Treat what you planned. The On-Board Imager™ kV imaging system provides improved tumor targeting using high-resolution, low-dose digital imaging in the treatment room. Users can confidently manage patient and target movement—both before and during treatments—with digital kV radiographic, cone-beam CT (CBCT) and fluoroscopic images.

What is the On-Board Imager?
The On-Board Imager acquires high-quality digital images in the treatment room, allowing you to position a patient accurately before treatment. The On-Board Imager consists of a kV X-ray source and an amorphous silicon panel that can be added to the Clinac® iX linear accelerator or the Trilogy™ configuration of the Clinac iX linear accelerator. The On-Board Imager employs robotically controlled arms that operate with three axes of motion, optimizing positioning of the imaging system for the best possible view of the target.

Why Use the On-Board Imager?
The On-Board Imager makes Dynamic Targeting™ IGRT more efficient and convenient. This device detects movement due to changes in patient setup, internal organ movement or movement associated with breathing.

It enables users to:
- Improve tumor targeting, thus improving the effectiveness of treatments,
- Reduce side effects by reducing treatment margins,
- Develop new treatments using hypofractionated or ablative techniques.

A Versatile Device
The On-Board Imager enables online patient repositioning by visualizing bony anatomy or radiopaque markers in pairs of radiographs—or by visualizing soft-tissue and bony anatomy in cone-beam CT images. When used in conjunction with the Real-Time Position Management (RPM™) respiratory gating system, the On-Board Imager also enables fluoroscopic pretreatment gating verification and gated radiographic anatomic image matching. And in combination with the PortalVision™ MV imaging system, the On-Board Imager allows for filmless acquisition of MV and kV radiographic pairs without gantry rotation, thus speeding up the acquisition process. Users choose the optimal imaging technique that is right for their patient’s individual clinical situation.

Convenient Dynamic Targeting IGRT Process
Once the patient is set up, all subsequent imaging activities can be performed remotely, generating a smooth, convenient clinical process. First, digital images are obtained. Then, manual or automated image registration algorithms provide immediate, online analysis of the images and suggest any necessary changes to the couch position to optimally position the patient for their treatment. The therapist can then reposition the couch remotely from the treatment console, retract the imaging arms, and continue with the treatment—all without going back into the treatment room.

The combination of robotic technology and integrated software control of all treatment parameters offers the automation, speed, and flexibility needed to make the IGRT process clinically practical. With the On-Board Imager, you can obtain kV images, adjust patient positioning as needed, and complete the treatment, all within the standard treatment time.
The planning and delivery of tightly defined dose distributions in three dimensions is a challenge that has been solved. Yet aligning the treatment beam to the target volume remains a key challenge to improving outcomes because patients, tumors, and normal tissues all move.

**Interfraction motion**—changes in position caused by day-to-day set-up conditions—can lead to uncertainties in treatment positioning. **Intrafraction motion**—changes in position during a treatment session because of normal respiratory and organ motion—can also create treatment positioning uncertainties. If the motion is greater than the treatment planning margin, the prescription dose to the target may not be achieved or the tolerance dose to the normal tissues may be exceeded.

To minimize both types of motion, the On-Board Imager introduces pretreatment online imaging to the clinical process.
The On-Board Imager identifies the patient’s position at the time of treatment so that small couch adjustments can position the patient optimally. The system has two modes of operation: 1) Radiographic repositioning, and 2) Cone-beam CT repositioning. The On-Board Imager is designed for convenience so that all steps in the patient repositioning process can be performed remotely—saving time and simplifying the process.

**Radiographic Repositioning**

**Anatomy registration**

Anatomy registration is preferred when the target can be visualized directly, or when bony structures are reliable surrogates for the target.

The process has been designed to be fast, efficient, and to minimally interfere with clinical throughput, including the ability to move the couch remotely once the desired position of the patient has been determined.

**Radiopaque marker registration**

Radiopaque marker registration is similar to anatomic registration, except that radiopaque markers, rather than patient anatomy, are used to reposition the patient.

The On-Board Imager software identifies and matches marker seeds in the reference CT and pretreatment images. The residual error in the match is quantified and displayed, and the therapist can manually fine-tune the match. When a satisfactory match is achieved, couch corrections can be downloaded to the accelerator to remotely move the couch.

