

Treatment planning based on CBCT images acquired for on-line positioning verification

- Report for Work Group of Treatment Planning

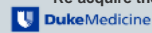
- 1) Sua Yoo – Duke Univ.
- 2) Jean Pouliot – Univ. of California – San Francisco
- 3) Daniel Letourneau – Princess Margaret Hospital
- 4) Lei Xing – Stanford Univ.



ANPM 2010 Annual meeting – Philadelphia, PA
Therapy Educational Course – Thurs. 8:30AM – 9:25AM – Ballroom A

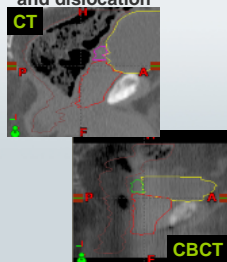
Main use of on-board CBCT

- 3D positioning verification or target localization
 - 2D projection images (KV/MV) are not enough.
 - 3D positioning information.
 - Soft tissue information
 - Targets, critical organs and patient anatomy.
 - Organ deformation/dislocation, target volume change,
 - Patient weight (overall size) change
- Verification plan (or evaluation plan) to confirm the dose for
 - Target coverage
 - Critical organ sparing
- Re-plan?
 - Modify the original plan or re-plan based on CBCT?
 - Re-acquire the planning CT and re-plan?

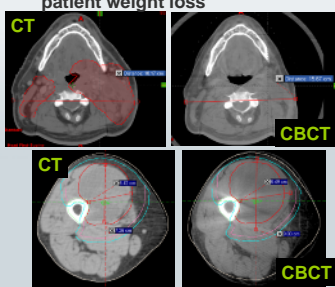


Needs for dose-calculation based on CBCT

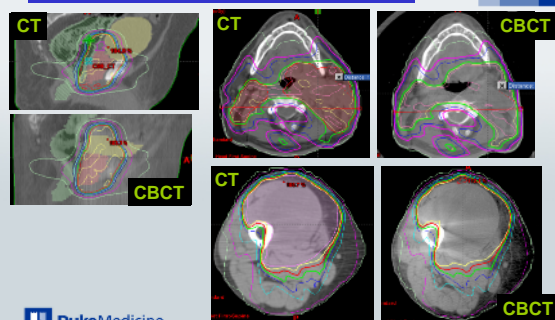
Organ deformation and dislocation



Target volume change and/or patient weight loss



CBCT-based dose calculation



Procedures

1) CBCT images in HU values (HU calibration)

- HU linearity/ HU uniformity
- Image quality: scatter/artifacts

1) Transfer CBCT images to treatment planning system

2) HU-to-ED conversion

3) Dose calculation



Feasibility of CBCT-based dose cal-

Siemens MVBCT

- Dose calculation using MVBCT - Morin O, Chen J, Gillis A, Aubin M, Aubry JF, Bose S, Chen H, Descovich M, Xia P and Pouliot J. Int J Rad Oncol Biol Phys 2007;67(4):1202-1210
- Calibration of MV CBCT for radiotherapy dose calculation: Correction of cupping artifacts and conversion of CT numbers to electron density - Petit S., van Elmpt W., Nijsten S., Lambin P., and Dekker A. Med. Phys. 2008;35(3):849-865.

Varian KV CBCT

- Dosimetric feasibility of CBCT-based treatment planning compared to CT-based treatment planning Yoo S and Yin F., Int. J. Rad Oncol Biol Phys 206;66(5):1553-1561
- Evaluation of on-board KV CBCT-based dose calculation - Yang Y, Schreibmann E, Li T, Wang C, and Xing L. Phys. Med. Biol 2007;52:685-705
- Cone beam computerized tomography: the effect of calibration of the Hounsfield unit number to electron density on dose calculation accuracy for adaptive radiation therapy. Hatton J., McCurdy B., and Greer P.B., phys Med Biol. 2009;54:N329-46.

Elekta KV CBCT

- Quantitative evaluation of cone beam CT data used for treatment planning. - Houser C., Nawaz A.O., Galvin J., and Xiao Y., Med. Phys. 2006;33:2285-6.
- Online Planning and Delivery Technique for Radiotherapy of Spinal Metastases using Cone-beam CT: Image Quality and System Performance. - Letourneau D., Wong R., Moseley D.J., Sharpe M., Ansell S., Gospodarowicz M., and Jaffray D.A. Int J Radiat Oncol Biol Phys. 2007;67:1229-1237.
- Investigation of usability of CBCT data sets for dose calculation - Richter A., Hu Q., Steglich D., Baier K., Wilbert J., Guckenberger M., and Flentje M. Radiother Oncol. 2008;3:42-1-13.



