

Cone beam computed tomography (CBCT) for radiation therapy patient positioning

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Abstract

Cone-beam computed tomography (CBCT) for patient positioning during radiation therapy represents a recent and significant advance in what is now being called image-guided radiation therapy (IGRT).

With CBCT, a full CT scan of the patient on the treatment couch is obtained immediately before radiation delivery, with the CT scan taken and reconstructed in less than 2 minutes. The CT scan can then be automatically registered to the CT taken earlier for treatment planning to facilitate precise repositioning of the patient to the treatment machine isocenter. Development of CBCT for radiation therapy is a rapidly growing field, following the impetus for image guided radiation therapy. At the same time, other methods of verifying patient position before radiotherapy treatment are progressing as well. Other kV-imaging-based methods include a sliding gantry CT scanner installed in an existing treatment room and in-line cone-beam CT where the imaging beam is mounted opposite to the treatment beam sharing the same isocenter. Megavoltage (MV) imaging-based methods include MV CBCT and helical tomotherapy MV CT.

This presentation will discuss the concept and role of CBCT in IGRT. It will cover the CBCT solutions of the Elekta Synergy and Varian OBI systems.

Outline

- Motivation
- Concept and implementations
 - Elekta XVI
 - Varian OBI
- Workflow
- Quality Assurance

Motivation

- Modern treatment planning and delivery systems allow for higher doses to PTV and lower doses to normal tissue.
- With the resulting steep dose gradients, motion management becomes an even more critical part of the process.

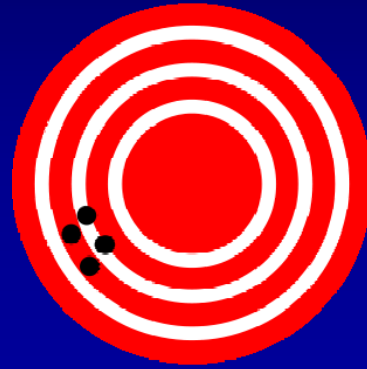
Types of motion

Interfractional motion

Change in patient position between treatment session.

- Patient setup changes
- Patient anatomy changes (tumor shrinking, organ fill status)

If not managed: delivery of a treatment session will have low accuracy (with possibly high precision).



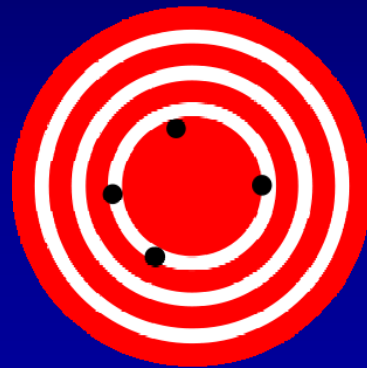
Types of motion

Intrafractional motion

Change in patient position during a treatment session.

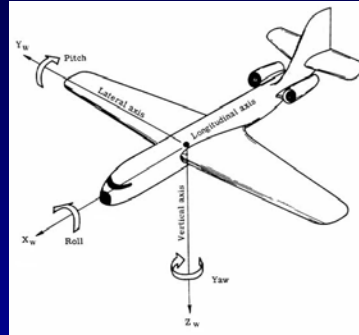
- Breathing
- Gas passing
- Uncooperative patient

If not managed: delivery of a treatment session will have low precision (with possibly high accuracy).

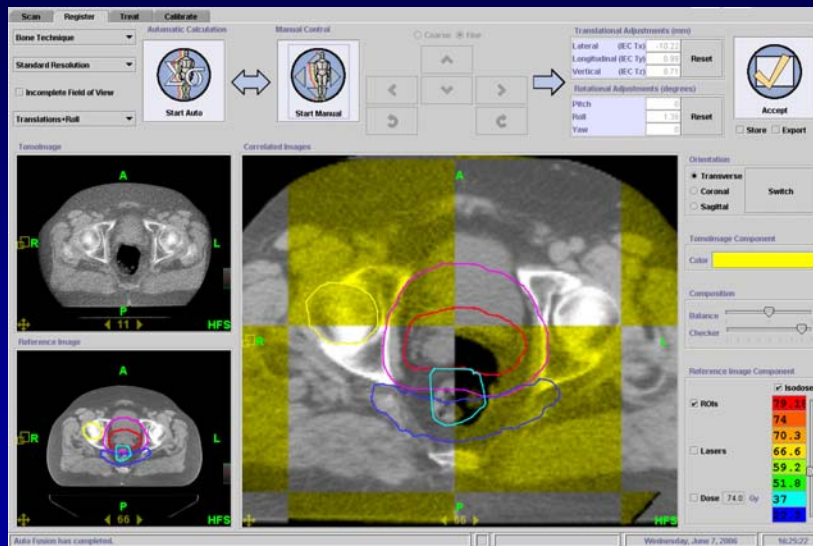


Role of CBCT

- helps reduce interfractional motion
 - patient position adjustment
 - no-go condition identification
- assesses 3D patient status
 - tumor evaluation
 - adaptive planning
- future: 4D CBCT “samples” intrafractional motion



