Deformable Image Registration performances in Head and Neck patients: impact of daily imaging quality

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BACKGROUND

This work is part of an Italian multi-institutional study aimed to evaluate the performances of regions of Interest (ROI) propagation with various deformable image registration (DIR) commercial systems in clinical settings.

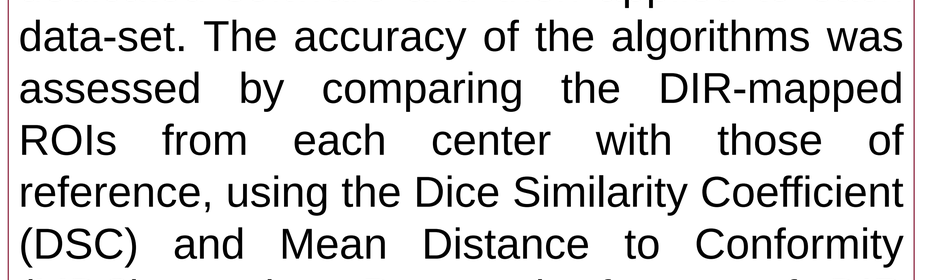
In this phase the purpose was the evaluation of performances of (DIR) to propagate ROIs, against image quality typical of Cone Beam CT (CBCT) and Megavoltage Cone-beam CT (MVCT) images, using computational phantoms based on real HN patient images.

MATERIALS & METHODS

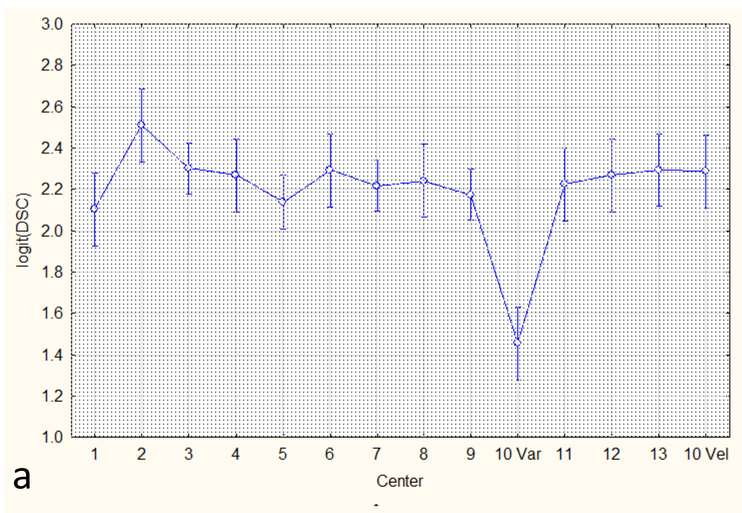
Fourteen institutions joined the study with five commercial DIR solutions. Three real patient data-sets from different on board imaging devices (kVCBCT and MVCT provided by different vendors) were used; their image quality was evaluated in terms of Spatial Resolution and CNR. Two specific Deformation Vector Fields (DVF) with realistic level of deformations, were generated with a dedicated software and then applied to each data-set. The accuracy of the algorithms was assessed by comparing the DIR-mapped ROIs from each center with those of reference, using the Dice Similarity Coefficient (DSC) and Mean Distance to Conformity (MDC) metrics. Prognostic factors of DIR performances were carried out.

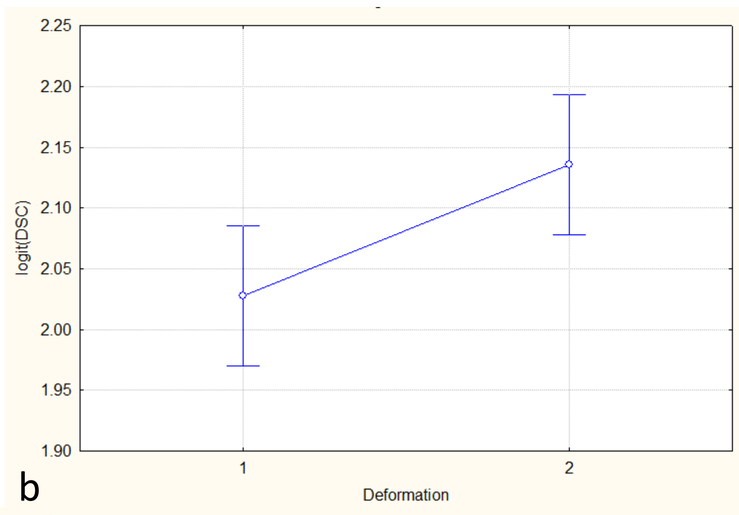
To investigate the impact of image quality parameters on the DIR results a four way ANOVA was performed on logit function of DICE index.

