

**Table 1** Standard and Nonstandard IMRT Delivery Systems

System	Gantry	Beam Geometry	Collimated	Modulated	Imaging	Gating Potential
Conventional linac plus multileaf	C-arm	Cone-beam, noncoplanar	Jaws + conventional multileaf	Jaws + conventional multileaf	Portal image, fluoroscopy, kvCT, infrared reflectors	Breath-hold, beam trigger, multileaf tracking
Conventional linac minus multileaf	C-arm	Cone-beam, noncoplanar	Jaws ± tertiary attenuator	Jaws ± tertiary attenuator	Portal image, fluoroscopy, kvCT, infrared reflectors	Breath-hold, beam trigger, jaw tracking
Serial tomotherapy (MIMiC)	C-arm	Fanbeam, coplanar, sequential, indexed trajectory	Jaws + binary multileaf	Binary multileaf	Portal image, fluoroscopy, kvCT, infrared reflectors	Breath-hold during each slice
Helical tomotherapy (Hi-Art)	Ring	Fanbeam, coplanar, helical trajectory	Jaws + binary multileaf	Binary multileaf	MVCT, infrared reflectors	Delivery synchronized with breathing cycle
Robotic linac (CyberKnife)	Robotic arm	Pencil-beam, noncoplanar	Circular collimator	Superposition of pencil-beams by robotic arm	Biplanar radiography, infrared reflectors	Beam trigger, robotic tracking

**Problems with IMRT:**

- (1) Difficult to interpret plans and isodose distributions
- (2) Time-consuming for both planning and execution
- (3) Higher integral dose, due to increased number of beams

**Treatment times: (2Gy)**

Fixed field IMRT with MLCs=20 minutes

Tomotherapy= 5 minutes

**Tomotherapy:**

Both axial and helical forms of tomotherapy deliver radiation using a rotating intensity-modulated fan beam, the modulation varying with gantry angle. But while axial tomotherapy dose distributions are delivered slice by slice, with patients being sequentially and discretely translated through the linac gantry rotational plane between slices, helical distributions are delivered without interruptions; patients are translated smoothly through the bore of the machine as its gantry continuously and synchronously rotates, the therapy equivalent of spiral computed tomography.

**Advantages of tomotherapy:**

- (1) Reduced dose to critical structures
- (2) Improved dose homogeneity in target volume

**Disadvantages of tomotherapy:**

- (1) Can only deliver coplanar beams
- (2) Only 6MV photon beams are available with current systems.

## **IMAT:**

Intensity-modulated arc therapy (IMAT) is a rotational delivery approach developed for conventional linac-plus-multileaf systems. Modulation is achieved by delivering successive arcs, for each of which the multileaf-defined beam aperture changes with gantry angle in a different way. For example, an IMAT delivery might begin with a conformal arc, the multileaf tracking the silhouette of the PTV, continue with a succession of arcs in which particular critical structures are blocked, and finish off with arcs specifically designed to make the PTV dose distribution as uniform as possible.

## **Cyberknife:**

The CyberKnife is a modern radiotherapy system developed primarily for radiosurgery applications, comprising a light compact 6-MV linac carried on a highly precise computer-driven robotic arm. The position and orientation of the final segment of the arm is determined by 6 different mechanical subsystems. The linac is located on this final arm segment and can be moved and angled with much greater generality than can a conventional C-arm gantry-mounted accelerator.

Patients are treated lying still on a couch while the robot maneuvers the linac around them. Setup is monitored throughout treatment, analysing repeat images acquired by 2 radiograph cameras on-the-fly to check the positional invariance either of the skull or of implanted radiopaque fiducials.

Adjustments to the robot trajectory can be made to account for any patient movement. The overall spatial accuracy of the robotic delivery and movement correction process has been assessed and found to be appropriate for frameless radiosurgery of targets in the head and body.

The CyberKnife radiation beam is shaped by 1 of 12 fixed cylindrical collimators. Viewed narrowly, the CyberKnife is not an IMRT delivery system, because its radiation beam photon fluence is collimated but not modulated. However it can generate dose distributions similar to IMRT by delivering many unmodulated circular fields from a range of source positions and angles, with robotic arm trajectories and beam weighting optimized iteratively by dedicated software.

## **Jaw-Modulated Linear Accelerators:**

The modulated fields could be made up entirely from rectangular segments shaped by the jaws alone. The chief advantage of this approach is that it circumvents the need for a multileaf, reducing equipment costs; the main disadvantage is that more segments are used and so fields take longer to deliver. Jaw-based IMRT can produce similar dose-distribution to MLC-based IMRT but the process is more time-consuming.