IGRT and no-go conditions



CBCT imaging components

- kV source and kV imaging panel at 90° to treatment line
 - used for three imaging modes: planar, fluoro, CBCT
 - mounted on arms that are motorized to varying degrees



CBCT imaging components



Storage of Elekta XVI components



CBCT imaging components

Storage of Varian OBI components



CBCT imaging components

Storage of Varian OBI components



CBCT imaging components

Storage of Varian OBI components



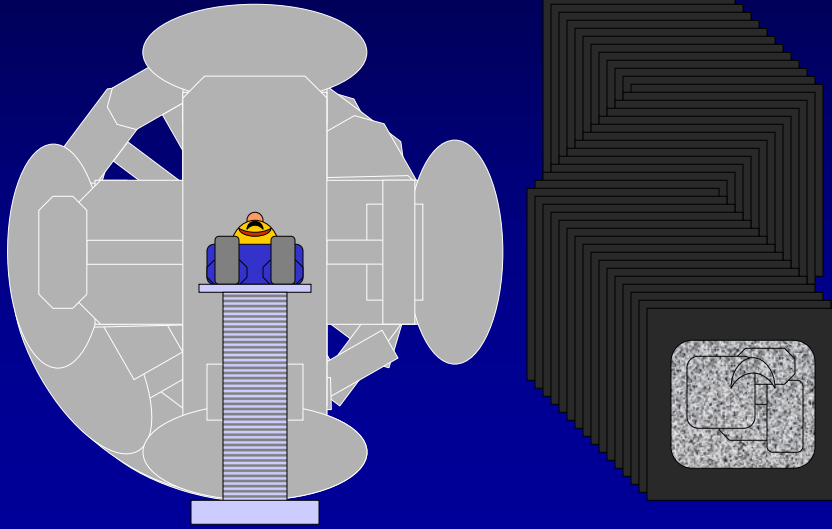
CBCT imaging components

Storage of Varian OBI components



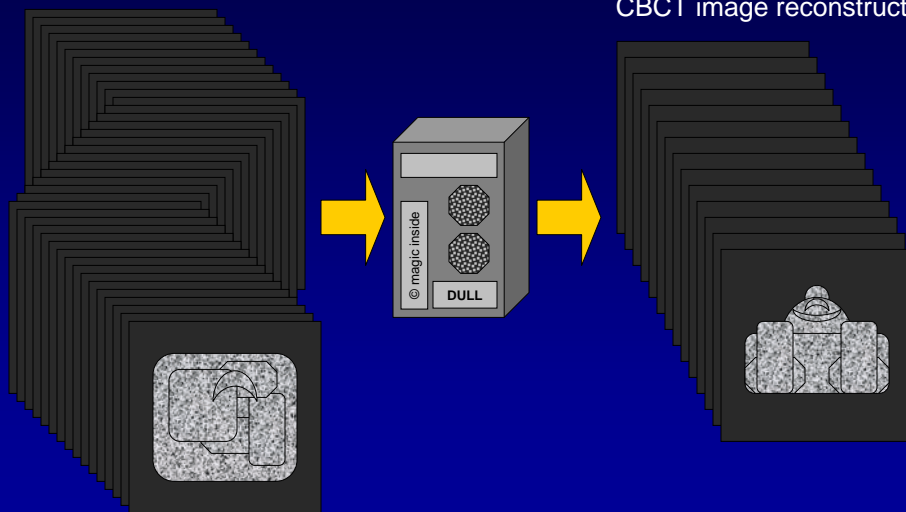
CBCT imaging procedure

Raw image acquisition



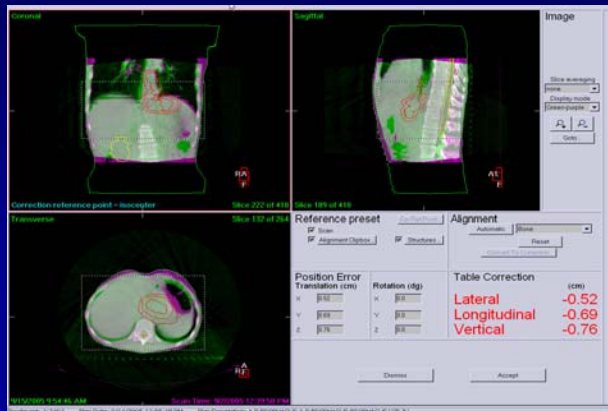
CBCT imaging procedure

CBCT image reconstruction



CBCT - 3D alignment

- CBCT is 3D aligned with reference image / planning CT
 - various tools, including contours, ROIs, color overlay
- shifts necessary to align image sets correspond to couch shifts needed to correct patient setup
- translations and/or rotations



