

# Image-Guided Radiotherapy for Target Localization in Prostate Cancer with Implanted Markers

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To precisely localize target in prostate cancer, image-guided radiotherapy was performed using the ExacTrac<sup>®</sup> x-ray system (Brainlab, Germany) with implanted markers. For three prostate cancer patients, three gold markers were implanted into prostate. Orthogonal portal images were acquired every treatment and CT scans were repeated 3~5 times during the course of treatment. After correcting setup errors calculated by the system, the position of the implanted markers and the distance between them were detected in daily portal images and in CT images, and analyzed retrospectively. Deviation of the relative position of the implanted markers and the distance between them were less than 1 mm in lateral, longitudinal, and vertical direction for three patients, both in portal images and CT images. This study reveals that image-guided radiotherapy using the ExacTrac<sup>®</sup> system is useful to verify positioning errors and localize prostate target with implanted markers, reducing the planning target volume (PTV) margin as well as irradiation to rectum and bladder.

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Key words: Target localization, Prostate cancer, Image-guided radiotherapy, Implanted markers

## INTRODUCTION

It has been reported that higher radiation dose leads to better treatment results in prostate cancer.<sup>1)</sup> However, not only is prostate a moving organ,<sup>2)</sup> there are also critical organs very near it, such as rectum and bladder. Therefore, to deliver higher dose to a target and to spare surrounding normal tissues at the same time, localizing the target precisely is essential for prostate cancer.<sup>3,4)</sup> For high-precision treatment, image-guided radiotherapy was performed for prostate cancer, using the ExacTrac<sup>®</sup> x-ray system (Brainlab, Germany) with implanted markers.

## METHODS AND MATERIALS

For three prostate cancer patients, three gold markers were implanted into prostate. Following patients' setup with skin markings, both the ExacTrac<sup>®</sup> x-ray images and orthogonal portal images were taken every treatment. The ExacTrac<sup>®</sup> system fused these two images, calculated position shifts for correcting setup errors, and moved the couch to the planned position. At first, position shifts for bony markers were calculated and treatment couch was moved according to them. In order to verify inter-treatment setup errors, this procedure was repeated for the implanted markers. CT scans were repeated 3~5 times during the course of treatment. After correcting setup errors, the position of the implanted markers in prostate and the distance between the markers due to their inter-treatment variations were detected in daily portal images and in CT images, and analyzed retrospectively (Fig. 1, 2).

## RESULTS AND DISCUSSION

The correction shifts calculated by the ExacTrac<sup>®</sup> system with bony markers and with implanted markers for three patients were shown in Table 1.

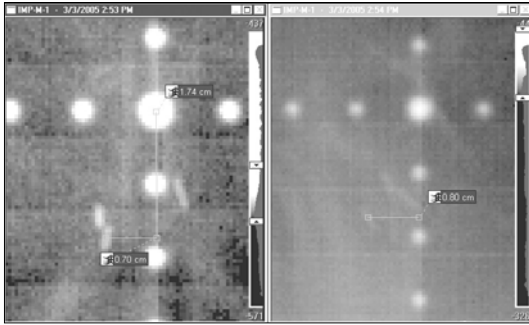


Fig. 1. Verification of inter-treatment errors in portal images: position of the implanted markers in prostate and distance between the markers due to their inter-treatment variations were acquired.

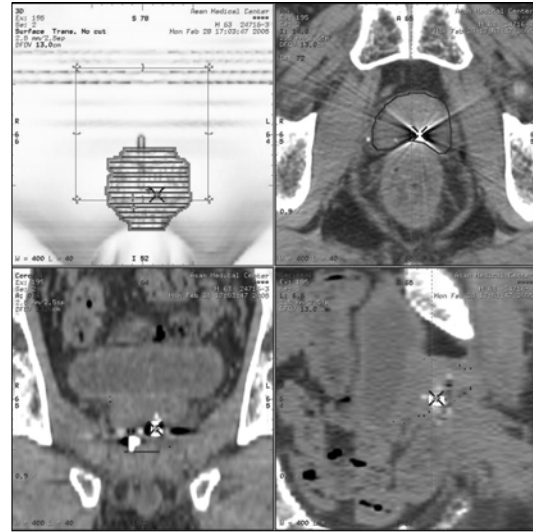


Fig. 2. Verification of inter-treatment errors in CT images: position of the implanted markers in prostate and distance between the markers due to their inter-treatment variations were acquired.

Table 1. Correction shifts calculated by the ExacTrac<sup>®</sup> system with bony markers and with implanted markers for three patients (mm)

Direction	Patient #1		Patient #2		Patient #3	
	Bony markers	Implanted markers	Bony markers	Implanted markers	Bony markers	Implanted markers
Lateral	0.50 ± 0.69	-0.62 ± 1.12	2.21 ± 0.58	1.82 ± 0.75	0.15 ± 1.55	-0.89 ± 1.28
Longitudinal	-1.95 ± 0.85	0.51 ± 1.27	-3.19 ± 0.46	-7.15 ± 2.65	-1.37 ± 1.09	-3.80 ± 2.03
Vertical	0.15 ± 1.31	1.49 ± 2.26	3.27 ± 1.07	0.07 ± 3.17	-5.84 ± 2.12	-4.96 ± 3.45

After correcting positioning errors with the implanted markers, deviation of the relative position of the implanted markers and the distance between them were less than 1 mm in lateral, longitudinal, and vertical direction for three patients, both in portal images and CT images, as shown in Fig. 3.

