Evaluating the Impact of Software Distortion Correction on Target Doses in Cranial Stereotactic Radiosurgery

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INTRODUCTION

Brainlab's Elements is a neurosurgery software suite which proposed a novel MR distortion correction method based on CT image set information. This first involves a rigid registrations of sub-volumes of the MR image to corresponding planning CT sub-volumes and later these registrations are interpolated to generate a single continuous deformation field map. This process creates a new MR image set, called Corrected MR image set (corrMR).

No literature currently exists studying the impact of Brainlab's Elements distortion on the target dose for cranial stereotactic radiation treatments. In this study, we aim to evaluate the impact of Brainlab MR distortion correction on the target dose of radiation compared to the original treatment plan without distortion correction.

AIM

In this study we evaluated the impact of Brainlab MR distortion correction on target dose.

METHOD

- A retrospective analysis of MR distortion correction on previously treated 24 cranial targets was done (5 single target and 19 multi-target single isocenter) .
- Original planning MR-CT fusion was used for MR distortion correction. A single certified radiation oncologist re-contoured gross tumor volume (corrGTV) on corrMR image set.
- A 1mm clinical margin was applied to the GTVs to define planning target volumes (corrPTV).
- New targets and the original treatment plan exported to MIMs software for evaluation.
- The clinical significance of distortion correction software was investigated in terms of displacement of targets, dose coverage of corrected targets and inverse Conformity index of corrPTV.

RESULTS

The median distortion displacement of targets center of mass was 1.06 mm with maximum displacement of 2.58 mm (mean 1.05 mm). Figure 1 indicates the displacement of targets on cranial CT image set. With mean and median about 1 mm, about half of the GTVs were within 1 mm clinical margins (Figure 2).

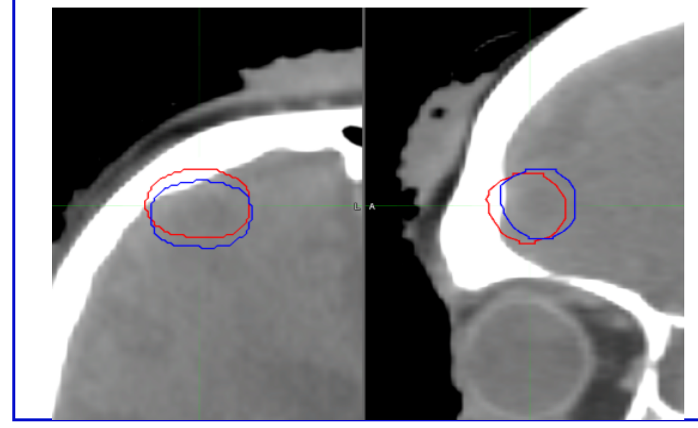


Figure 1: Displacement of PTV in a) axial and b) sagittal view due to MR distortion. Both targets are shown on cranial CT image set.