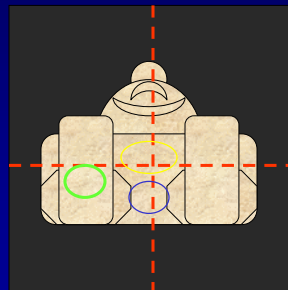
CBCT - data preparation

In preparation the following data needs to be provided

- planning CT
- structure set
- iso center information

Details are system dependent

- send directly
- send via RV
- “local load”

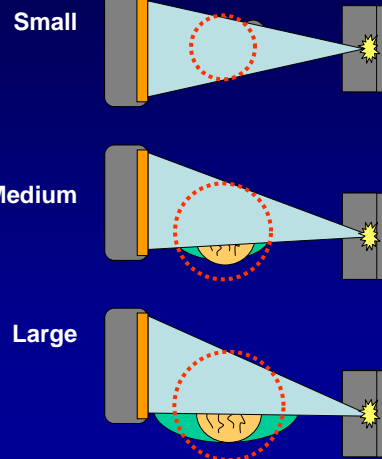


CBCT patient workflow

- Select / Load Patient
- Extend imaging gear
- Select imaging parameters
- Bring gantry in start position
- Fire kV while moving gantry
- Reconstruct CBCT
- Align CBCT with reference
- Adjust patient position / shift
- Record shifts
- Retract imaging gear (opt)
- Treat



Field of view = diameter of CBCT volume



CBCT

kV source - Elekta XVI



- (1) kV source support arms
- (2) kV source operator handle
- (3) kV source lock button
- (4) collimator cassette
- (5) filter cassette
- (6) cables

Label	FOV	Nominal axial length
S20	small	26 cm
M2	medium	2.5 cm
M10	medium	12.5 cm
M20	medium	26 cm
L2	large	2.5 cm
L10	large	12.5 cm
L20	large	26 cm

CBCT

kV source - Varian OBI



- on robotic arm with 3 joints
- blades to control field size including full fan / half fan mode
- field up to 15 cm long
- optional bow tie filters



Patient dose from CBCT

- System dependent
 - kV / mAs settings
 - # of projections (angle of rotation, images per degree)
 - kV system properties (including bow tie filter use)
 - kV system field size
 - Patient dependent
 - size and shape of patient
 - body part
- dose and image quality are closely related
→ image quality (only) needs to be good enough for purpose
- risk / benefit ratio needs to be considered

Quality Assurance

System Safety

- check interlocks on tube, panel and arms

Alignment of kV and MV lines

- verify isocenter 3D agreement
- verify registration and alignment process

Image quality

- monitor image quality parameters
- watch for degradation

Patient dose

- measure base value (surrogates: air dose, HVL)
- monitor changes

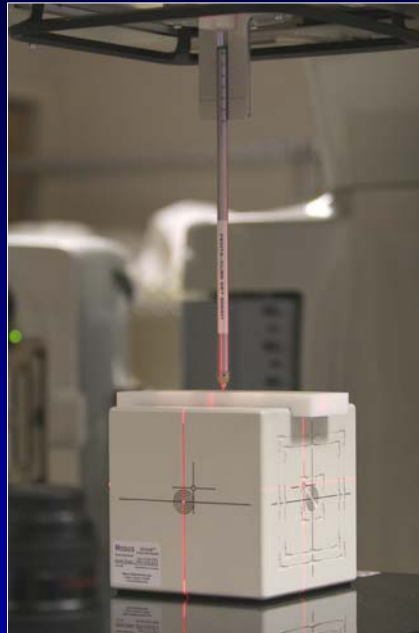
Penta Guide™

- QA phantom
- 2 sets of cross hairs
- Custom hood for ODI check at 92 cm



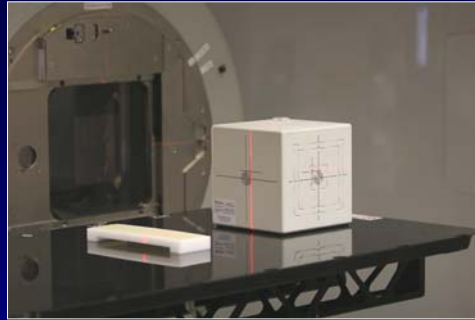
QA workflow

- Setup ODI test
- 92 cm to hood of the Penta Guide™ cube
- Verify ODI readout



QA workflow

- Take off hood
- Setup cube using beam cross hair at gantry 180° and 270° (or 90°) → use offcenter cross hair on cube
- Acquire CBCT
- Align with reference image
- Adjust couch position
- Acquire CBCT and verify alignment with reference
- Verify alignment with iso-center cross hair on cube
- Check lasers

