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Image-guided Radiation Therapy:
Surface Tracking

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American Society of Radiologic Technologists

Image-guided Radiation Therapy: Surface Tracking

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Arguably the strongest guiding principle in radiation therapy is to increase the therapeutic ratio, which involves maximizing dose to the diseased area while minimizing dose to surrounding normal tissues. This principle has been the driving force for research and technical innovations in radiation therapy.

The most recent advances involve image-guided radiation therapy and image-guided adaptive radiation therapy. These approaches have allowed the radiation oncology team to correct for positional errors, with a focus on changes caused by interfraction and intrafraction motion. This article discusses video surface imaging and optical tracking, which are used to further improve confidence in target volume localization.

After completing the article, the reader should be able to:

- Understand the basic processes and elements involved with surface tracking systems.
- Explain how the use of surface tracking improves planning target volumes and therapeutic ratios.
- Describe how to apply basic quality assurance concepts to surface tracking processes.
- Distinguish between the advantages and disadvantages of the surface tracking systems discussed.
- Discuss possible applications for surface tracking methods not currently used.

The International Commission on Radiation Units and Measurements (ICRU) published Report 50 in 1993, titled *Prescribing, Recording, and Reporting Photon Beam Therapy*. The report identified various volumes used in treatment planning for radiation therapy and was designed to aid in the selection of appropriate beam sizes and beam arrangements. In 1999, ICRU Report 62, a supplement to Report 50, further developed radiation therapy volumes (see **Figure 1** and **Box**).[1,2]

According to the ICRU guidelines, the planning target volume (PTV) should take into account the net effect of all possible geometrical variations and inaccuracies. The goal is to ensure that the prescribed radiation dose actually is absorbed in the clinical target volume (CTV). The PTV size and shape depends on the CTV, but also can be contingent on the treatment technique used. The radiation oncology team adjusts PTV size and shape to compensate for the effects of organ and patient movement, as well as inaccuracies in beam and patient setup.[1,2]

The objective of radiation treatment and treatment planning is to maximize prescribed dose to the target volume while minimizing dose to surrounding normal structures, sometimes referred to as organs at risk. Radiation oncology teams can accomplish this objective through a variety of methods, all of which can influence and potentially reduce PTV margins.[1,2]

Patient motion falls into 2 general categories: interfraction variation, which occurs between treatments, and intrafraction motion, which occurs during a treatment. Day-to-day setup variation (interfraction) and the differences that occur within the same fraction (intrafraction) have a significant impact on the dose delivered to the patient.

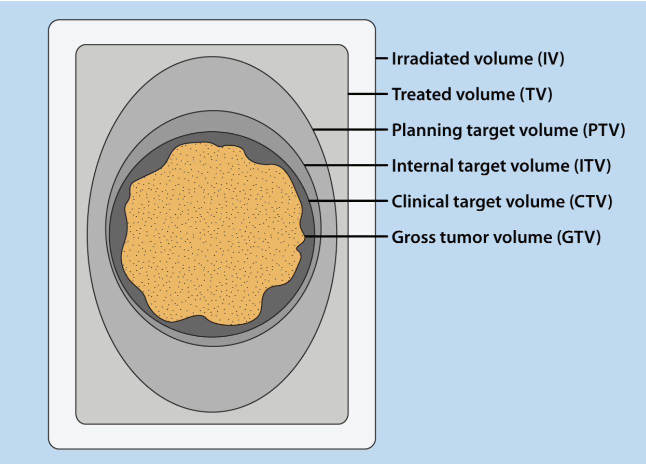

Figure 1. *Volumes used for radiation treatment planning. The gross tumor volume (GTV) includes the palpable or visible tumor. The clinical target volume (CTV) includes the tumor and presumed microscopic spread. The internal target volume (ITV) consists of the CTV and an internal margin built into the treatment plan. The planning target volume (PTV) includes the CTV and margins that account for geometric uncertainties. The treated volume represents the minimum target dose that adequately covers the PTV plus an additional margin to cover limitations in treatment technique. The irradiated volume contains tissue that receives a significant amount of the prescribed dose.*

Box

Tumor Volumes

Gross tumor volume (GTV)	Consists of the gross demonstrable tumor, including the primary mass, any metastasis and lymphadenopathy. The GTV is determined by visual or palpable assessment and through diagnostic imaging. If the tumor has been resected, an outline of the tumor volume from preoperative images can be substituted.
Clinical target volume (CTV)	Includes the demonstrable tumor and any area of presumed malignancy. The CTV represents the true extent of the tumor location; no other cancerous cells are identified or presumed to be outside this volume. Radiation doses to this area must be adequate to achieve treatment goals.
Internal target volume (ITV)	Compensates for any changes to the CTV during therapy due to physiologic movement and variations in target position, shape and size. This volume includes the CTV and an internal margin built into the plan.
Planning target volume (PTV)	Includes the CTV and margins accounting for geometric uncertainties in treatment setup, beam quality and consistency, and patient movement. This volume also must represent the organs at risk, emphasizing the need to minimize doses to these areas. Precision in contouring both the tumor and the dose-limiting structures is very important. Although it is difficult to reproduce an exact contour, the radiation oncologist must be diligent when contouring all volumes.
Treated volume	Represents the minimum target dose that adequately covers the PTV. The treated volume includes an additional margin to cover limitations of the treatment technique.
Irradiated volume	The largest of all volumes, containing tissue that receives a significant amount of the prescribed dose. A significant dose is sometimes defined as approximately 50% of the prescribed target dose. Conformal techniques have decreased the size of irradiated volumes over the years, but it is still important to document dose to critical structures within this volume.

Adapted from International Commission on Radiation Units & Measurements. Prescribing, Recording, and Reporting Photon Beam Therapy. *Bethesda, MD; International Commission on Radiation Units & Measurements; 1993 and 1999. ICRU Report 50 and ICRU Report 62 (Supplement to ICRU Report 50).*