

Electromagnetic tracking as a quality assurance tool for complex intracavitary and interstitial cervix brachytherapy implants

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OBJECTIVES

To quantify the positional accuracy of electromagnetic tracking (EMT):

- Using a prototype integrated EMT/BT afterloader (Flexitron with an integrated EMT sensor; Elekta)^{1,2},
- For treatment verification in complex intracavitary and interstitial cervix brachytherapy (BT) implants,
- By performing a phantom study (see fig.1) using the Venezia™ applicator (Elekta).

METHOD

The Venezia™ applicator, i.e. a 70mm intrauterine tube, with $\Phi = 30$ mm lunar ovoids and 8 needles, was embedded in silicon.

The applicator was reconstructed from CT images for planning:

- Using a library file containing the measured source path for the intracavitary channels,
- Manually for the interstitial needles.

The EMT sensor was automatically moved by the afterloader through the implant during the experiments.

EMT-measured and planned dwell positions were rigidly registered. The residual errors, defined as the Euclidean distance, were analyzed for:

- All dwell positions together,
- Needles and intracavitary channels separately (in the latter case: registering the intracavitary channels on its straight parts while evaluating its curved parts).

Effects of the dwell time, distance d_{FG} between implant and Field Generator (FG), and EM-field orientation were investigated.

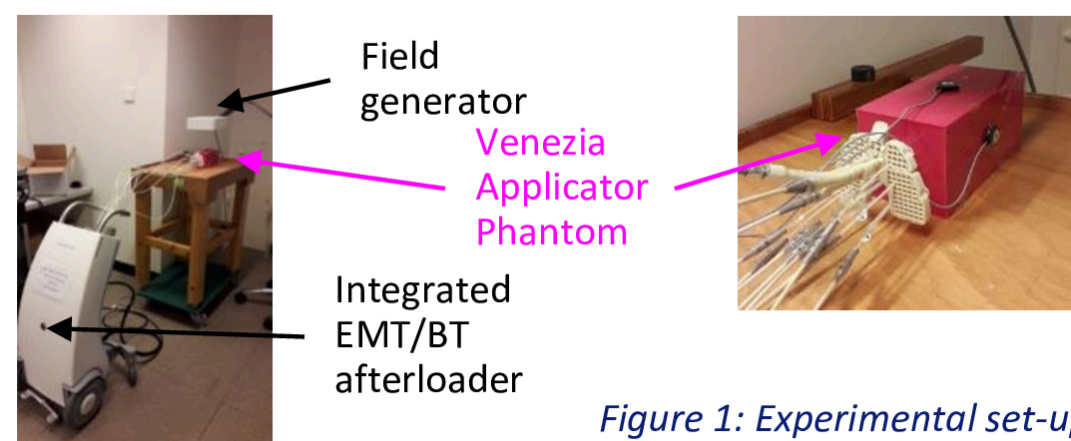


Figure 1: Experimental set-up.

RESULTS

Dwell time and d_{FG}

All dwell positions together:

- Median residual error 0.88 mm (95%-CI max. 2.66 mm) for $d_{FG} = 200$ mm and FG parallel to the applicators main axis.
- No differences observed for dwell times down to 0.5 s.
- Residual error larger for 300 mm d_{FG} , as compared to 100 and 200 mm.

EM-field orientation

Needles only:

- No differences in the residual error as a function of the EM-field orientation (range 0.5 – 0.7 mm) (fig.2).

Intracavitary channels only:

- Orientation dependency when rotating the FG around the applicators left-right axis (fig.2 upper panel); median residual error:
 - 1.2 - 2.2 mm for the lunar ovoids;
 - 2.1 - 2.9 mm for the intrauterine tube.

CONCLUSIONS

EMT is a promising QA tool for complex cervix BT implants:

- A high accuracy is achieved for dwell position detection in the needles (< 1mm residual error in a phantom set-up).
- Further research is needed for application in the intracavitary channels (< 5 mm residual error in a phantom set-up).

REFERENCES

¹ Kallis et al. 2018 Phys Med Biol. 63(9) 095008

² Heerden van et al. 2019 Radiother Oncol 133: S34-S35.

RESULTS

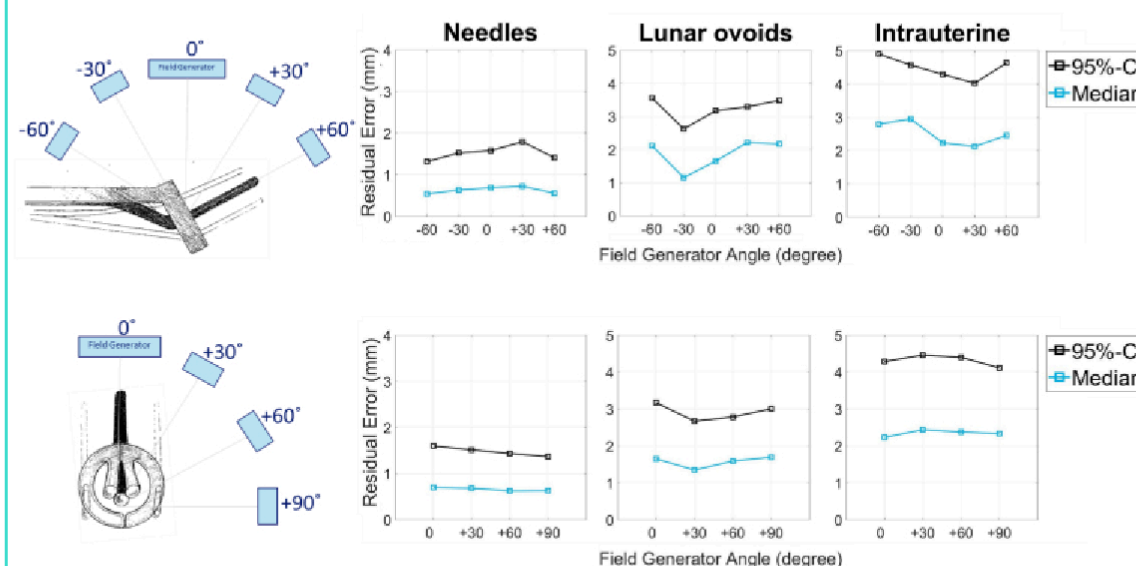


Figure 2: Residual error as a function of the FG orientation.