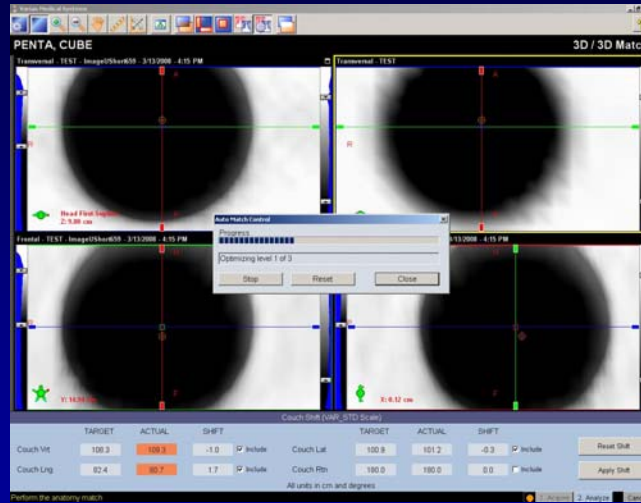


QA workflow



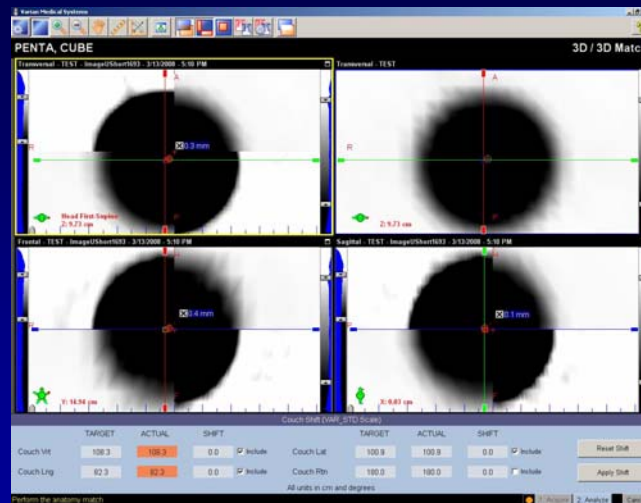
- Align with reference image

QA workflow



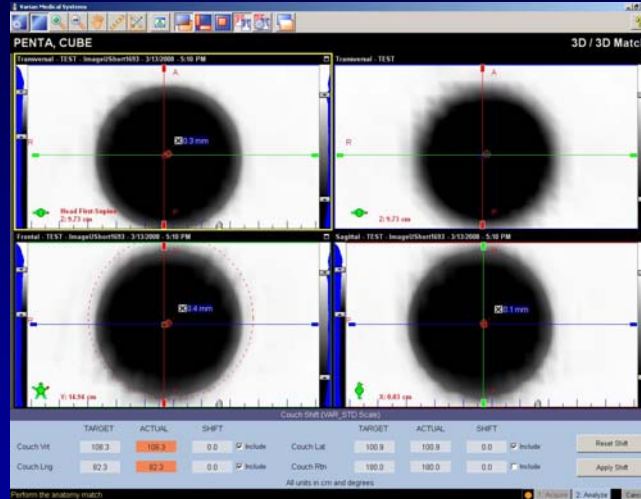
- Align with reference image

QA workflow



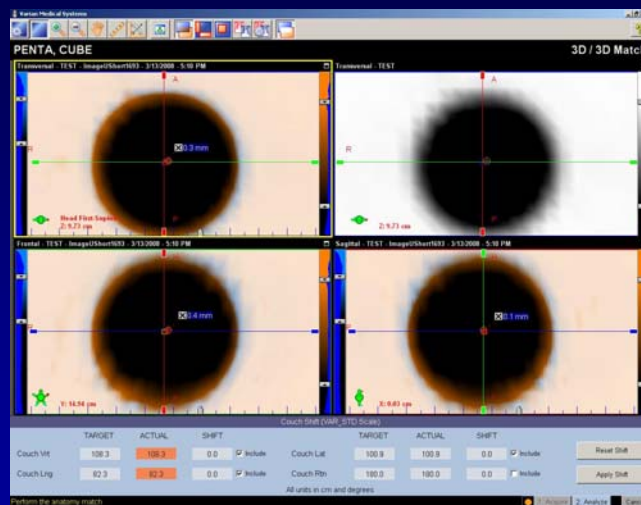
- Align with reference image

QA workflow



- Align with reference image

QA workflow



- Align with reference image

OBI image quality QA with CATPHAN



Thank you!

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