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Variability of treatment planning of seed implantation: A Japanese multicenter simulation study

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ABSTRACT

PURPOSE: This multicenter study was conducted to evaluate the current variability of treatment planning of seed implantation in Japanese centers and the feasibility of two virtual trials.

METHODS AND MATERIALS: Two types of contour data were sent to 12 radiation oncologists with a request letter that asked them to make treatment plans on the data in the same manner as in their own practice. Five of the 12 radiation oncologists were asked to participate in the two virtual trials in which the D90 (dose to the hottest 90% of prostate volume) was 1) required to be set at just 180 Gy and 2) increased as much as possible without violating other limitations.

RESULTS: A relatively high dose with a small deviation was irradiated to the prostate in Japanese centers (mean D90 = 188 Gy; SD = 10 Gy). In the virtual trials, all five physicians could achieve 180 Gy for the D90 with a very small deviation, although the urethral dose showed relatively large deviations. Dose escalation without increase of urethral dose or V150 was difficult, although the rectum could be spared by most of the physicians.

CONCLUSION: Our study showed a relatively high dose with a small deviation was prescribed to the prostate in Japanese centers. Consolidated protocols such as D90 = 180 Gy could be available for future trials. Meanwhile, our study suggested that some cautions might be needed for urethral dose and the V150, even when a relatively low D90 was requested.

Keywords: Prostate cancer; Brachytherapy; Low-dose-rate; Treatment plan; Variability

Background

Prostate cancer is estimated to be the most common cancer in men, not only in Europe (1) and North America (2), but also in Japan (3). Although there are many treatment options available for localized prostate cancer, seed implantation is considered to be one of the most cost-effective treatments (4), and it could also reduce costs to the

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Japanese health insurance system, which supports an increasingly aging population.

Seed implantation was introduced in Japan in 2003. In the past 13 years, use of this technique has spread across our country, and it is estimated that over 3000 prostate cancer patients were treated with this procedure at over 100 hospitals in 2016. To promote this treatment in our country, we believe that high-level evidence is needed, similar to that of the Androgen Suppression Combined with Elective Nodal and Dose Escalated Radiation Therapy (ASCENDE-RT) trial (5) in Canada. To start a new prospective trial, we need to consolidate our protocols of treatment planning, including the dose limitations for organs at risk. However, there are no available data regarding 1) how much variability of treatment planning currently exists among Japanese hospitals, 2) the feasibility of unifying dose volume histogram (DVH) parameters such as the prostate D90, and 3) how much dose escalation is realistic when many centers collaborate. These questions motivated this multicenter simulation study, and the information we acquired will be essential before any multicenter trials can be started.

Methods and materials

This study was not subject to the approval of institutional review boards because no patient data or medical records were used.

To evaluate each treatment planning protocol, both DVHs and plan quality metrics (PQMs) were used. The parameters for evaluation of the DVH were a dose to the hottest 90% of the prostate volume (D90); a prostate volume receiving at least 100% dose (V100); a prostate volume receiving at least 150% dose (V150); a dose to the hottest 30% of the urethral volume (UD30); a dose to the hottest 5% of the urethral volume (UD5); and a rectal volume receiving at least 100% dose (RV100). In this study, the recommended doses such as UD30 $<$ 125%, UD5 $<$ 150%, and V150 $<$ 50% were defined by reference to the consensus guidelines of the American Brachytherapy Society (ABS) (6) and European Society for Radiotherapy & Oncology (ESTRO) (7).