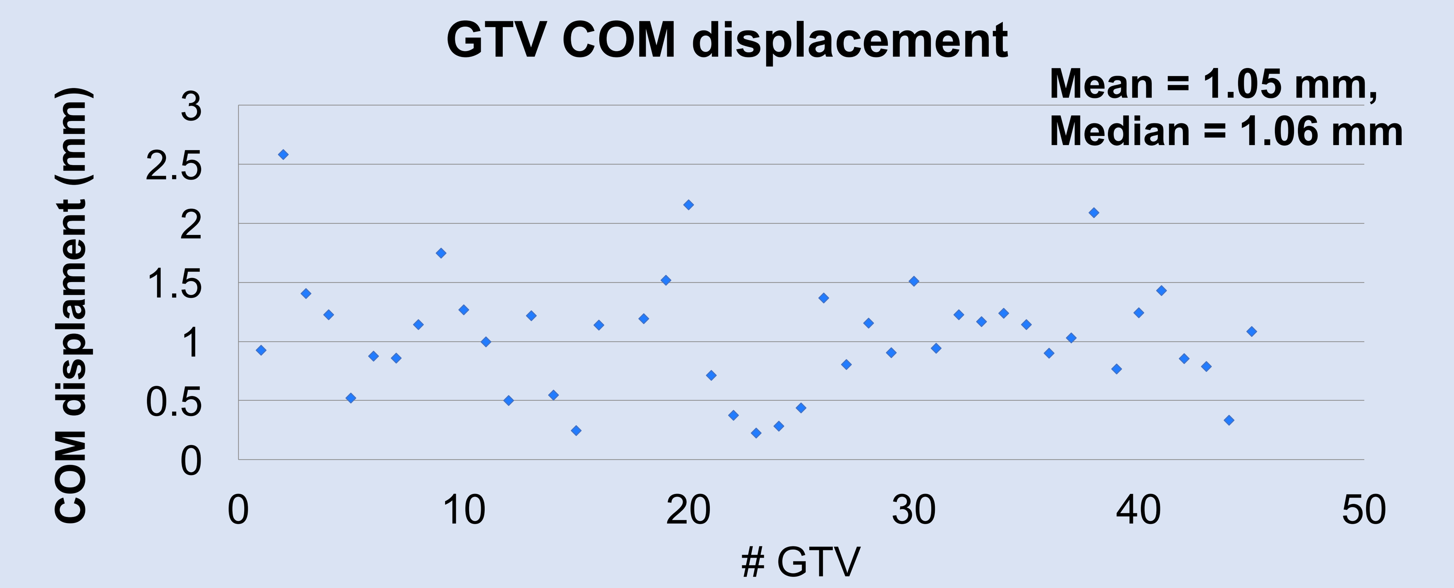


Figure 2: Displacement of center of mass (COM) of target volumes due to distortion correction

For original treatment plans, all PTVs satisfy the clinical criterion (prescription covers 95% of the volume) with median 98% coverage. However after distortion correction, only seven out of twenty four PTVs meet the clinical criterion with median prescription coverage of 93% (Figure 3).

Figure 4 shows minimum dose to target volumes relative to prescription dose for