapy (ART) is a technique which minimizes the dosimetric impact of anatomical changes that may occur during treatment. One of the milestones of ART for dose warping is deformable image registration (DIR) between images acquired during treatment and original planning images. The aim of this study is to propose a method to evaluate the performances and characterize the use of a b-spline DIR algorithm implemented in Velocity® v.3.2.0 (Varian Medical Systems, USA).

**Methods:** Two types of dataset were used to perform the evaluation, numerical phantoms and physical phantoms (called “Phydeform”). IMSIMQA™ software (OSL, UK) provides a numerical phantoms library and the opportunity to generate deformation. For algorithm characterization, deformation scenarios on simple volumes were created and two sets of images were systematically obtained for each induced deformation: initialCT and deformedCT. The evaluation related to the comparison of deformation vectors field via error histograms and contours with metrics like DICE and MDC (Mean Distance Conformity). The contour comparison was done between distorted contours obtained by Velocity® and expert contours on deformedCT. Voxel’s size influence with DIR was also evaluated.

Physical phantom « Phydeform » with cubic shape of a homogenous material was used to evaluate the spatial deformation with markers and dose deformation with detectors like TLD’s (IRSN, France) and MOSFET’s (Best Medical, Canada). Two images series were compared: no-deformedCT and deformedCT obtained following the application of uniform compression on phantom. Marker’s position was evaluated between non deformed and deformed reference. Three fixed beams were delivered. The conditions were selected for highlighting dose variation between reference and deformed phantom state. Dose “deformed” value obtained after DIR application was compared with detectors measurement.

**Results:**

For numerical phantoms, average Dice values are 0.83 (± 2σ = 0.1) and 1.8mm for MDC for tested deformation scenarios. For vector fields comparison, the criterion 95% voxels not exceeding 2mm is respected. A reduced voxel size improved results.

The markers position comparison between reference frame “no deformed – deformed” and “no deformed – deformed after DIR” gives us an uncertainty associated with voxels mapping of 10.3% on average. In terms of dose, uncertainty associated with voxels mapping is 4.3% for MOSFET's and 10.4% for TLD's.

**Conclusions:**

ART software commissioning requires images deformation and dose warping validation. Results with numerical and physical phantoms make it possible to consider implementation of the first clinical applications using Velocity®.

Keywords: Adaptive radiotherapy, Deformable image registration, Numerical phantoms, Physical phantoms, dose accumulation