ACCURAY®

TREATING LUNG TUMORS WITH SYNCHRONY®

Radixact®

TREATING LUNG TUMORS WITH SYNCHRONY®

The Challenge

Treating lung tumors with radiation can be a difficult task, as the target changes position with respiration. Depending on the target location, movement of the target can be as much as 50 mm, with the most movement typically in the superior-inferior direction.[1] This movement is patient-specific, can vary in magnitude, period, and regularity during simulation, imaging, and treatment, and can also change significantly between treatment sessions.[2-5]

The Problem with Conventional Systems

Conventional radiation treatment systems require clinicians to make trade-offs to compensate for motion of targets due to respiration. Clinical compromises are made with respect to margin size, delivery efficiency, and natural patient behavior. These compromises can affect clinical outcomes, treatment delivery cost, patient satisfaction, and ultimately practice viability.

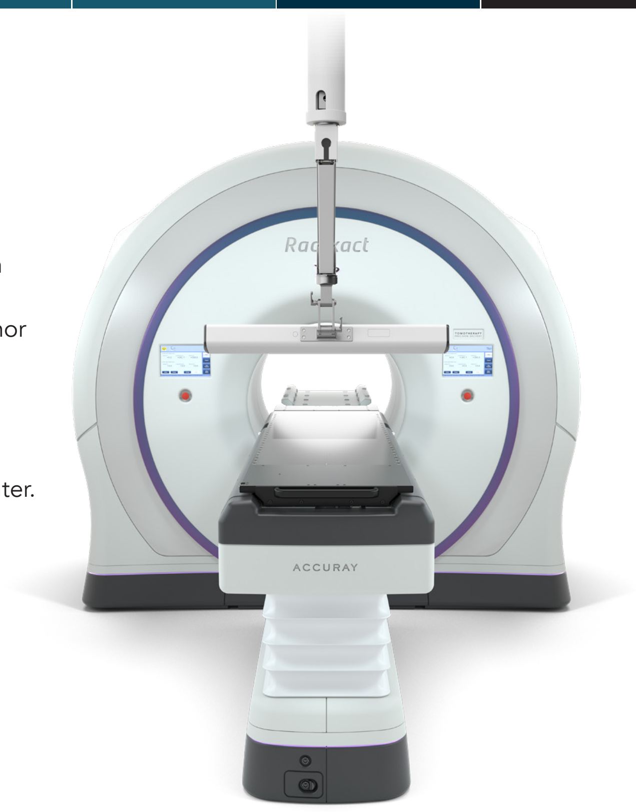
Synchrony®: Confidence in Motion

BEST 5 4 3 2 1 WORST

	Motion Synchronization	Conventional Motion Compensation Methods				
TREATMENT DELIVERY FACTORS	**Synchrony®**	**Gating**	**Breath Holding**	**Restraint**	**Monitor Motion Stop & Move Patient**	**Internal Target Volume (ITV)**
Natural Patient Behavior	5	3	2	1	4	5
Efficient Delivery	5	2	2	3	1	4
Minimal Margins	5	3	3	3	2	1

The Accuray Solution – Synchrony®

Synchrony® enables continuous delivery of radiation treatment to tumors while they are in motion by synchronizing the delivery beam position to the tumor location precisely, with sub-millimeter accuracy, and at all times during delivery of a treatment fraction. Synchrony frees clinicians from being forced to evaluate and make trade-offs that may be less than optimal for their patients, their practice, or their center.



The Synchrony® Principle

The Synchrony® principle is easy to understand and the system is intuitive to use. Simply **Track, Detect,** and **Correct**.

TRACK

Pick a target that should be monitored for movement.

DETECT

Look for a change in the position of the target at the right frequency.

