Prostrate intrafraction motion assessment using a temporary-implanted wired electromagnetic tracking system

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Physics track: Intrafraction motion management

Introduction and objectives

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 at our department.

Methods

A group of **nine patients** was studied, each of them implanted with an electromagnetic transmitter and two gold seeds in the prostate gland as shown in *Figure 1*. Planning CT scan is acquired in supine position (full bladder and empty rectum). Prescription dose is 70.0 Gy (2.5 Gy/fraction). The implanted transmitter is surgically removed at the end of therapy.

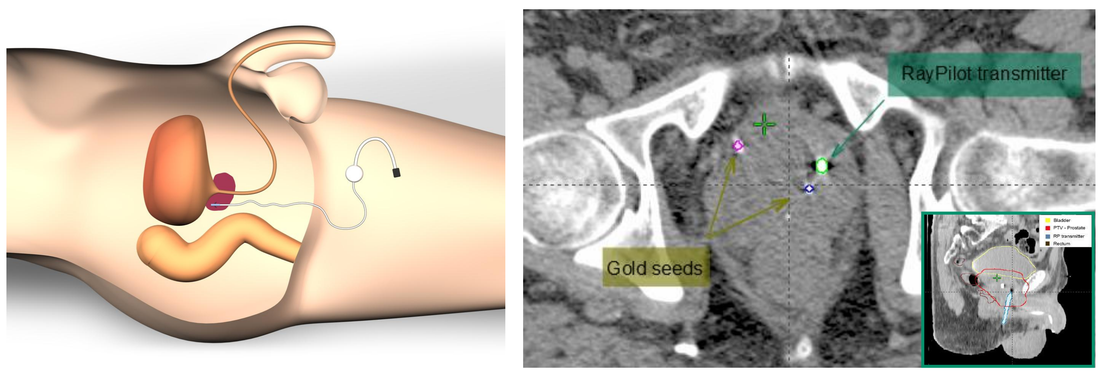

Figure 1. Images of the trasmitter implant. The trasmitted is connected to the external receiving system by a wire which passes through the patient perineum. The trasmitter is implanted in the prostate gland and it is used as fiducial marker together with the two implanted gold seeds.

The tracking system (Raypilot System, Micropos Medical AB) provides the 3-D real-time position of the transmitter itself, which is passively employed as a surrogate of prostate motion.

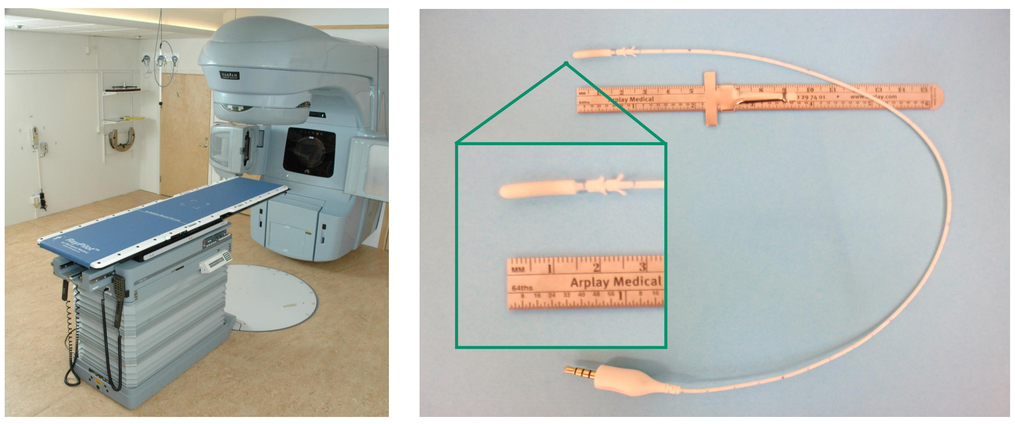

Figure 2. Layout of the system. The receiver consists in a flat bed placed on the usual linac treatment bed. The receiveing antennas are located in an area in correspondence with the patient pelvis. The transmitter is a 17-mm long by 3-mm wide.

The target volume is initially positioned using the tracking system and repositioned according to the gold seeds location, after kV portal images have been acquired. The difference in these two positions was registered as *interfraction* target displacements.

