STEREOTACTIC RADIOSURGERY (SRS)

This Model Policy[1] addresses coverage for Stereotactic radiosurgery (SRS).

Description

Stereotactic radiosurgery (SRS) is a distinct discipline that utilizes externally generated ionizing radiation to inactivate or eradicate definite target(s) in the head without the need to make an incision. To assure quality of patient care, the procedure involves a multidisciplinary team consisting of a neurosurgeon, radiation oncologist and medical physicist. (For a subset of tumors involving the skull base, the multidisciplinary team may include a head and neck surgeon with training in SRS).

For the purpose of this document, SRS is strictly defined as radiation therapy delivered in one to five fractions via stereotactic guidance, with approximately 1 mm targeting accuracy to intracranial targets and selected tumors around the base of the skull. For coverage guidance regarding extracranial target treatments delivered with stereotactic guidance in or near the spine or elsewhere, refer to ASTRO's Stereotactic Body Radiation Therapy (SBRT) Model Policy[11].

SRS couples anatomic accuracy and reproducibility with very high doses of highly precise, externally generated, ionizing radiation, thereby maximizing the ablative effect on the target(s) while minimizing collateral damage to adjacent tissues. The adjective "stereotactic" describes a procedure during which a target lesion is localized relative to a known three-dimensional reference system that allows for a high degree of anatomic accuracy. Examples of devices used in SRS for stereotactic guidance may include a rigid head frame affixed to a patient, fixed bony landmarks, a system of implanted fiducial markers or other similar systems.

Treatment

All SRS procedures include the following components:

1. Position stabilization (attachment of a frame or frameless).
2. Imaging for localization (CT, MRI, angiography, PET, etc.).
3. Computer-assisted tumor localization (i.e., "image guidance").
4. Treatment planning – number of isocenters; number, placement and length of arcs or angles; number of beams, beam size and weight, etc.
5. Isodose distributions, dosage prescription and calculation.
6. Setup and accuracy verification testing.
7. Simulation of prescribed arcs or fixed portals.
8. Radiation treatment delivery.

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[1] ASTRO model policies were developed as a means to efficiently communicate what ASTRO believes to be correct coverage policies for radiation oncology services. The ASTRO model policies do not serve as clinical guidelines and they are subject to periodic review and revision without notice. The ASTRO Model Policies may be reproduced and distributed, without modification, for noncommercial purposes.

SRS Treatment Planning

SRS plans are highly customized to the target volume(s) and may be geometrically more accurate than conventionally fractionated external beam treatment plans.

a. Immobilization

The patient is immobilized via a frame affixed to the skull or a stereotactic mask fixation system ("frameless").

b. Imaging

Three-dimensional image acquisition of the target region by simulation is an essential prerequisite to SRS treatment planning. In general, a CT or MR scan of the target region is performed and serves as the baseline image set used for dose calculations and, in selected cases in which a CT was performed, for co-registration of MR image sets in order to better define the target and surrounding anatomy.

c. Contouring

Defining the target and avoidance structures is in itself a multi-step process:

i. The radiation oncologist reviews the three-dimensional images and outlines the treatment target on each slice of the image set. A neurosurgeon may be involved in the contouring process. The summation of these contours defines the Gross Tumor Volume (GTV). Some patients may not have GTVs if they have had previous treatment with surgery, in which case treatment planning will be based on CTVs as described below.

ii. The radiation oncologist may draw a margin around the GTV or surgical bed to generate a Clinical Target Volume (CTV), which encompasses the areas at risk for microscopic disease (i.e., not visible on imaging studies).

iii. To account for potential uncertainty in patient immobilization and/or imaging, a final margin is then added to create a Planning Target Volume (PTV).

iv. Nearby normal structures that could potentially be harmed by radiation (i.e., "organs at risk" or OARs) are also contoured.

d. Radiation dose prescribing

The radiation oncologist assigns specific dose requirements for the PTV, which typically include a prescribed dose that must be given to at least 90 to 95 percent of the PTV. This is often accompanied by a minimum acceptable point dose within the PTV and a constraint describing an acceptable range of dose homogeneity. Additionally, PTV dose requirements routinely include dose constraints for the OARs (e.g., upper limit of mean dose, maximum allowable point dose and/or a critical volume of the OAR that must not receive a dose above a specified limit). A treatment plan that satisfies these requirements and constraints should maximize the potential for disease control and minimize the risk of radiation injury to normal tissue.