CORRECT

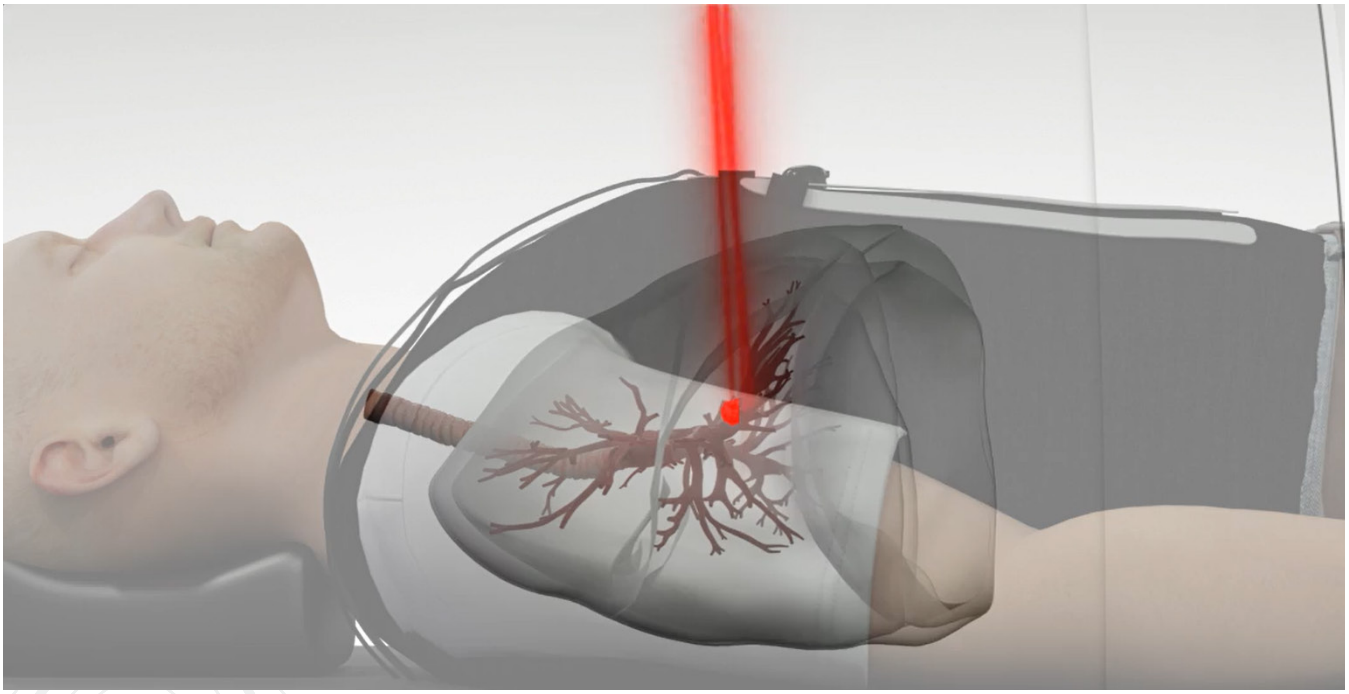
Move the treatment beam to synchronize it to the detected position of the tracked target.

Synchrony for Respiratory Targets

Synchrony, when used for targets that move with respiration, enables the treatment beam to be proactively synchronized to the predicted location of the target, rather than reactively moving to the latest detected target position. This can mean the most precise delivery, allowing further reductions in margin size.

To enable proactive beam synchronization, the Radixact® System tracks and detects the target over the full patient respiratory cycle to create a breathing model. The detected target position is correlated with the respiratory pattern throughout treatment delivery, producing a continuously updated map of where the target is predicted to be, based upon the previously correlated positions.

Proactive beam synchronization is available for Synchrony tracking methods that utilize Respiratory Modeling™: Synchrony Lung Tracking™ with Respiratory Modeling and Synchrony Fiducial Tracking™ with Respiratory Modeling.

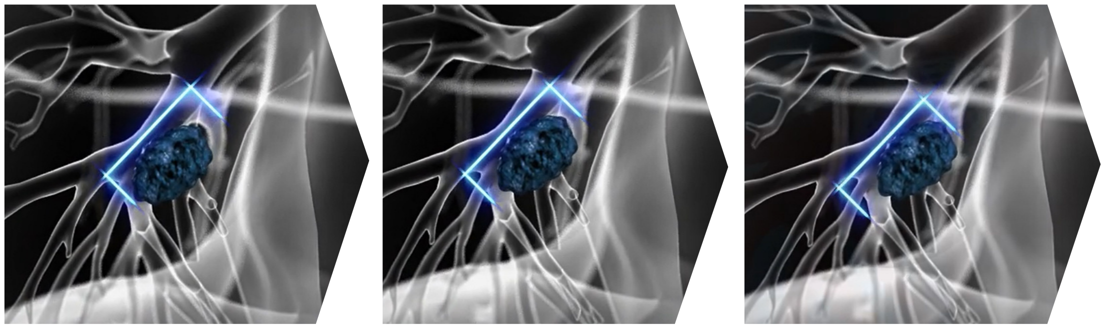


TRACK

Synchrony® with Respiratory Modeling™ on the Radixact® System

Track

Treatment Target Tracking: Radixact® with Synchrony® can track well-defined lung targets directly without fiducial markers. For less-defined lung targets, fiducial markers may be used to identify target position.