Tx verification/evaluation using ...

Siemens MVBCT

- Dose recalculation in megavoltage cone-beam CT for treatment evaluation: removal of cupping and truncation artefacts in scans of the thorax and abdomen - Petit S.F., van Elmpt W.J.C., Lambin P., and Dekker A.L., Radiother Oncol. 94: 359-366; 2010

Varian KV CBCT

- Lee L, Le Q, and Xing L, Retrospective IMRT dose reconstruction based on cone-beam CT and MLC log-file, Int. J. Radiat. Oncol. Biol. Phys. 2008;70(2):637-644.
- Mechalakos J., Lee N., Hunt M., Ling C.C., and Amols H.J., The effect of significant tumor reduction on the dose distribution in intensity modulated radiation therapy for head-and-neck cancer: a case study., Med. Dosim. 2009;34:250-5.

Elekta KV CBCT

- McDermott L.N., Wendling M., Nijkamp J., Mans A., Sonke J.J., Mjinheer B.J., and van Herk M., 3D in vivo dose verification of entire hypo-fractionated IMRT treatments using an EPID and cone-beam CT, Radiother Oncol. 2008;86:35-42.
- Jain P., Marchant T., Green M., Watkins G., Davies J., McCarthy C., Loncaster J., Stewart A., Magee B., Moore C., and Price P., Inter-fraction motion and dosimetric consequences during breast intensity-modulated radiotherapy (IMRT). Radiother Oncol. 2009;90:93-8.



Adaptive re-planning and correction methods

Siemens MVBCT

- Correction of megavoltage cone-beam CT images for dose calculation in the head and neck region Aubry J.F., Beaulieu L. and Pouliot J., Med. Phys. 35(3): 900-907; 2008.
- Correction of Megavoltage Cone-beam CT Images of the Pelvic Region Based on Phantom Measurements for Dose Calculation Purposes- Aubry J.F., Cheung J., Gottschalk A., Morin O., Beaulieu L. and Pouliot J., J. Appl. Clin. Med. Phys. 10(1), 33-42; 2009.

Varian KV CBCT

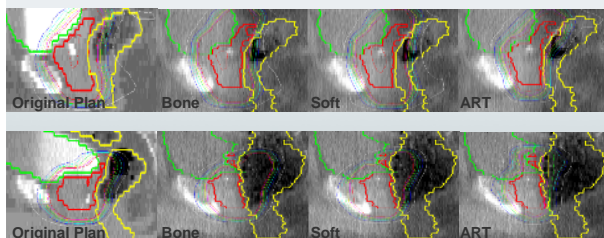
- Ding G.X., Duggan D.M., Coffey C.W., Deeley M., Hallahan D.E., Cmelak A., and Malcolm A, A study on adaptive IMRT treatment planning using KV cone-beam CT, Radiotherapy and Oncology. 2007;85:116-25.
- Wu Q. J., Thongphiew D., Wang Z., Mathayomchan B., Chankong V., Yoo S, Lee W. R., and Yin F, On-line re-optimization of prostate IMRT plans for adaptive radiation therapy, Phys. Med. Biol. 2008;53(3):673-91.
- Zhu L., Xie Y., Wang J., and Xing L., Scatter correction for cone-beam CT in radiation therapy., Med. Phys. 2009;36:2258-68.

Elekta KV CBCT

- Online Planning and Delivery Technique for Radiotherapy of Spinal Metastases using Cone-beam CT: Image Quality and System Performance. - Letourneau D., Wong R., Moseley D.J., Sharpe M., Ansell S., Gospodarowicz M., and Jaffray D.A. Int J Radiat Oncol Biol Phys. 2007;67:1229-1237.



Study using CBCT-based dose cal-



DukeMedicine

Thongphiew et al – Med Phy 2009

Purpose of this session



- The next three speakers will present
 - Current status of CBCT system for CBCT-based dose calculation
 - Limitations and concerns in clinical practices
 - FOV limitation to include the entire patient body.
 - HU calibration/ HU linearity/ HU uniformity
 - Scatter and artifacts
 - HU-to-ED conversion
 - Siemens MV CBCT, Elekta KV CBCT and Varian KV CBCT.

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