e. Dosimetric planning, calculations and dose verification

The medical physicist or a supervised dosimetrist calculates a multiple static beam and/or modulated arc treatment plan to deliver the prescribed radiation dose to the PTV and simultaneously satisfy the normal tissue dose constraints by delivering significantly lower doses to nearby organs. Dose-volume histograms are prepared for the PTV and OARs. Here, an arc is defined as a discrete complete or partial rotation of the linear accelerator gantry during which there is continuous motion of the multileaf collimator (MLC) to deliver an optimized radiation dose distribution within the patient. The calculated beams or arcs are then delivered either to a phantom or a dosimetry measuring device to confirm that the intended dose distribution for the patient is physically verifiable and that the beams or arcs are technically feasible.

Documentation of all aspects of the treatment planning process is essential.

SRS Treatment Delivery

SRS can be delivered using a variety of stereotactic and convergent-beam technologies including, but not limited to: multiple convergent cobalt sources; protons; multiple, coplanar or non-coplanar photon arcs or angles; fixed photon arcs; or image-directed robotic devices that meet the criteria. Despite the variety of stereotactic radiosurgical techniques, many commonalities exist. The shape of the beam aperture used with linear accelerator-based systems is usually defined by secondary collimation positioned near the patient to reduce the beam penumbra. A large number of such beams sequentially irradiate the target, typically using a dynamic delivery. Gamma ray treatment devices also position the collimation near the patient's skin surface to control the penumbra. In this case, numerous gamma ray beams, depending on the model, simultaneously irradiate a single point (called the isocenter) within the patient. Robotic, non-isocentric, frameless SRS is a type of SRS treatment consisting of dozens of non-isocentric beams with distinctive quality assurance procedures and continuous target tracking that result in comparable dose conformality and reduction in intrafraction systematic error. Intensity modulated radiation therapy (IMRT) is also used for SRS. In this case, a single isocenter can be used with off-axis beams created by an MLC so that the equivalent effect obtained with multiple isocenters is achieved. The MLC is often placed as a tertiary device nearer the patient and with narrow leaves to improve penumbra.

While being irradiated, the patient may be immobilized when appropriate, and patient and target positioning are verified to ensure accurate treatment delivery. The target is defined by high-resolution stereotactic imaging. Stereotactic localization of the lesion uses an appropriate imaging modality to identify a reference point for positioning the individual treatment beams. This type of localization procedure allows physicians to perform image-guided procedures with a high degree of anatomic accuracy and precision. Traditionally, a rigid frame that included a fiducial system for precisely locating coordinate positions within the frame was attached to the patient's head. Alternatively, "frameless" approaches can be used. SRS typically is performed in a single session; however, it can be performed in a limited number of sessions, up to a maximum of five.

Imaging, planning and treatment typically are performed in close temporal proximity. The delivery of a high dose of ionizing radiation that conforms to the shape of the lesion mandates an overall accuracy of approximately 1 mm. This leaves little room for error in the overall process. Strict protocols for quality assurance (QA) must be followed and multiple checking, preferably repeated by different individuals, is required at critical junctures. Additional information can be found in the ASTRO QA White Paper, which critically evaluates guidance and literature on the safe delivery of stereotactic radiotherapy and provides recommendations on how to reduce or eliminate errors[10].

Documentation Requirements

The patient's record must support the necessity and frequency of treatment. Medical records should include not only the standard history and physical but also the patient's functional status and a description of current performance status. See Karnofsky Performance Status and Eastern Cooperative Oncology Group (ECOG) Performance Status listed under "Indications and Limitation of Coverage."

Documentation should include the date and the current treatment dose. A radiation oncologist and a neurosurgeon must evaluate the clinical aspects of the treatment, and document and sign this evaluation as well as the resulting management decisions. A radiation oncologist and medical physicist must evaluate the technical aspects of the treatment and document and sign this evaluation as well as the resulting treatment management decisions.

