ABSTRACT SUBMISSION FORM

Please email to: info@mriinrt2018.com with 'abstract' as the subject

6th MR in RT Symposium 2018

Name (First, last)	Daan de Muinck Keizer
Mailing address (including province/state, country, postal/zip code)	D.M. de Muinck Keizer, Radiotherapie, UMC Utrecht, Postbus 85500, 3508 GA Utrecht
Institution/organization	Divisie Beeld, Radiotherapie, UMC Utrecht
Position	PhD Student
Telephone (including country prefix)	+3188 75 69667
Email	d.m.demuinckkeizer@umcutrecht.nl

The submission is to be considered in the following category

☒ Oral presentation preferred

☐ Poster presentation only

Trainee status

☒ I am a trainee (student or postdoctoral fellow)

☒ I wish to be a candidate for best student paper/poster

PRESENTATION TITLE

Cine-MR based intra-fraction motion assessment for MR-Linac treatment of prostate cancer

AUTHOR(S)

D.M. de Muinck Keizer*[1], A.U. Pathmanathan[2], A. Andreychenko[1], L.G.W. Kerkmeijer[1], J.R.N. van der Voort van Zyp[1], C.A.T. van den Berg[1], J.C.J. de Boer[1]
[1]*University Medical Centre Utrecht, Utrecht, The Netherlands*
[2]*Royal Marsden Hospital NHS Foundation Trust and Institute of Cancer Research, London, UK*

ABSTRACT

Cine-MR based intra-fraction motion assessment for MR-Linac treatment of prostate cancer
Purpose: The goal of our study is to progress towards real-time MR-guided radiotherapy with extreme hypofractionation of the prostate with sub-mm precision. We have collected an extensive 3D cine-MR dataset to investigate the intrafraction motion of the prostate during the period of a RT fraction. The results presented here reflect natural intrafraction motion of the prostate, obtained by fast and robust automatic tracking of fiducial markers (FM) on 3D cine-MR images with sufficient temporal resolution.
Materials & Methods: Twenty-nine patients undergoing hypofractionated prostate RT, with four implanted cylindrical gold FMs (5mm length, 1mm diameter), had repeated cine-MR imaging sessions at the University Medical Center Utrecht after each of five weekly fractions. During these imaging sessions, patient position and immobilization was similar to that during prostate RT.
Each cine-MR examination consisted of 55 sequentially obtained 3D datasets ('dynamics') and were acquired with a balanced 3D gradient echo sequence (TR=4 ms, TE=1.98 ms, flipangle=30°) that provides good anatomical as well as FM contrast. Each dynamic was acquired over a 11 second period, with a voxel size of $0.96\times0.96\times2$ mm^3. Each cine-MR exam covers a 10 minute period, which is similar to the duration of a RT fraction.
The locations of the FMs in the first dynamic were manually determined by a clinician, who provided the top and bottom location of each FM. The FM centers in subsequent dynamics were automatically determined using in-house developed Python code. A local template around the fiducial center was obtained and these templates from the first dynamic were registered to subsequent dynamics using cross-correlation.
Center of mass (COM) translations and rotations were obtained by calculating the rigid transformations between the FM template of the first and subsequent dynamics.The results from the algorithm were verified by comparing the COM locations with the locations found by the clinician at the halfway-dynamic (after 5 minutes) and end dynamic (after 10 minutes).
Results: The mean 3D error in the COM position found by the clinician compared with the algorithm is 0.4 mm. The algorithm analyzed 7315 dynamics over 133 scans of 29 patients and a graphical representation of these results are provided in figure 1 and 2. Full automatic analysis of a single dynamic took 1.3 seconds, which is sufficient to analyze an incoming cine-MR data stream. The population results in the figures show that the magnitude of intrafraction displacements continuously increased over the 10 min interval. Next to the small overall trends, the spread of the displacements increased monotonously.