PTVs and GTVs for original plan and after distortion correction. The median of relative min PTV dose is 92% for original plan, reduced to 82% after distortion correction. The relative min GTV dose is reduced to 94% or less for eleven patients. Forty out of forty two GTVs still achieved 98% or more coverage by prescription dose because of clinical margins (1 mm to single targets and 1 - 1.5 mm margins to multi-met targets).

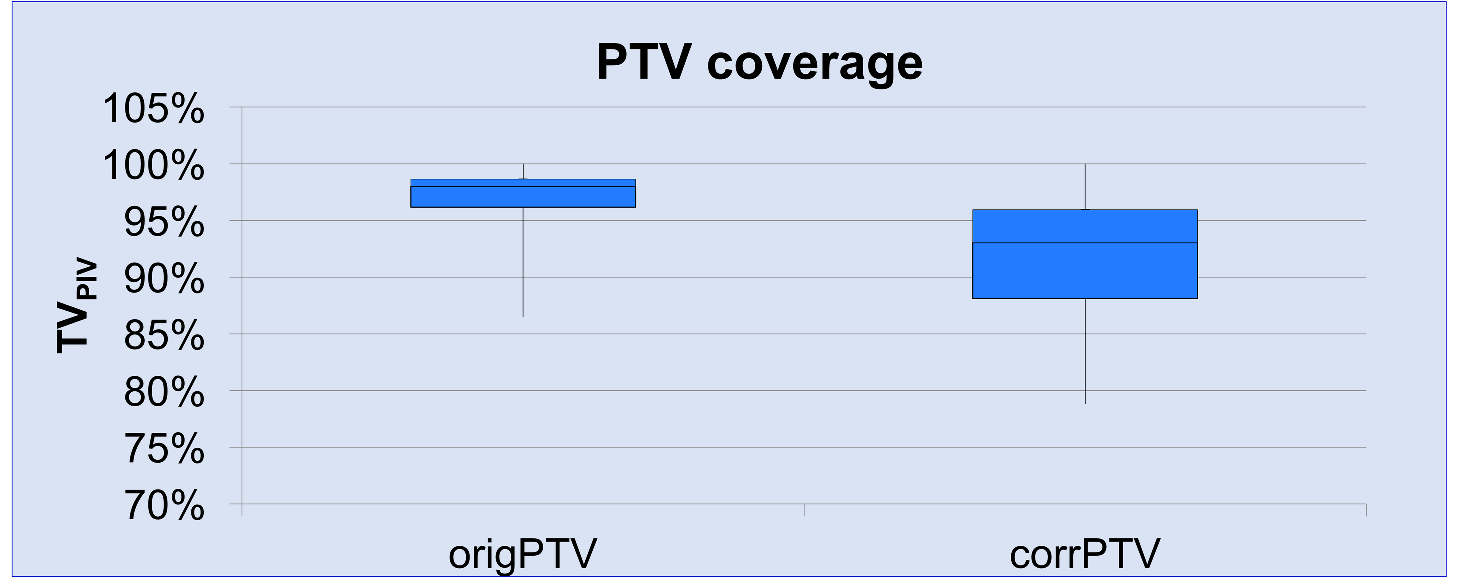
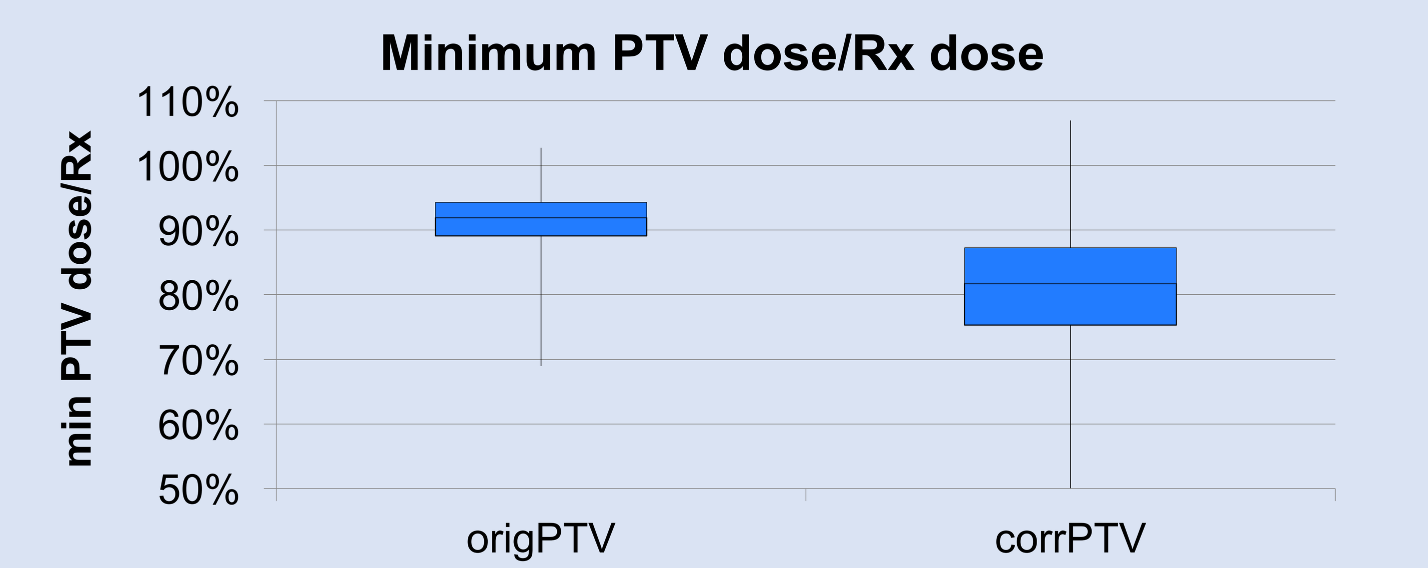