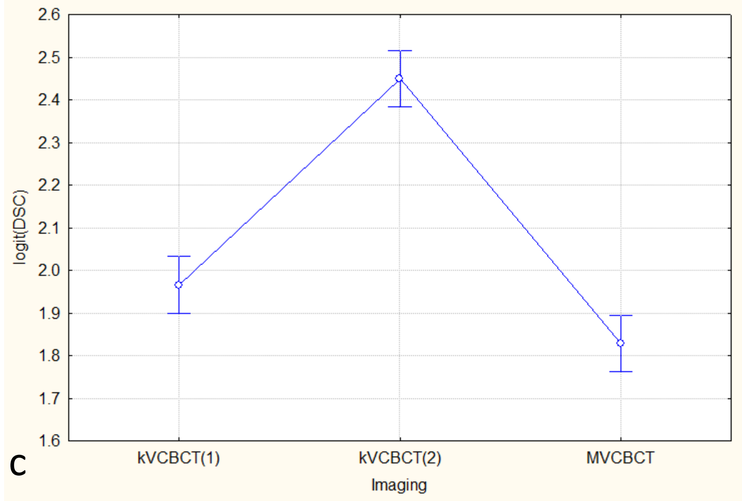
The following variables were analysed: institution, ROI, imaging device, deformation amplitude and DIR algorithm.

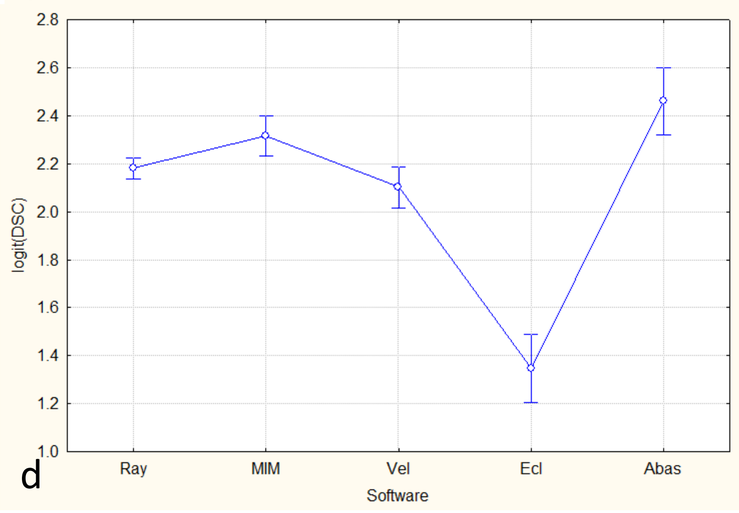


RESULTS









Based on more than 700 DIR-mapped ROIs the 4-way ANOVA analysis states that DIR algorithm, image quality and organ type are significant predictors of DIR performances. Spatial resolution for the three imaging systems kVCBCT-1, kVCBCT-2 and MVCT are 3, 6 and 5 line pair/cm respectively. CNR (teflon) are 48, 73 and 20, respectively.

Putting together all DSC data of all institutions (fig. a) for the first DVF, the mean DSC was 0.88 ± 0.05 (1 SD), and the mean MDC is 0.38 ± 0.96 (1 SD); for the second DVF, the mean DSC was 0.86 ± 0.11 (1 SD), and the mean MDC is 0.43 ± 1.08 (1 SD). A slightly dependence from applied DVF is detected (p=0.035) with a post hoc test (fig. b). The thyroid, located near the FOV border, was the underperformer organ with large errors (unacceptable). All other organs were mapped with an acceptable accuracy (at voxel size level). One imaging system (fig. c) performs statistically better than the others, and one algorithm produced unsatisfactory results respect all the others (fig. d).

CONCLUSIONS

This work studies the impact of CBCT and MVCT image quality on DIR performance in a ground truth provided scenario. Clinical issues like Adaptive Radiation Therapy (ART) need accurate and robust DIR software. The reported result highlight that in HN district the image quality and the implemented algorithm are strictly related to DIR performances. CNR appears to be a significant parameter that affects the results

REFERENCES

Your elastic solution group: Multi-institutional study to evaluate DIR algorithms for structure delineation via computational phantoms (Physica Medica 32:24 · February 2016) DOI: 10.1016/j.ejmp.2016.01.083

Performance of commercially available deformable image registration platforms for contour propagation using patient-based computational phantoms: A multi-institutional study (*Medical Physics* 45 (2) 2018): 748-757. https://doi.org/10.1002/mp.12737

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