Indications and Limitations of Coverage and/or Medical Necessity

Indications for Coverage:

1. Primary central nervous system malignancies, generally used as a boost or salvage therapy for lesions <5 cm.
2. Primary and secondary tumors involving the brain parenchyma, meninges/dura or immediately adjacent bony structures.
3. Benign brain tumors such as meningiomas, acoustic neuromas, other schwannomas, pituitary adenomas, pineocytomas, craniopharyngiomas, glomus tumors orhemangioblastomas.
4. Arteriovenous malformations and cavernous malformations.
5. Other cranial non-neoplastic conditions such as trigeminal neuralgia and select cases of medically refractory epilepsy, movement disorders such as Parkinson’s disease and essential tremor, and hypothalamic hamartomas.
6. As a boost treatment for larger cranial or spinal lesions that have been treated initially with external beam radiation therapy or surgery (e.g., sarcomas, chondrosarcomas, chordomas, and nasopharyngeal or paranasal sinus malignancies).
7. Metastatic brain, independent of the number of lesions if other positive clinical indications exist, with stable systemic disease, Karnofsky Performance Status 40 or greater (and expected to return to 70 or greater with treatment), and otherwise reasonable survival expectations, OR ECOG Performance Status of 3 or less (or expected to return to 2 or less with treatment).
8. Relapse in a previously irradiated cranial where the additional stereotactic precision is required to avoid unacceptable vital tissue radiation.
9. Patients treated under the paradigm of Coverage with Evidence Development (CED) provided the patient is enrolled in either an IRB-approved clinical trial or in a multi-institutional patient registry adhering to Medicare requirements for CED.

ICD-9-CM and ICD-10-CM Codes That May Be Associated with Medical Necessity

Note: Diagnosis codes are based on the current ICD-9-CM and ICD-10-CM codes that are effective at the time of Model Policy publication. Any updates to ICD-9-CM or ICD-10-CM codes will be reviewed by ASTRO, and coverage should not be presumed until the results of such review have been published/posted.

These ICD diagnosis codes support medical necessity under this Model Policy:

SYSTEM	SITE	ICD-9 CODES	ICD-10 CODES
Neoplasm of the Head and Neck	Nasopharynx; Malignant	147.0 – 147.9	C11.0 – C11.9
	Nasal cavities, middle ear, and accessory sinuses; Malignant	160.0 – 160.9	C30.0 – C31.9
Neoplasms of the Central Nervous System	Brain/Spinal Cord −Malignant −Secondary −Benign −Uncertain Behavior −Unspecified Nature	191.0 – 191.9 198.3 225.0 237.5* 237.9* 239.6*	C71.0 – C71.9 C79.31 D33.0 – D33.2 D43.0 –43.4* D43.8-43.9* D43.4* D49.6*
	Other nervous system; Secondary	198.4* 198.89*	C79.40 – C79.49* C79.89 – C79.9*
	Spine	198.5*	C79.51 – C79.52*
	Cerebral Meninges: −Malignant −Secondary −Benign −Uncertain Behavior	192.1 198.4 225.2 237.6	C70.0 – C70.9 C79.32 D32.0 – D32.9 D42.0 - D 42.9
	Cranial Nerves: −Malignant −Benign	192.0 225.1	C72.20 – C72.59 D33.3
Neoplasms of the Endocrine Gland	Pituitary, Pineal, Aortic Body and other Paraganglia: −Malignant −Benign −Uncertain Behavior −Unspecified Nature	194.3 – 194.6 227.3-227.5 227.6*; 237.0-237.1 237.3* 239.7*	C75.1 – C75.5 D35.2 – D35.5 D35.6*; D44.3 – D44.5 D44.6 – D44.7* D49.7*
Diseases of the Nervous System	Parkinson's Disease Tremor	332.0** 333.1**	G20; G21.4** G25.0 – G25.2**
	Epilepsy	345.11 345.3 345.91	G40.411 – G40.419 G40.301– G40.319 G40.911 – G40.919
	Trigeminal Nerve Disorders	350.1 350.8 350.9##	G50.0 G50.8 G50.9##
	Facial Nerve Disorders	351.0 – 351.9	G51.0 – G51.9
	Disorders of Other Cranial Nerves	352.0 – 352.9*	G52.0 – G53*
Other	Congenital abnormalities of cerebrovascular system	747.81*	Q28.2 – Q28.3*
Reirradiation	Various regions	990#	T66.XXXA#

* ICD-9-CM and ICD-10-CM codes are all limited to use for lesions occurring either above the neck or in the spine.
** ICD-9-CM 332.0 and 333.1 codes (ICD-10-CM codes G20, G21.4, G25.0 – G25.2) are limited to the patient who cannot be controlled with medication, has major systemic disease or coagulopathy, and who is unwilling or unsuited for open surgery.
# ICD-9-CM 990 or ICD-10-CM T66.XXXA (Effects of Radiation, Unspecified) may only be used where prior radiation therapy to the site is the governing factor necessitating SRS in lieu of other radiation therapy. An ICD diagnosis code for the anatomic diagnosis must also be used.
ICD-9-CM codes 350.1, 350.8 and 350.9 (ICD-10-CM codes G50.0, G50.8 and G50.9) are limited to the patient who cannot be controlled with medication.