Figure 3: Prescription coverage of planning target volume on original plan and after distortion correction. Here the box plot represent min, fist quartile, second quartile, median, third quartile, fourth quartile and max values of target volume covered by prescription isodose volume (TV_{PIV}).



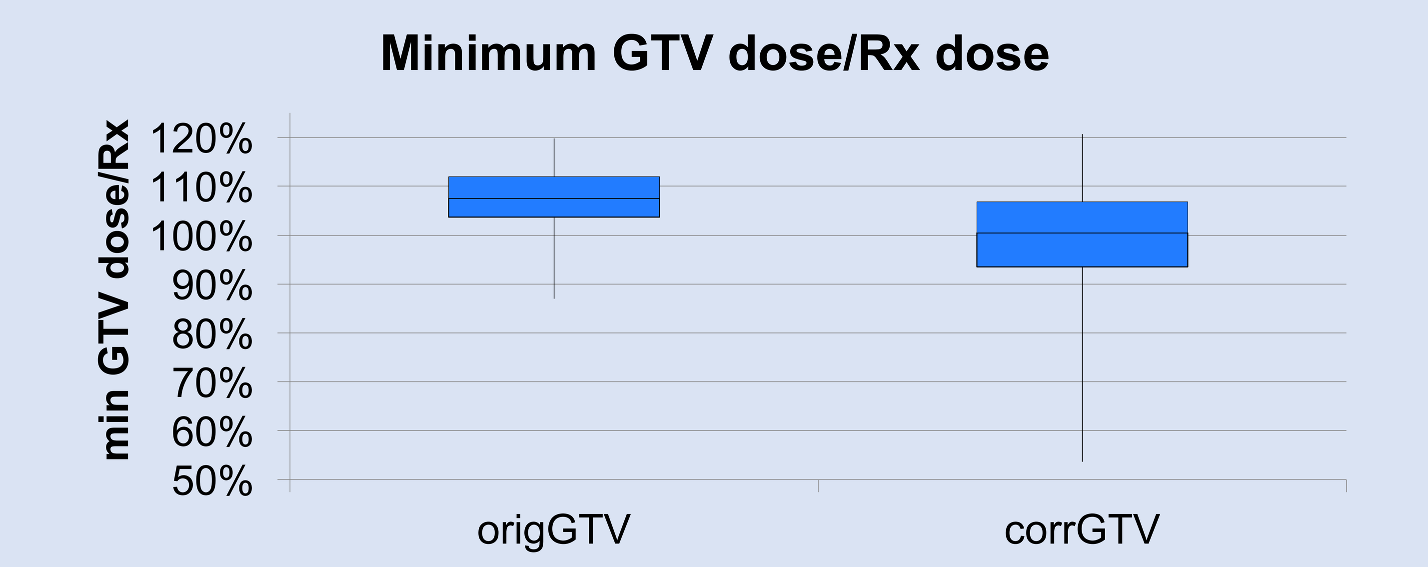


Figure 4 Relative minimum target volume dose to prescription dose for original plan volume and corrected volume after distortion correction for a) PTV, b) GTV. Here the box plot represent min, fist quartile, second quartile, median, third quartile, fourth quartile and max values of minimum target volume dose relative to prescription.

The average inverse Conformity index (iCI) of corrected PTVs after the distortion correction increased by 0.2 (p<0.01), indicating reduced conformity of dose to target volume. The median of iCI for PTV increased from 1.21 to 1.43.

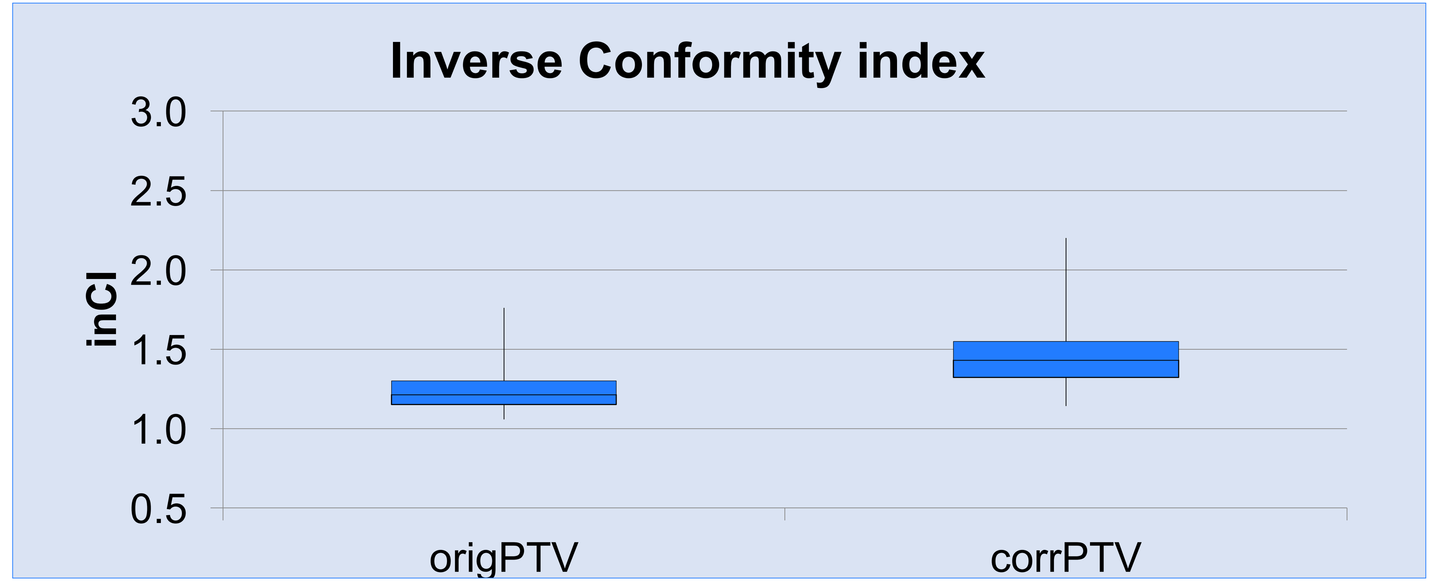


Figure 5: Inverse Conformity Index (inCI) of planning target volume for original plan volume and corrected volume after distortion correction.

CONCLUSIONS

This study indicates that MR distortion in certain cases can cause geometric miss of stereotactic radiosurgery targets. Brainlab Elements software distortion correction can improve MR-CT fusion and treatment accuracy.

REFERENCES

Cranial Distortion Correction, Brainlab Technical Background

J. Weygand et. al. Spatial Precision in Magnetic Resonance ImagingeGuided Radiation Therapy: The Role of Geometric Distortion, Int J Radiat Oncol Biol Phys 2016; 95:1304-1316.

J. Calvo-Ortega et. al.,Evaluation of a novel software application for magnetic resonance distortion correction in cranial stereotactic radiosurgery, Med Dosi 2019; 44; 136-143.

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