Respiratory Tracking: LED markers on a patient's chest or abdomen are monitored to determine the respiratory phase.

DETECT

Synchrony® with Respiratory Modeling™ on the Radixact® System

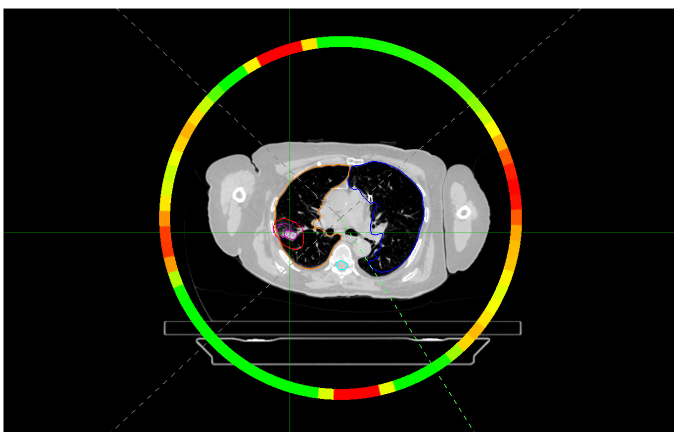
Detect

Treatment Target Detection: A kV beam line enables the Radixact® System to take images to determine the internal position of the treatment target or its fiducial surrogate. The kV beam line is positioned ninety degrees from the linear accelerator on the gantry and rotates around the patient producing sequential monoscopic images.

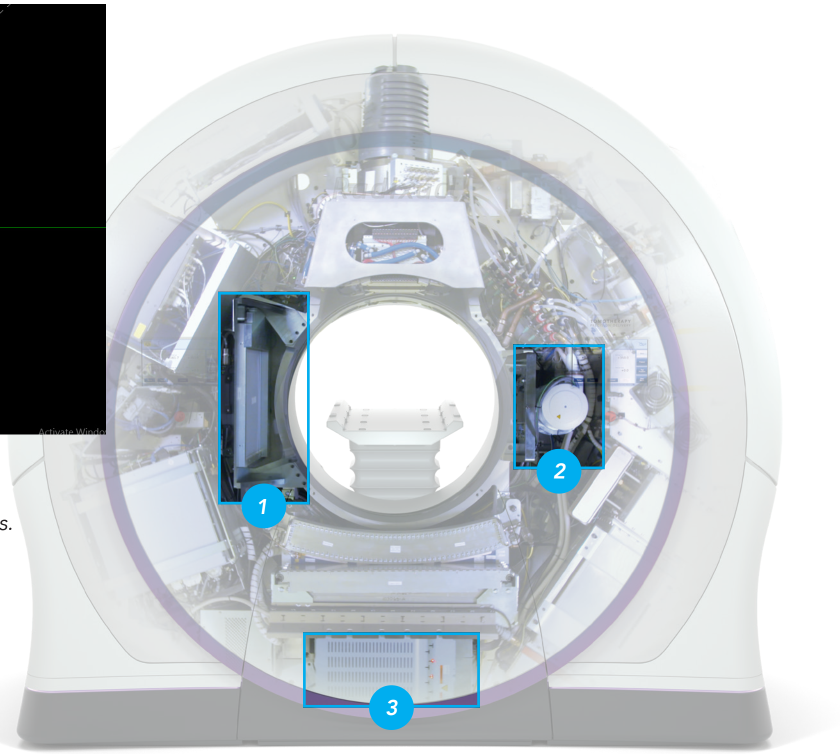
- Any-angle imaging allows the selection of two to six imaging angles, at least 30 degrees apart, per gantry rotation to ensure that target is always visible, and motion can be detected
- The system assists clinicians in the selection and customization of optimal imaging angles. The selected angles may be modified during treatment delivery
- The total imaging dose, for all images taken in preparation for and during a Synchrony® treatment, is less than a typical CBCT image taken with conventional systems
- No additional time is required for imaging during delivery; kV images are taken with the beam on, while treatment is delivered

Respiratory Motion Detection: An optical camera mounted on the ceiling or wall monitors LED markers which are placed on the patient's chest or abdomen. The camera detects the change in amplitude of the LED markers which reflect the external breathing pattern of the patient