## CONCLUSION

The motion of prostate, which has been reported up to 20 mm<sup>2</sup>, can cause geometrical uncertainties in daily localization of target volume. With the help of the ExacTrac<sup>®</sup> system, inter-treatment errors were reduced to less than 1 mm for all three patients. It means that the planning target volume (PTV) margin for prostate, which is usually 10~15 mm<sup>2</sup>, can be reduced to 3~5 mm. Tight margin makes it possible to concentrate dose on target and spare critical organs<sup>3</sup>, so that this study reveals that image-guided radiotherapy using the ExacTrac<sup>®</sup> system is useful to localize prostate target with implanted markers. Moreover, since the ExacTrac<sup>®</sup> system guarantees that the position of prostate is precisely verified prior to each treatment fraction, it can substitute for daily portal images in verifying setup.

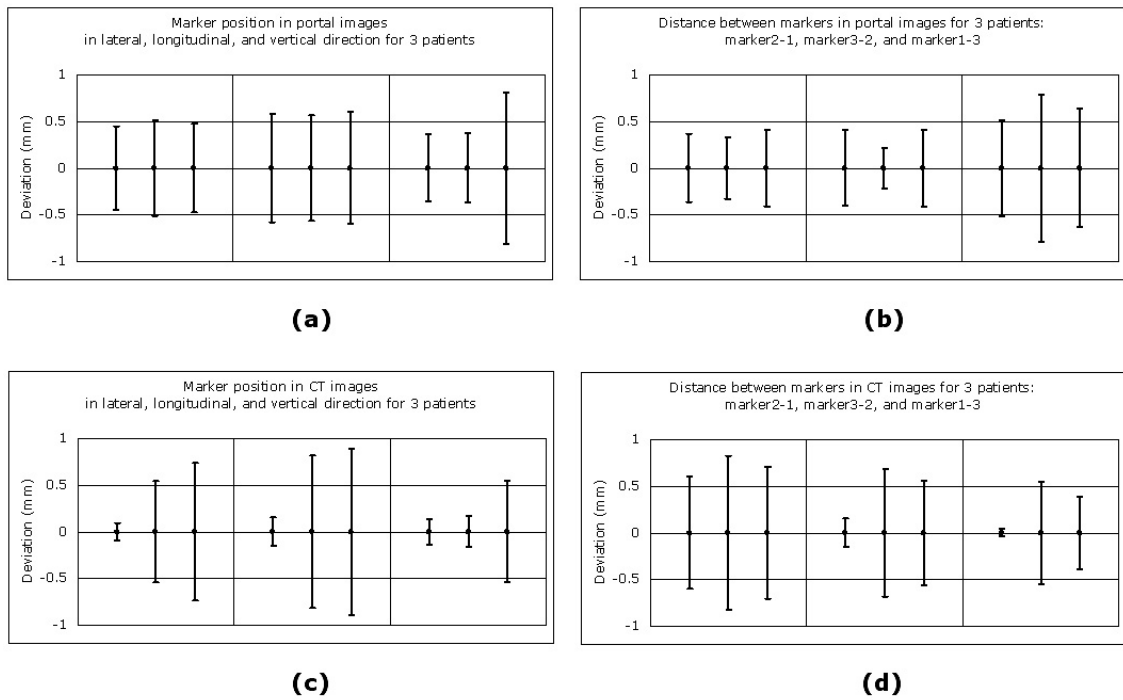


Fig. 3. Deviation of marker position and distance between markers in portal images and CT images in lateral, longitudinal, and vertical direction for three patients: (a) marker position and (b) distance between markers in portal images, and (c) marker position and (d) distance between markers in CT images.

## REFERENCES

1. Hanks GE, Hanlon AL, Epstein B, Horwitz EM: Dose response in prostate cancer with 8~12 years' follow-up. *Int J Radiat Oncol Biol Phys* 54:427-35 (2002)
2. Dawson LA, MahK, Franssen E, Morton G: Target position variability throughout prostate radiotherapy. *Int J Radiat Oncol Biol Phys* 42:1155-61 (1998)
3. Smitsmans MHP, Wolthaus JWH, Artignan X, et al: Automatic localization of the prostate for on-line or off-line image-guided radiotherapy. *Int J Radiat Oncol Biol Phys* 60:623-35 (2004)
4. Ghilezan M, Yan D, Liang J, Jaffray D, Wong J, Martinez: A Online image-guided intensity-modulated radiotherapy for prostate cancer: how much improvement can we expect? A theoretical assessment of clinical benefits and potential dose escalation by improving precision and accuracy of radiation delivery. *Int J Radiat Oncol Biol Phys* 60:1602-10 (2004)