Hull and East Yorkshire Hospitals
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2D 3D Imaging Audit on Rotational Errors on Pelvic Radiotherapy Patients with Long PTVs

Robins Kpaul*,Tom Murray

Department of Radiotherapy, Queen's Centre, Hull & East Yorkshire Hospitals NHS Trust, Castle Road, Cottingham, HU16 5JQ, UK.
* Corresponding author: robins.kpaul@hey.nhs.uk

Introduction

Cone beam CT (CBCT) is used for all VMAT pelvis patients to do online image corrections and to check the suitability of the patient preparation. The maximum field of view (FOV) of the CBCT is 16 cm (Varian iX) or 17.5 cm (Varian True beam); in some instances this length is not sufficient to cover the planning target volume and organ at risk structures. When the nodal irradiation is involved in pelvis VMAT treatment, the PTV is often over 16 cm. Rotational errors on CBCT can lead to a PTV mismatch on superior end of the nodal treatment field. Advanced imaging functionality on Varian True Beams will certainly facilitate the analysis of longer target volume and anatomy. But the software currently only aids in checking the image offline (away from treatment machine) and the process is much complex in attaining an accurate image match corrections. In order to check the coverage of the nodal volume, kV planar images have been taken as per of the in-house imaging protocol. This imaging strategy has slightly increased the appointment time and the patient set up time. On this account an imaging audit has been undertaken to find out the relation with rotational errors of CBCT with translational errors (X, Y, Z directions) on KV planar images. This may facilitate reducing the number of patients requiring planar kV images based on evidenced selection criteria. For the purpose of this audit the 2D and 3D imaging results have been taken and analysed fro 10 patients.

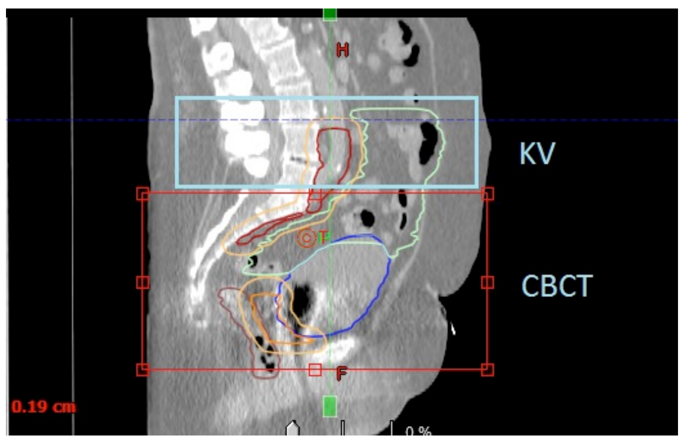

Figure 1:- Sagittal CT image showing the respective imaging volumes CBCT (red) and kV planar (blue)

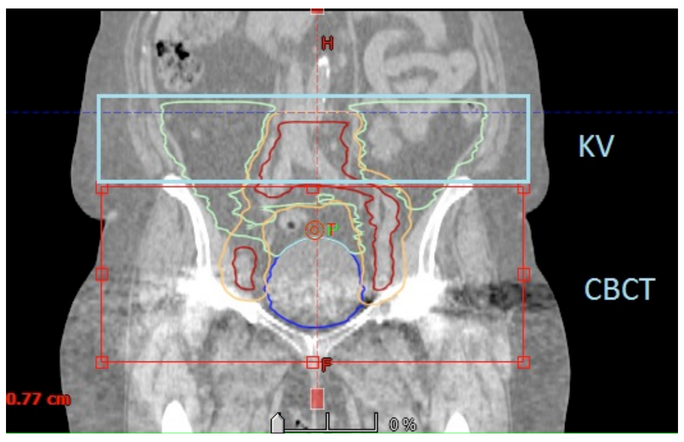

Figure 2:- Coronal CT image showing the respective imaging volumes CBCT (red) and kV planar (blue)

Methodology

CBCT has been taken as the initial assessment and this image should include all anatomy of the high dose region especially the inferior end of the planning target volume, where volumetric imaging is of the most benefit. For this reason the CBCT volume never compromises on the inferior end of the volume. Anatomy matching was performed on the basis of bony match. This was then verified with soft tissue details and correction applied according to the image match results. The bladder and bowel volume need to be assessed at this stage. This process is followed by a 2D/2D KV planar imaging on the superior aspect of the nodal PTV (Figure 1 & Figure 2). As the lower lumbar spine and sacrum are good surrogates for the internal and external iliac nodal chains and the upper pre sacral nodes (Shih et al 2005), these 2D planar images were matched with vertebrates without any rotational corrections. If the correction values were outside the departmental PTV margins then further intervention was needed in achieving a good treatment position.