- Amplitude of breathing is monitored at ~100 Hz providing real-time information to the system
- System design ensures a sufficient number of LED markers can be seen during treatment regardless of patient body type



Imaging angle section window: *Color wheel automatically indicates best imaging angles. Green dashed lines, which can be interactively moved, indicate selected imaging angles.*



Radixact kV imaging system components:
1) Flat panel detector, 2) kV imaging source, 3) kV power supply

Radixact®

CORRECT

Synchrony® with Respiratory Modeling™ on the Radixact® System

Correct

The dynamic jaws and ultra-fast binary multi-leaf collimator (MLC) allow the Radixact® System to automatically synchronize the treatment delivery beam position to the target position in real-time.

- With an MLC response time less than thirty milliseconds and the dynamic jaws capable of moving ten millimeters in a tenth of a second, the system is able to quickly respond to clinical target movement
- Treatment beam synchronization does not require pausing or stopping treatment delivery, therefore treatment is continuously and efficiently delivered
- Treatment beam synchronization is automatic with no manual intervention required

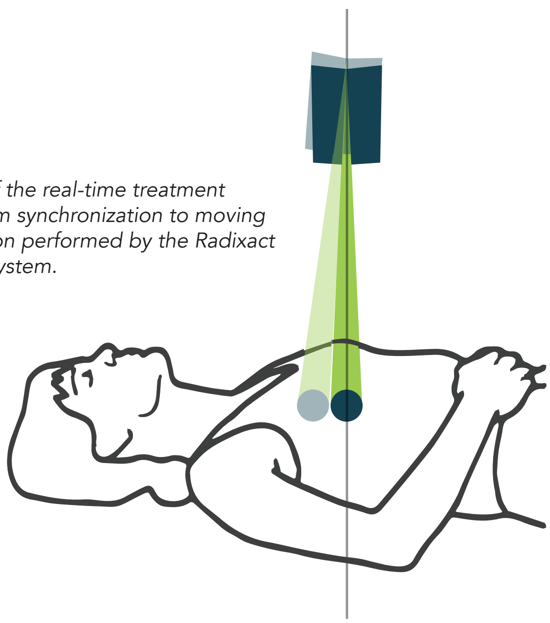
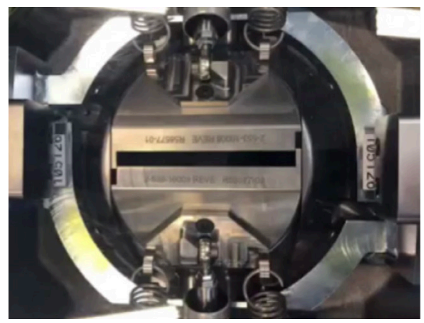
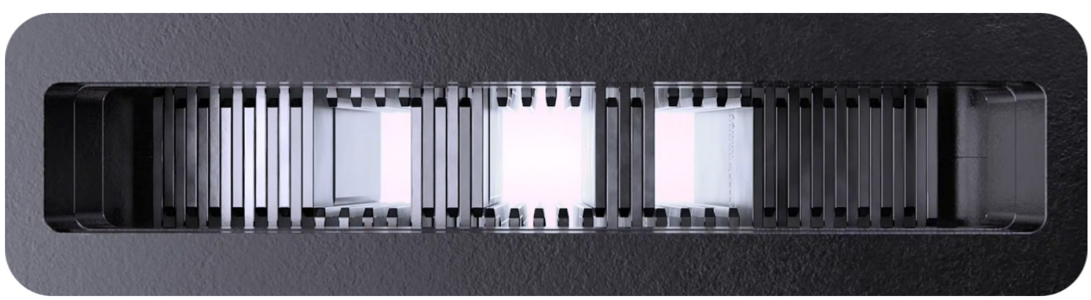


Illustration of the real-time treatment delivery beam synchronization to moving target position performed by the Radixact collimation system.



Dynamic jaws correct for motion in the superior/inferior direction.



Binary MLC corrects for motion in the anterior/posterior and mediolateral directions.