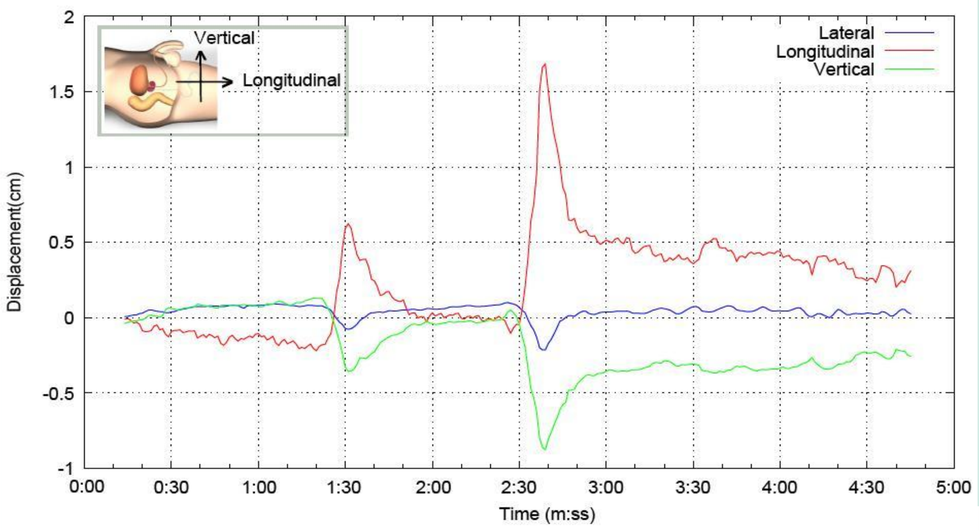

Figure 3. Recorded intrafraction displacement. A transient excursion of about 20 seconds duration is shown.

Real-time *intrafraction* motion displacement between actual and initial (*prefraction*) transmitter position is recorded at every fraction, without affecting radiation beam delivery. CTV-to-PTV margins were retrospectively assessed with Van Herk's method (90% population coverage to minimum 95% prescribed dose [1]), either **considering or neglecting the contribution due to intrafraction motion**, as proposed in similar studies with other target 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*.

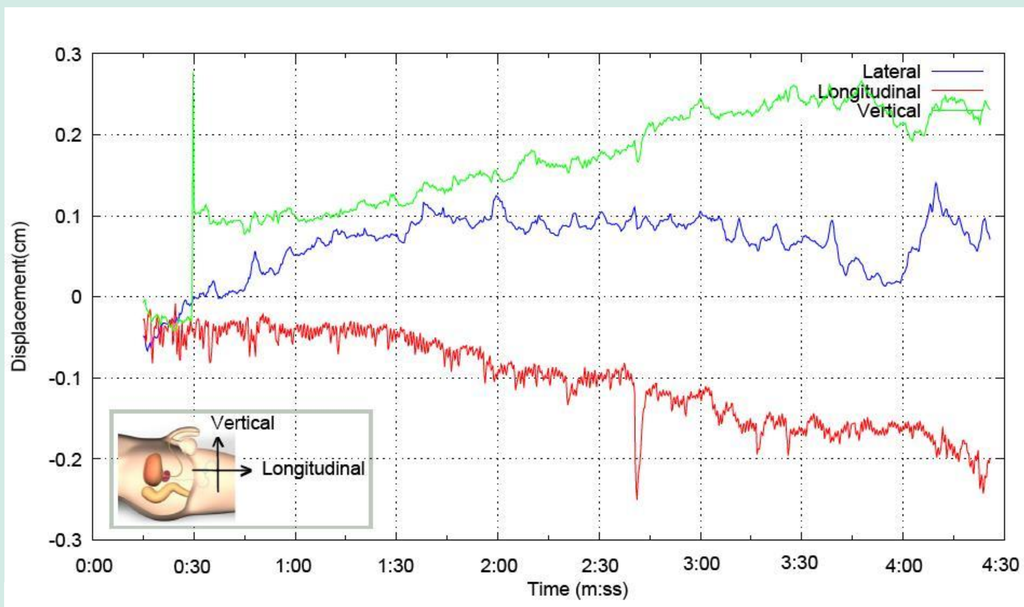

Figure 4. Recorded intrafraction displacement. It is possible to observe a stable drift of the prostate along the treatment session.

Measured interfraction motion (cm)

	AP	CC	LR
Mean	-0,027	-0,075	0,026
Σ_{inter}	0,098	0,222	0,072
σ_{Inter}	0,221	0,296	0,183

Measured intrafraction motion (cm)

	AP	CC	LR
Mean	0,005	0,011	0,008
Σ_{intra}	0,044	0,027	0,026
σ_{Intra}	0,188	0,123	0,084

Margins (cm)

	AP	CC	LR
Excluding intrafraction motion	0,401	0,763	0,309
Including intrafraction motion	0,472	0,784	0,333
Difference	0,071	0,021	0,024

Table 1. Evaluated prostate margins for a group of 9 patients. AP= anterior - posterior; CC = cranial - caudal; LR = left- right. Σ = sistematic error, σ = random error

Conclusions

- *Interfraction* motion: relevant in CC direction -> due to daily variations in bladder and rectum filling.
- *Intrafraction* motion: larger in the AP direction -> abdominal movements.
- Detected spikes -> sudden rectal air passage.
- In case of **severe hypofractionated** treatments **->** treatment target repositioning or beam-gating techniques are necessary.

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

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