68 imaging pairs were re assessed and a retrospective image matching has been done on each image pair. All the translational errors and rotational errors are tallied in relation to the KV planar images. Vertical displacement was found to be the largest of these, which is logical. Patient results show a maximum displacement of 0.5cm in the vertical direction when the pitch value is within 3°.

Analysis by first principles

If one assumes the scenario were the impact of any pitch value would have the utmost effect, we take the inferior volume of the PTV to be covered by the CBCT with the superior portion of the PTV unverified by imaging. If one assumes a PTV of 23cm, then the point of rotation can be assumed to be 8cm superior from the most inferior aspect of the PTV. The most superior end of the PTV will therefore be 15cm from the point of rotation. Assuming the angle of rotation (pitch) is 3° this will result in a vertical displacement of 0.8cm (Fig 3). Any systematic vertical displacement of the entire volume, will be accounted for and corrected, so all that remains will be the displacement due to pitch. In nodal cases a PTV margin of at least 1cm is used and therefore the CTV would be covered in this situation.
This situation is a simplification of the situation in vivo as it will not be the case that there will be a single axis of rotation, rather there will be a compound bend in the patient anatomy (i.e. a bend in the spine/rotation of the pelvis). The implications of this will be that the vertical displacement may differ slightly from the value calculated from simple geometry.
In order to verify that the value calculated via first principles is valid, a sample of patient match results has been assessed (figure 4 & figure 5 shows the correlation of pitch value with couch vertical correction).

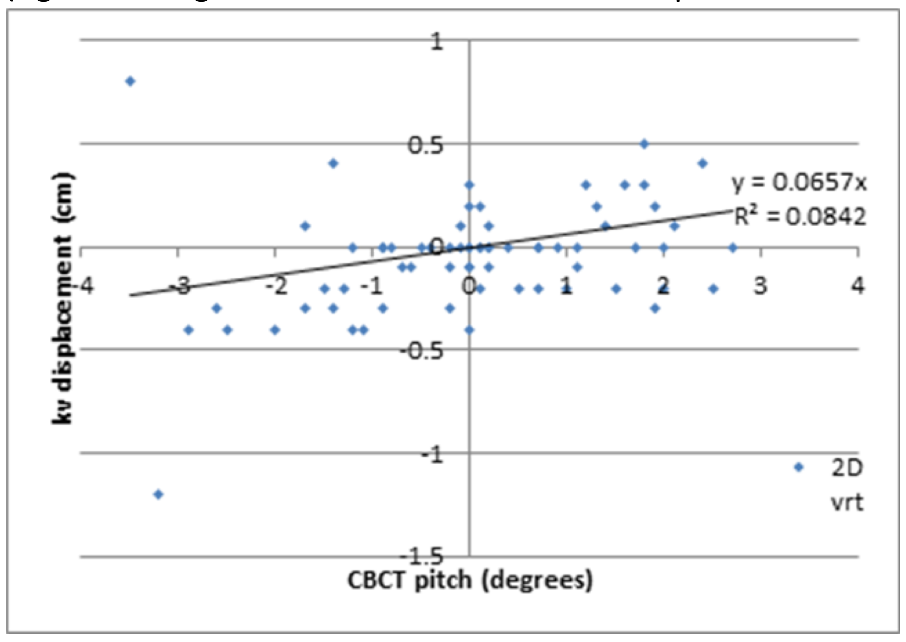

Figure 4:- Graph showing the overall displacement as measured by the kV match against the CBCT pitch

