Utilizing 3-D and 4-D ultrasound systems to improve radiation treatment of cervix and prostate cancer patients.

Radiotherapy plays an important role in modern treatment for cancer, such as cervical and prostate radiation treatment. One of the major issues in radiotherapy is that the target should be aligned to the planned target volume prior to each treatment fraction, for which different kilovoltage (kV) and megavoltage (MV) image guided radiotherapy (IGRT) methods are developed. However, these ionization systems provide poor visualization of soft tissue, and therefore the bone matching is frequently applied as a daily tumor alignment method in cervical radiotherapy. In this project, the Clarity 3D ultrasound system, non-invasive, non-ionizing, and good in visualization soft tissue, was used to apply uterine matching for determining the uterine shifts relative to the bone structure. The main purpose was to investigate the reliability of the Clarity system as a possible IGRT method. We found that the conventional probe (C-probe) has limitations, while applying transabdominal US (TAUS) scan, when it came to capturing the entire uterus owing to the difficulty in probe handling. Contrarily, the novel autoscan-probe (A-probe) was shown to be capable of capturing the entire uterus in almost all of the scans. The operators found the A-probe to be more user-friendly, and image acquisition was also performed more smoothly. In conclusion the A-probe is a more reliable IGRT tool, and it might replace the kV- and the MV IGRT systems.

In prostate radiotherapy, the movement of the prostate during radiation delivery (intrafractional prostate motion) remains challenging. To determine the intrafractional prostate motion, various imaging techniques have been introduced, such as kV, and MV imaging, CineMRI, implanted markers and transponders. Most of the systems are based on acquiring pre- and posttreatment images, which has limitations in addressing real-time prostate motion, and includes inter-observer variations while matching image to image. In this project, the recently developed transperineal ultrasound 4D autoscan probe is used to investigate the real-time prostate monitoring. The purpose of this study was to investigate the feasibility of the 4D autoscan in tracking the prostate for a duration of 2 to 2.5 minutes. We found that most of the intrafractional prostate motion is less than 2 mm, which was in concordance with previously reported data. Thus, during a RapidArc/VMAT plan delivery with a beam-on time of approximately 2.5 minutes, the intrafractional prostate motion is negligible. But, since the prostate motion increases with monitoring time, the prostate displacement during 3D conformal and IMRT plans must be taken into consideration. Additionally, we conducted a prostate probe pressure study, in which TAUS scan was simulated, using a C-probe, while the prostate was continuously monitored using the TPUS autoscan. We found that the TAUS induced pressure displacement of the prostate, in most cases, was clinically irrelevant. Since this conclusion was in opposition to most of the previously published results, which reported displacements of up to 7 mm, we discovered that 4D real-time monitoring is the most reliable method for determining the pressure displacement compared to US/US or US/CT matching methods, in which the considerable inter-observer variability, due to variations in applied probe pressure and image/image match, limits the accuracy of the readings.

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