Name (First, last)	Daan de Muinck Keizer
Mailing address (including province/state, country, postal/zip code)	D.M. de Muinck Keizer, Radiotherapie, UMC Utrecht, Postbus 85500, 3508 GA Utrecht
Institution/organization	Divisie Beeld, Radiotherapie, UMC Utrecht
Position	PhD Student

Conclusion: We have demonstrated that we have developed a robust, fast and accurate FM tracking algorithm in cineMR data, which allows for continuous monitoring and correction of intrafraction motion in a MR-Linac. We found a continuous increase with time in intrafraction motion magnitude (translations and rotations) over a 10 min period, which hardly flattened. The amplitude and temporal behavior of the found intrafraction motion stresses the importance of real-time MR-guidance by fast imaging and dose re-optimization for hypofractionated prostate RT.

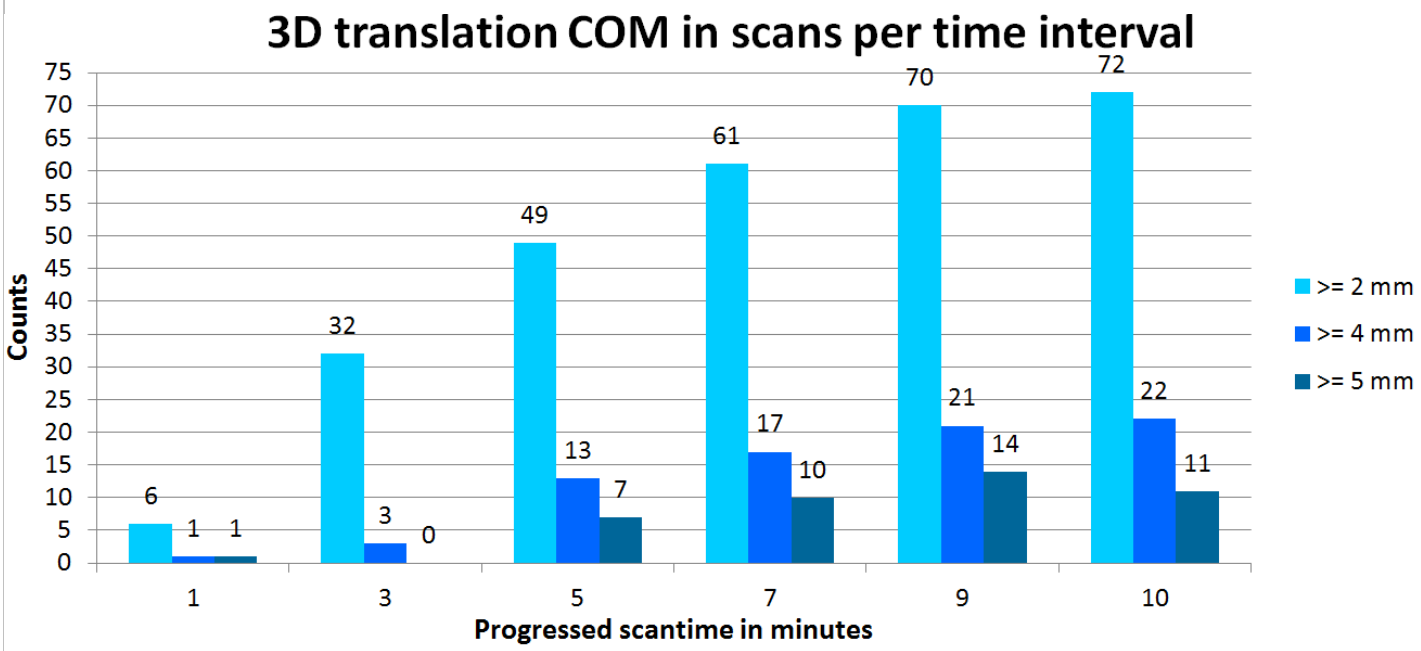

Figure 1: Overview of the found absolute translations of the center of mass in scans, in which the found translation is at least 2, 4 or 5 mm. The results are provided for the time intervals of 1, 3, 5, 7, 9 and 10 minutes after the start of the imaging protocol.