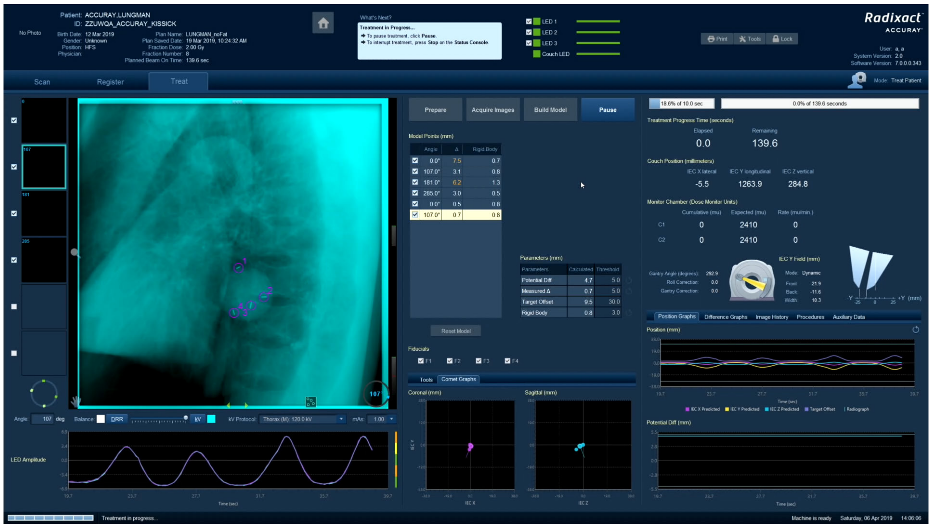
Synchrony® with Respiratory Modeling™ on the Radixact® System

Correlation

Conventional Systems: Surrogate structures such as the chest wall or diaphragm are often used to indicate tumor position as a tumor tends to move in relationship with the surrogate. The common belief is that if you know where the chest wall or diaphragm is, you know where the tumor is in relation to it and can correlate the position of the two throughout the respiratory cycle.

However, there are uncertainties in the displacement and phase relationship between the surrogate and the tumor that change during simulation, imaging, and treatment while also changing between sessions. Therefore, surrogates such as surface markers or spirometers, cannot be used alone or even in combination with out of date correlation information, commonly images taken at simulation or before treatment, to properly determine tumor position during treatment.[6-8]

Synchrony® on Radixact Respiratory Modeling™: Creates a correlation model between respiration as detected by LED markers on the patient's chest and the actual position of the tumor from kV images. The Synchrony System, before and during treatment, continuously monitors the respiratory pattern and on a regular interval monitors the tumor position, such that the correlation between the two is continuously updated. This ensures that the system knows where the tumor has been and can accurately predict where the tumor will be. This enables accurate proactive treatment beam synchronization on the Radixact System.



Images are at the same gantry angle, at two different breathing phases. Target is observed at two different sup/inf positions, and the jaw position has moved to correct for that motion.

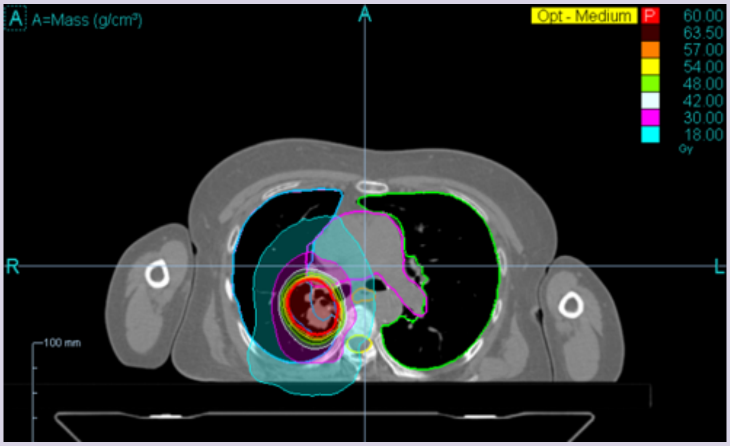
THE Synchrony® ADVANTAGE

Automated, real-time tracking, detection and beam correction synchronizes the treatment beam delivery with target motion enabling more accurate, more efficient and more comfortable radiation therapy treatments, without compromise.

Allowing patients to behave naturally, without restraints or breath holding required, means the system can be applicable to a larger patient population, provides greater patient comfort, and improves the patient experience in comparison to conventional motion compensation.

Providing clinicians with the accuracy and confidence to prescribe tight margins, the system offers the potential for better clinical outcomes with fewer side effects, the ability to retreat if required in the future, and the freedom to hypofractionate treatment delivery to a larger extent than conventional systems.