Limitations of Coverage

SRS is not considered medically necessary under the following circumstances:

1. Treatment unlikely to result in functional improvement or clinically meaningful disease stabilization, not otherwise achievable.
2. Patients with wide-spread cerebral or extra-cranial metastases with limited life expectancy unlikely to gain clinical benefit within their remaining life.
3. Patients with poor performance status (Karnofsky Performance Status less than 40 or ECOG Performance greater than 3); see below for further scoring information regarding Karnofsky and ECOG Performance Status scales.
4. For ICD-9-CM code 333.1 (ICD-10-CM code G25.0-G25.2), essential tremor, coverage should be limited to the patient who cannot be controlled with medication, has major systemic disease or coagulopathy, and who is unwilling or unsuited for invasive surgical procedure. Coverage should further be limited to unilateral thalamotomy.

Karnofsky Performance Status Scale[6]

100 Normal; no complaints, no evidence of disease.
90 Able to carry on normal activity; minor signs or symptoms of disease.
80 Normal activity with effort; some signs or symptoms of disease.
70 Cares for self; unable to carry on normal activity or to do active work.
60 Requires occasional assistance but is able to care for most needs.
50 Requires considerable assistance and frequent medical care.
40 Disabled; requires special care and assistance.
30 Severely disabled; hospitalization is indicated although death not imminent.
20 Very sick; hospitalization necessary; active supportive treatment is necessary.
10 Moribund, fatal processes progressing rapidly.
0 Dead.

ECOG Performance Status Scale

Grade 0: Fully active, able to carry on all pre-disease performance without restriction.
Grade 1: Restricted in physically strenuous activity, but ambulatory and able to carry out work of a light or sedentary nature, e.g. light house work, office work.
Grade 2: Ambulatory and capable of all self-care but unable to carry out and work activities. Up and about more than 50 percent of waking hours.
Grade 3: Capable of only limited self-care, confined to bed or chair more than 50 percent of waking hours.
Grade 4: Completely disabled. Cannot carry on any self-care. Totally confined to bed or chair.
Grade 5: Dead.

Eastern Cooperative Oncology Group, Robert Comis MD, Group Chair.

Physicians' Current Procedural Terminology (CPT®)/HCPCS Section

Note: CPT is a trademark of the American Medical Association (AMA)

SRS Treatment Planning

There are no specific codes for clinical treatment planning and simulation for SRS. However, because of the complexity of SRS and the need for three-dimensional conformal or IMRT dosimetric treatment planning, the following codes are usually appropriate for SRS cases. Use of IMRT planning is based on the delivery system and medical necessity. Whether a physician treats one or more lesions, treatment planning CPT code 77295 or CPT code 77301 should only be used once for the entire episode.

CPT® CODE	DESCRIPTION	SRS-SPECIFIC GUIDELINES
77263	Therapeutic radiology treatment planning; complex	Given the complexity of SRS, a complex treatment planning code is justified.
77295 OR 77301	3-dimensional radiotherapy plan, including dose-volume histogram Intensity modulated radiotherapy plan, including dose-volume histograms for target and critical structure partial tolerance specifications (Dose plan is optimized using inverse planning technique for modulated beam delivery [eg, binary, dynamic MLC] to create highly conformal dose distribution. Computer plan distribution must be verified for positional accuracy based on dosimetric verification of the intensity map with verification of treatment set-up and interpretation of verification methodology)	At a minimum, three-dimensional simulation is essential to provide accurate stereotactic treatment delivery. Report once per course of therapy.

Medical Radiation Physics, Dosimetry and Treatment Devices

There are no SRS specific codes for medical radiation physics, dosimetry, treatment devices and special services. However, the following codes can be used as described below.