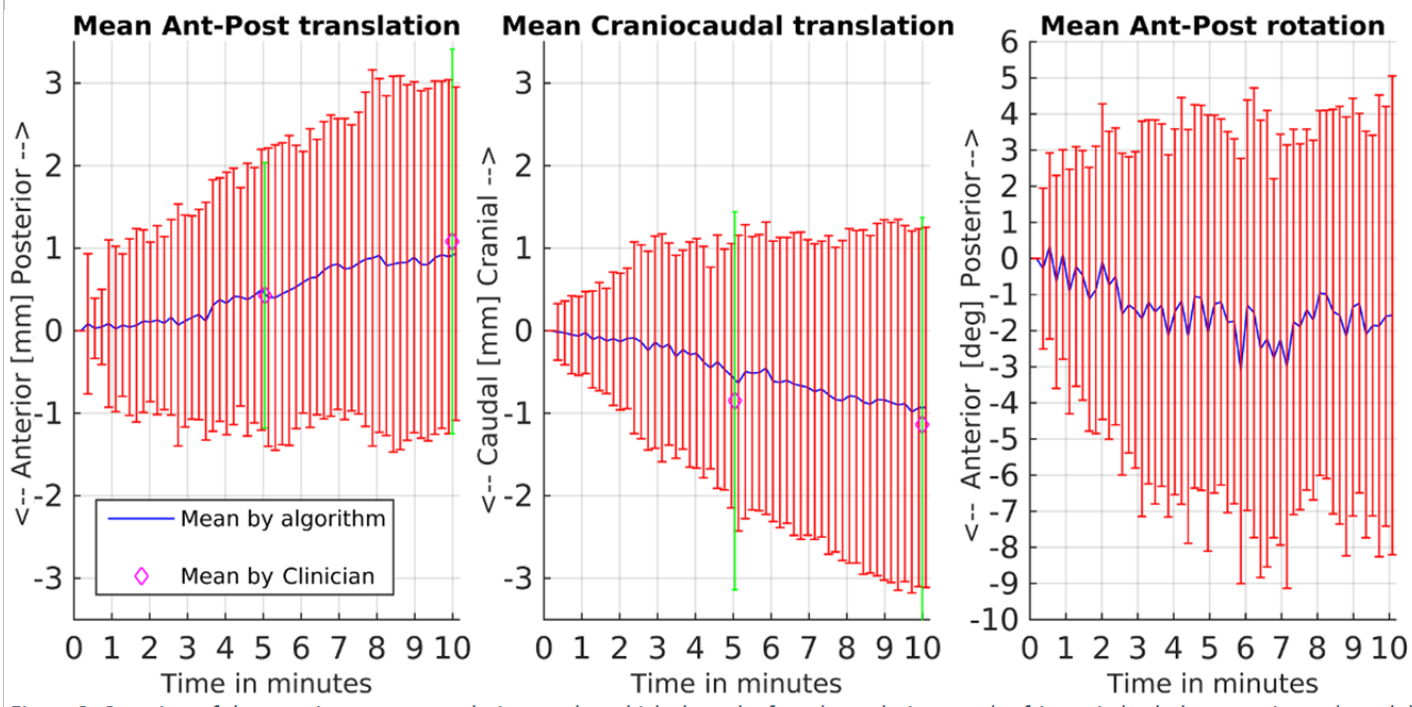

Figure 2: Overview of the most important population results, which show the found translation trends of 1 mm in both the posterior and caudal direction with the found spread at each time point (over patients and fractions) as error bars. The mean anterior-posterior rotation (about the LR-axis) is provided on the right hand side and shows a mean rotation trend of 2 degrees in the anterior direction over a 10 minute time period. The mean validation result by the clinician is provided for the translation results at 5 and 10 minutes as the purple diamond and green error bar.