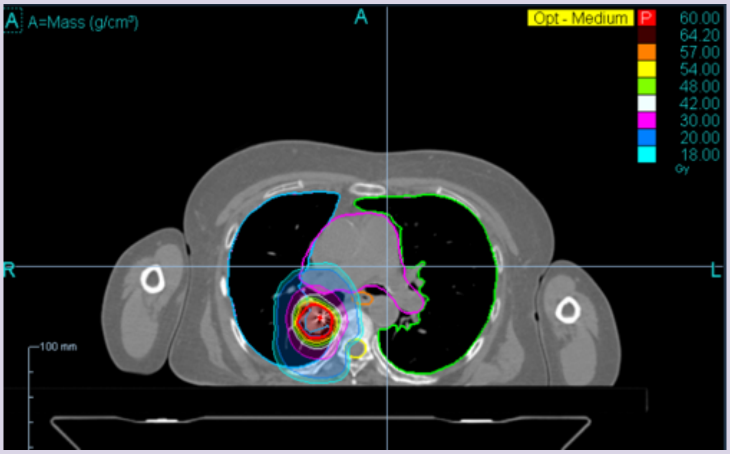
SMALLER TREATMENT VOLUMES MAKE A DIFFERENCE



Plan with ITV to encompass motion

Region	ITV Plan Volume (cc)	Synchrony Plan Volume (cc)	% Reduction with Synchrony
High Dose	27.96	8.76	68.67%
V20 Right Lung	163.43	61.4	62.43%
V5 Right Lung	450.68	315.18	30.07%

Dose-volume histogram (DVH) parameters, such as lung V20, play an important role in radiation treatment planning for thoracic malignancies including pulmonary toxicity risk prediction. The lung V20 is defined as the percentage of normal lung receiving at least 20 Gy and is dependent on the total lung volume (TLV). The V5 is the percentage receiving at least 5 Gy.



Synchrony Plan

Radixact®

THE Synchrony® ADVANTAGE

CONTINUED

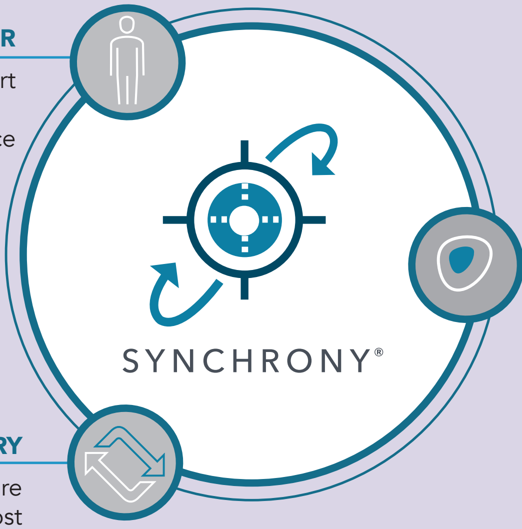
Automatically and continuously delivering treatment, without the inefficiency of gating or stopping and manually moving the patient when motion is detected, the system is not resource intensive or workflow disruptive. It can provide more efficient treatments at a lower cost which can increase profitability compared to conventional motion compensation methods[9].

The Radixact System with Synchrony® enables clinicians to expand patient-first treatment like no other system in the world by providing the flexibility to quickly, easily and confidently treat any tumor, even those that move, using the approach and fractionation schedule that best addresses the individual clinical needs of patients.

NATURAL PATIENT BEHAVIOR

Greater Patient Comfort

Improving the Patient Experience



MINIMAL MARGINS

Potential for Better Clinical Outcomes with Fewer Side Effects

Freedom to Hypofractionate Treatment Delivery

EFFICIENT CONTINUOUS DELIVERY

More Efficient Treatments to More Patients at a Lower Cost

Potential for Increased Profitability

For more information, contact your Accuray Sales Representative

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Important Safety Information

Most side effects of radiotherapy, including radiotherapy delivered with Accuray systems, are mild and temporary, often involving fatigue, nausea, and skin irritation. Side effects can be severe, however, leading to pain, alterations in normal body functions (for example, urinary or salivary function), deterioration of quality of life, permanent injury, and even death. Side effects can occur during or shortly after radiation treatment or in the months and years following radiation. The nature and severity of side effects depend on many factors, including the size and location of the treated tumor, the treatment technique (for example, the radiation dose), and the patient's general medical condition, to name a few. For more details about the side effects of your radiation therapy, and to see if treatment with an Accuray product is right for you, ask your doctor.

Radixact®