Three radiation oncologists (N.K., T.O., and H.I.), who did not participate in the examinations described below, constructed a modified PQM (Fig. 1) for seed implantation

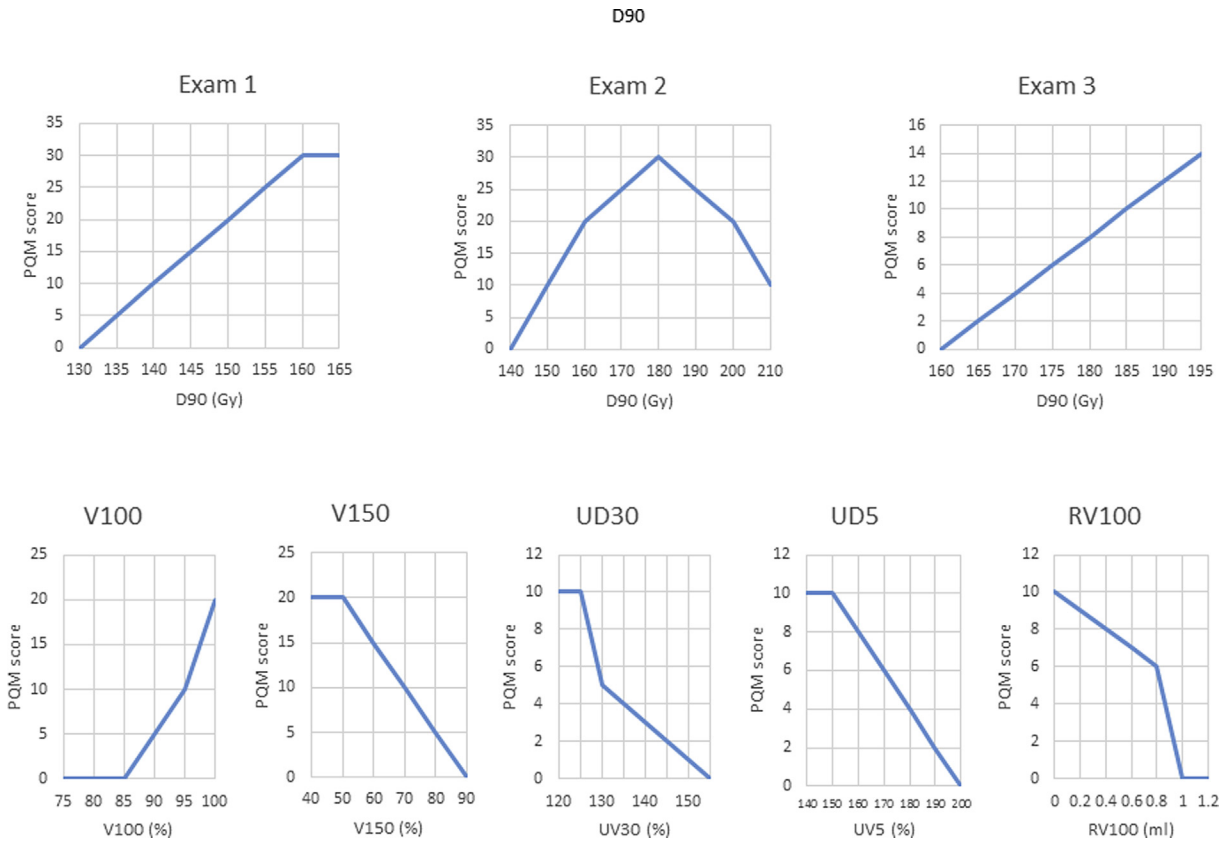

Fig. 1. Plan quality metric system for the three examinations. The recommended dose volume histogram (DVH) parameters were as follows: V100 $>$ 100% (max 20 points) and V150 $<$ 50% (max 20 points); UD30 $<$ 125% (max 10 points); UD5$<$150% (max 10 points); RV100 $<$ 1 mL (max 10 points); D90 $\geq$ 160 Gy for examination 1 (max 30 points); D90 = 180 Gy for examination 2 (max 30 points); and no limit D90 $>$ 160 Gy for examination 3 (no max points limit). Physicians were requested to make treatment plans adhering to the recommended DVH parameters, except for examination 1. The dose limit of V150 was omitted in examination 3. D90 = dose to the hottest 90% of prostate volume; V100 = prostate volume receiving at least 100% of prescription dose; V150 = prostate volume receiving at least 150% of prescription dose; UD5 = dose to the hottest 5% of urethral volume; UD30 = dose to the hottest 30% of urethral volume; RV100 = rectal volume receiving at least 100% of prescription dose.