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.

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 1. Images of the transmitter implant. The transmitter is connected to the external receiving system by a wire which pass through the patient’s 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, including the receiver placed in a flat bed on the usual linac treatment bed, 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.

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.

<table>
<thead>
<tr>
<th>Measured interfraction motion (cm)</th>
<th>Measured interfraction motion (cm)</th>
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<tbody>
<tr>
<td>Vlt</td>
<td>Lng</td>
</tr>
<tr>
<td>Mean</td>
<td>-0.027</td>
</tr>
<tr>
<td>Σκερ</td>
<td>0.098</td>
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<tr>
<td>σκερ</td>
<td>0.221</td>
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</tbody>
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PTV margins = 2.5Σ + 0.7σ¹

Table 1. Results. ¹ = systematic error, σ = random error. Sistematic 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

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