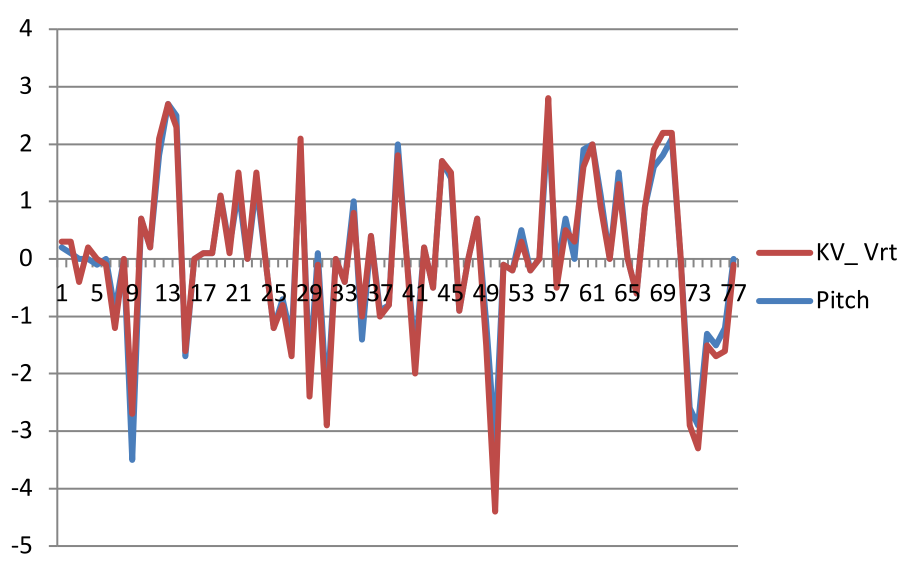

Figure 5:- Graph showing the direct relation of KV_Vrt and Pitch

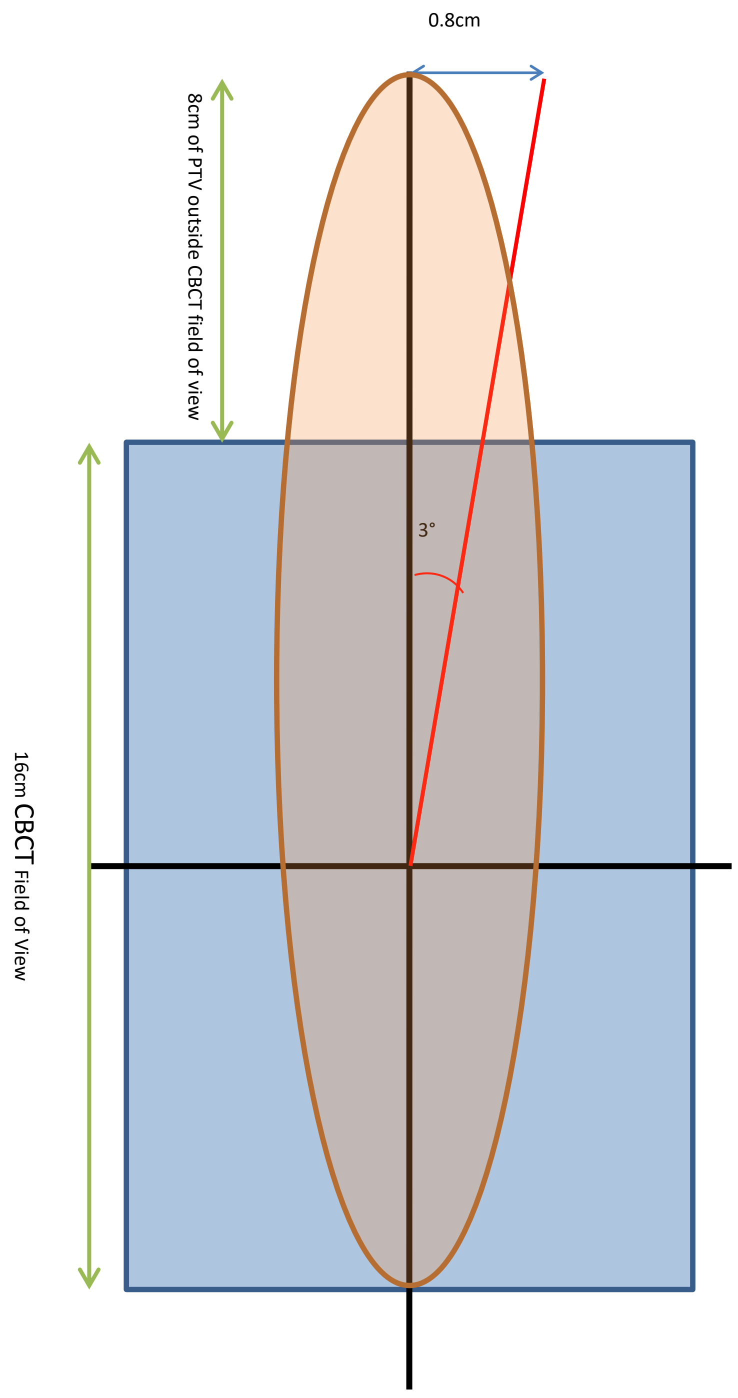

Figure 3: Geometric representation of the displacement encountered at the superior end of a 23cm PTV due to a 3° pitch

Results & Discussion

Analysis by first principles and the patient audit both confirm that the superior end of the planning target volume will be covered provided the PTV is 23cm or less and the CBCT pitch is less than 3°. Patients who fall within these criteria may not require additional planar kV verification. With the results of this imaging audit the departmental in-house imaging protocol has been amended and the patient appointment time has reduced in order to reflect this change.

References

H.A. Shih, M. Harisinghani, A.L. Zietman, et al.
Mapping of nodal disease in locally advanced prostate cancer: Rethinking the clinical target volume for pelvic nodal irradiation based on vascular rather than bony anatomy
Int J Radiat Oncol Biol Phys, 63 (2005), pp. 1262-1269