**Cone-beam CT Repositioning**

This operating mode is preferred when soft-tissue 3D visualization is important for patient repositioning, when small targets are being treated, when a small number of treatment fractions are being used or adaptive planning is desired.

The overall process is very similar to the radiographic repositioning technique, except cone-beam CT images, rather than a pair of radiographs, are acquired.

Therapists can adapt and refine a patient’s position based on daily cone-beam CT scans acquired immediately prior to treatment – while the patient is in the treatment position.

Image acquisition, image analysis and remote repositioning are all done in one system to optimize efficiency. And, tools are provided to register the cone-beam CT images with the planning CT images.

The measured shifts are automatically downloaded to the treatment couch of the Clinac iX or Trilogy systems greatly simplifying patient repositioning.

**Geared to performance, accuracy and image quality**

Cone-beam CT is designed for fast image acquisition to speed up the clinical process. It yields accurate CT numbers to simplify the display of the cone-beam CT images, and acquires a large field-of-view so that patients of all sizes can be scanned. Image acquisition is fast using a single, 1-minute, rotation around the patient regardless of the patient anatomy being scanned.

Successful cone-beam CT image acquisition relies on careful calibration of the imaging system. Tools to simplify geometry calibration and detector calibration are part of the cone-beam CT application. This maintains high image quality—essential for successful patient repositioning.

**Treatment adaptation**

After the treatment, the CBCT images can be imported into the Eclipse™ integrated treatment planning system for fusion with the planning CT. Dose distributions for each day’s treatment can then be calculated, allowing the user to monitor changes in the clinical target volume during the treatment course.
Convenient Clinical Process

1. **Patient setup**
   The therapist positions the patient as usual.

2. **Image acquisition**
   The therapist chooses to acquire either a pair of radiographs (kV/kV or MV/kV pair) or a cone-beam CT scan.

3. **Image analysis**
   The therapist can select from manual or automated image registration tools to register the OBI images with the reference images (kV radiographs, DRRs, or planning CT scans).

4. **Remote patient positioning**
   The couch is moved remotely with the press of a motion-enable button.

5. **Treatment delivery**
   The robotic arms can be retracted remotely, and the treatment can commence.
MANAGING INTRAFRACTION MOTION

Tumors that move because of respiratory motion may be more effectively treated using the RPM respiratory gating system. Gating automatically turns the treatment beam on and off in intervals synchronized with the patient’s respiratory pattern, effectively freezing the moving target.

Fluoroscopic pretreatment gating verification

Fluoroscopy is an effective tool for verifying just before treatment that the patient’s respiration is stable, that RPM gating is operating properly, and that the treatment aperture encompasses the full range of residual target motion.

Initial patient setup and breathing stabilization

The patient is positioned with the lightweight, retroreflective marker placed on the chest or abdomen. Visual and auditory bio-feedback helps stabilize the patient’s breathing. The RPM console traces the patient’s breathing pattern within the patient-specific thresholds that determine when the treatment beam will be gated on and off.

Pretreatment verification

On the On-Board Imager console, a visual representation of the treatment aperture alternates between green and red to show when the beam will be turned on and off during treatment. Activating fluoroscopy with a footswitch, the therapist qualitatively verifies just before treatment that the patient is breathing in a reproducible fashion and that the marker and gating thresholds are properly set to keep the target within the treatment aperture.

Gated radiographic anatomic image matching

This technique is similar to radiographic anatomic image matching. The difference is that the RPM respiratory gating system is used to acquire gated radiographs during the positioning process. The RPM respiratory gating system automatically acquires radiographs during the correct phase of the respiratory cycle, when the treatment beam is gated on. The images are compared with the DRRs, which are calculated using CT images acquired either prospectively, or retrospectively (4DCT) under RPM control. Alternatively, gated radiographs from the Acuity™ planning, simulation, and verification system can also be used as reference images.
Further information

For complete specifications, see the On-Board Imager specifications, RAD 9502. For more information about the On-Board Imager and Dynamic Targeting IGRT, contact your Varian Medical Systems representative or visit www.varian.com/DynamicTargetingIGRT or www.varian.com/CBCT.

Images, acquired using the Varian On-Board Imager, are courtesy of Duke University Medical Center, Stanford University Medical Center, Karolinska University Hospital, Hirslanden Klinik Aarau, and Josephine Ford Cancer Center.

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