Electromagnetic positioning, real time positioning and four- dimensional radiotherapy using the Raypilot system

First human experience

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Introduction

Electromagnetic positioning (EMP) for radiotherapy (RT) was first described by Lennernäs & Nilsson 1995 in Uppsala. The background to the development of EMP for RT was the wide margin used for RT of prostate cancer and that the three-dimensional systems (3DRT) did not describe the correct dose distribution because they could not specify the target position in real time throughout the RT treatment chain. Therefore goals for a new system and technology were determined in 1995. The goals include (1) the staff could be with the patient during positioning (no x-ray), (2) the system could be positioned in real time, (3) be independent and to be usable throughout the entire therapy chain for both photons and protons.

Material & Methods

The Raypilot system works as an add-on to existing linear accelerators, and with any table top including carbon fibre, and with any energy (Fig 1). The system consists of a receiving system, which is placed on the accelerator table top, an implanted transmitter that is placed in the ROI, and the RayPilot software. The transmitter is implanted using a modified Seldinger technique and a separate Chiba needle (Fig 2). A thin (≈1,5 mm) wire through the skin connects the transmitter to the rest of the system. The implant is fixated inside by pacemaker type barbs and exteriorly with a suture (optional). A transmitting antenna is located in the interior tip and a connector is located at the exterior end of implant (Fig 3). The position is calculated approximately 30 times per second. The accuracy in positioning of the system has a mean error of 0.45 mm (SD: 0.21 mm) (lab data).

***Figure 1**. The RayPilot® system together with a linear accelerator.*

***Figure 2**. The modified Seldinger technique, the transmitter and a separate Chiba needle (above).*

Results

In the first patient studies, the transmitter was implanted during the final high dose rate brachytherapy. Patients had epidural analgesia and a two-day course antibiotic due to the brachytherapy. The transrectal ultrasound used for the brachtherapy was utilized for the placement, and the Chiba needdle as a guide for the Seldinger instruments. The remaining external beam treatment took approximately 2.5 weeks. Further implantations have been performed in long term use/ fractionation (70Gy/2). Side effects were evaluated, and the implantation site was inspected daily. A transparent bandage was sometimes used over the skin exit. No infection occured and the implants were well tolerated by the patients although some complained of local rigidity, possibly due to the wire or the bandage.

***Figure 3**. The RayPilot® transmitter and two goldmarkers implanted in the prostate.*

Discussion

Real time positioning (RTP), EMP and 4DRT will be important techniques for the radiotherapy of the future. RTP/ 4DRT will reduce the dose to organs at risk (OAR) by reducing the planning target volume (PTV) and it will make it possible to treat cancer with minimal risk of side effects even with high doses, i.e. hypofractionation for PC. The technique can be used for gating and in other tumor-sites then PC. The ability to add other functions, such as patient identification and dose measurements, also makes the technology attractive for safety and quality improvement.