Stereotactic radiosurgery (SRS)

Definition

By definition, the term “radiosurgery” refers to the delivery of a therapeutic radiation dose in a single fraction, not simply the use of stereotaxy. Multiple-fraction delivery is better termed “stereotactic radiotherapy.”

Is a form of radiation therapy that focuses high-power energy on a small area of the body. Despite its name, radiosurgery is a treatment, not a surgical procedure.

The irradiation of tumors in the brain is challenging due to the proximity of radiation-sensitive critical structures and the tumors to be treated. In addition, irradiation above a certain level can cause irreversible damage to nerve tissue. The irradiation of benign and malignant brain tumors requires precise techniques to preserve critical structures while simultaneously administering a high radiation dose for maximum effectiveness. Therefore, stereotaxy, as a subspecialty of neurosurgery, has developed various irradiation techniques, e.g., intracerebral application of interstitial brachytherapy (SBT; stereotactic brachytherapy) and stereotactic radiosurgery (SRS). Due to the development of computer-controlled radiation techniques (e. g., Cyberknife) over the last 20 years, SRS has gained increasing importance [1)].

Radiological Parameters

With the currently available imaging modalities, scanning has become quick and robust providing a high degree of spatial resolution resulting in optimal contrast between normal and abnormal tissues. Magnetic resonance imaging (MRI) forms the backbone of Leksell radiosurgery. It produces images with excellent soft tissue details highlighting the target and surrounding “at-risk” structures conspicuously. However, one must be aware of the MRI distortions that may arise during treatment. Computed tomography (CT) has quick acquisition times giving excellent bony information but inferior soft tissue details. To avail benefits of both these modalities and overcome their individual fallacies and shortcomings, they are often co-registered/fused for stereotactic guidance. Vascular lesions like an arteriovenous malformation (AVM) are best planned with cerebral digital subtraction angiography (DSA) in conjunction with MRI. In specific cases, specialized imaging methods like magnetic resonance (MR) spectroscopy, positron emission tomography (PET), magneto-encephalography (MEG), etc., may be added to the treatment planning for stereotactic radiosurgery (SRS) [2)].

Modalities

Single-session stereotactic radiosurgery.

Four available stereotactic radiosurgery (SRS) modalities:

Leksell Gamma Knife Perfexion.

Novalis-Tx Dynamic-Conformal-Arc (DCA). Micro-multileaf collimator system of the Novalis linear accelerator (LINAC) (MML).

Dynamic-Multileaf-Collimation-Intensity-Modulated-radiotherapy (DMLC-IMRT)

Cyberknife.

see Gamma Knife stereotactic radiosurgery.

Stereotactic radiosurgery with an adapted linear accelerator (linac-SRS).

Gamma-Knife-Perfexion will comply with all SRS constraints (high conformity while minimizing low-dose spread). Multiple focal entries (Gamma-Knife-Perfexion and Cyberknife) will achieve better conformity than High-Definition-MLC of Novalis-Tx at the cost of treatment time. Non-isocentric beams (Cyberknife) or IMRT-beams (Novalis-Tx-DMLC-IMRT) will spread more low-dose than multiple isocenters (Gamma-Knife-Perfexion) or dynamic arcs (Novalis-Tx-DCA). Inverse planning and modulated fluences (Novalis-Tx-DMLC-IMRT and CyberKnife) will deliver the most homogeneous treatment. Furthermore, Linac-based systems (Novalis and Cyberknife) can perform image verification at the time of treatment delivery [3)]

The multiple focal entry systems (Gamma Knife and Cyberknife) achieve higher conformity than the Novalis system. The Gamma Knife delivers the steepest dose gradient of all examined systems. However, the Gamma Knife is known to require long beam-on times, and despite worse dose gradients, LINAC-based systems (Novalis and Cyberknife) offer image verification at the time of treatment delivery [4)].

see Intracranial stereotactic radiosurgery.

Indications

Stereotactic radiosurgery indications.

Complications

Adverse radiation effect

1)
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