

Real-time intrafraction target motion evaluation in prostate cancer radiotherapy using a temporary-implanted wired electromagnetic transmitter: influence on treatment margins

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Introduction

The aim of this work is:

- to evaluate intrafraction displacements of the prostate gland, using a **temporary implanted wired electromagnetic tracking system**;
- to assess the impact of intrafraction movements on treatment margins for prostate radiotherapy.

Materials and methods

A group of **nine patients** treated with radiation therapy of the prostate gland was studied. Each patient was implanted with an electromagnetic transmitter and two gold seeds in the prostate gland as shown in *Figure 1*.

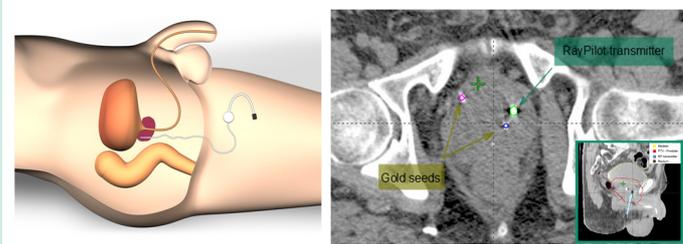


Figure 1. Images of the transmitter implant. The transmitter is connected to the external receiving system by a wire which passes through the patient perineum. The transmitter is implanted in the prostate gland and it is used as fiducial marker together with the two implanted gold seeds.

The tracking system (Raypilot System, Micropos Medical AB), an add-on device to the linear accelerator composed by the implanted transmitter and a flat receiver placed on the patient bed, provides the 3-D real-time position of the transmitter itself.

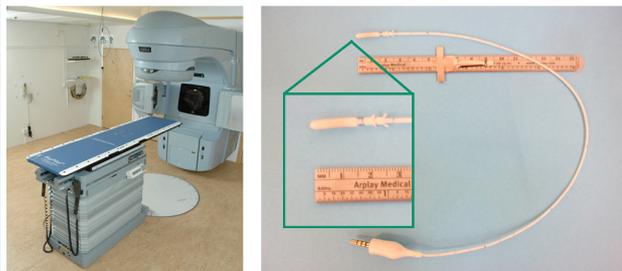


Figure 2. Layout of the system. The receiver consists in a flat bed placed on the usual linac treatment bed. The receiving antennas are located in an area in correspondence with the patient pelvis. The transmitter is a 17-mm long by 3-mm wide.

The implanted transmitter was used as a surrogate for prostate motion. **Intrafraction** motion data were recorded during every fraction (about 3 minutes) of the treatment, defined as the displacement between the transmitter position compared to the initial (*prefraction*) coordinates over treatment time.

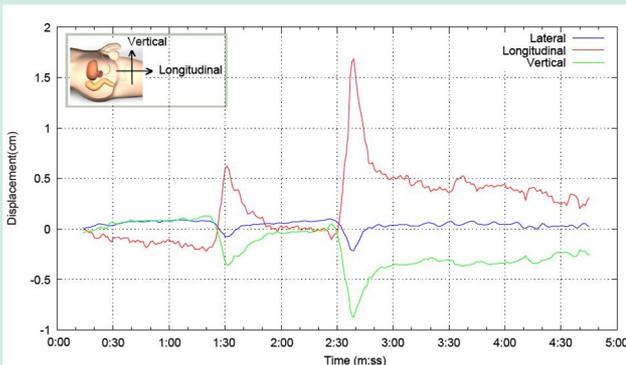


Figure 3. Recorded intrafraction displacement. A transient excursion of about 20 seconds duration is shown.

Interfraction target displacements were acquired at every treatment fraction by comparing the transmitter position to the gold seeds location on the kV portal images. CTV-to-PTV margins were retrospectively assessed with the method of Van Herk et al. [1], for pretreatment setup to implanted markers with or without intrafraction motion, as proposed in similar studies with other tracking system [2].

Results

Both transient excursions, typically within 20 seconds duration, and drifts of the prostate gland were observed during treatment. Spatial displacements **>11 mm** in the vertical and longitudinal planes, were identified in 1 patient, **>4 mm** in 3 patients, **< 4mm** in 5 patients. Evaluated treatment margins values are shown in *Table 1*.

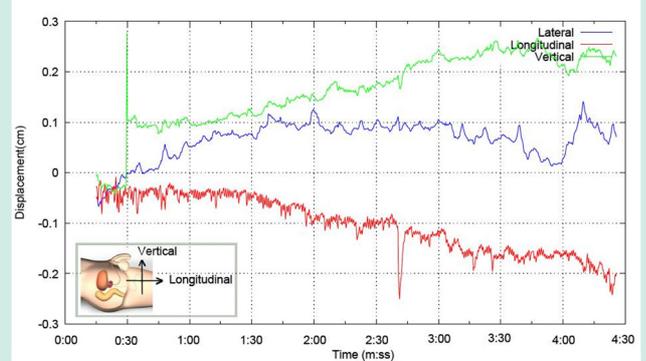


Figure 4. Recorded intrafraction displacement. It is possible to observe a stable drift of the prostate along the treatment session.

	Measured interfraction motion (cm)			Measured intrafraction motion (cm)			
	Vrt	Lng	Lat	Mean	Vrt	Lng	Lat
Mean	-0,027	-0,075	0,026	0,005	0,005	0,011	0,008
Σ_{inter}	0,098	0,222	0,072	Σ_{intra}	0,044	0,027	0,026
σ_{inter}	0,221	0,296	0,183	σ_{intra}	0,188	0,123	0,084

$$PTV \text{ margins} = 2,5\Sigma + 0,7\sigma^1$$

	Margins (cm)		
	Vrt	Lng	Lat
excluding intrafraction motion	0,401	0,763	0,309
including intrafraction motion	0,472	0,784	0,333

Table 1. Results. Σ = systematic error, σ = random error. Systematic and random errors, calculated for both interfraction and intrafraction motion, are added in quadrature.

Conclusions

- Including intrafraction motion in CTV-to-PTV margins definition leads to an **increase** of up to **18%** (vertical plane).
- Intrafraction motion impact on treatment margins could be considered **not negligible** in case of **severe hypofractionated** treatments.

References

- [1] van Herk et al, *The probability of correct target dosage: Dose population histograms for deriving treatment margins in radiotherapy*. Int J Radiat Oncol Biol Phys 2000;47:1121-1135
- [2] Litzenberg D et al, *Influence of intrafraction motion on margins for prostate radiotherapy*, Int J Radiat Oncol Biol Phys 2006;65, 2:548-553