CPT® CODE	DESCRIPTION	SRS-SPECIFIC GUIDELINES
77300	Basic radiation dosimetry calculation, central axis depth dose calculation, TDF, NSD, gap calculation, off axis factor, tissue inhomogeneity factors, calculation of non-ionizing radiation surface and depth dose, as required during course of treatment, only when prescribed by the treating physician	One unit for each arc in linear accelerator system. One unit for each shot in Cobalt-60. Maximum limit of 10 units.
77370	Special medical radiation physics consultation	May be reasonable and necessary if ordered by the radiation oncologist.
77334	Treatment devices, design and construction; complex (irregular blocks, special shields, compensators, wedges, molds or casts)	One unit for each unique combination of beam angle and collimator pattern or each unique arc; certain carrier limitations may apply. One unit for each helmet in Cobalt-60.
77338	Multi-leaf collimator (MLC) device(s) for intensity modulated radiation therapy (IMRT), design and construction, per IMRT plan	If IMRT planning code 77301 is used for coding treatment planning then typically one CPT 77338 would be used to code for the MLC devices.

Treatment devices are billed separately from the planning and delivery codes if appropriate.

SRS Treatment Delivery

It is not appropriate to bill more than one treatment delivery code on the same day of service, even though some types of delivery may have elements of several modalities (e.g., a stereotactic approach with IMRT). Only one delivery code is to be billed.

CPT® CODE	DESCRIPTION	SRS-SPECIFIC GUIDELINES
77371	Radiation treatment delivery, stereotactic radiosurgery (SRS), complete course of treatment of cranial lesion(s) consisting of 1 session; multi-source Cobalt-60 based. (For radiation treatment management, use 77432)	Technical charge for single fraction treatment delivery using cobalt-60.
77372	Radiation treatment delivery, stereotactic radiosurgery (SRS), complete course of treatment of cranial lesion(s) consisting of 1 session; linear accelerator based. (For radiation treatment management, use 77432)	Technical charge for single fraction treatment delivery using a Linac (linear accelerator).
77373	Stereotactic body radiation therapy, or stereotactic cranial radiosurgery 2-5 fractions-treatment delivery, per fraction to 1 or more lesions, including image guidance, entire course not to exceed 5 fractions (Do not report 77373 in conjunction with 77385, 77386, 77401, 77402, 77407, 77412) (For single fraction cranial lesion[s], see 77371, 77372)	Technical charge for multi fraction (2-5) treatment delivery for cranial lesions

Radiation Treatment Management

There is one radiation treatment management code specific to SRS, CPT® code 77432, and this code can only be used for single fraction cranial SRS. If cranial SRS is delivered in two to five fractions, use the SBRT management CPT code 77435 for the entire course of treatment. One can no longer bill CPT 77432 for the first fraction and CPT code 77427 (Radiation treatment management, 5 treatments) or 77431 (Radiation therapy management with complete course therapy consisting of 1 or 2 fractions only) for the remaining fractions, for the same treatment volume. For all spinal radiosurgery (one to five fractions) use the SBRT management CPT code 77435 once for the entire course of treatment. CPT code 77432 and CPT code 77435 cannot be billed for the same patient for the same episode of care, and Medicare does not reimburse CPT code 77432 and CPT code 77470 (Special treatment procedure) on the same day of service. A prolonged (four- to six-week) course of cranial radiation therapy should be billed using appropriate codes for conventionally fractionated radiation therapy. Fractionated stereotactic cranial and body radiation therapy codes apply only to hypofractionated (one to five fractions) radiosurgery using large doses per fraction. SRS treatments are to be performed under the direct supervision of a qualified medical physicist and a radiation oncologist.

CPT® CODE	DESCRIPTION	SRS-SPECIFIC GUIDELINES
77432	Stereotactic radiation treatment management of cranial lesion(s) (complete course of treatment consisting of 1 session) (The same physician should not report both stereotactic radiosurgery services [61796-61800] and radiation treatment management [77432 or 77435] for cranial lesions). (For stereotactic body radiation therapy treatment, use 77435)	For use of single fraction, complete course of therapy.
77435	Stereotactic body radiation therapy, treatment management, per treatment course, to one or more lesions, including image guidance, entire course not to exceed 5 fractions (Do not report 77435 in conjunction with other treatment management codes 77427- 77432) (The same physician should not report both stereotactic radiosurgery services [32701, 63620, 63621] and radiation treatment management [77435])	Professional charge for treatment management performed by the radiation oncologist. It includes the work of image guidance during treatment. This code can be reported only once for the entire course of treatment and not per fraction. This will apply to all SBRT up to a maximum of 5 fractions and all fractionated cranial SRS up to a maximum of 5 fractions. It will apply to all lesions treated during that entire course of treatment.

The physician work for 77435 can be summarized as follows: The radiation oncologist evaluates the patient prior to the procedure. Under the direct supervision of the radiation oncologist, the patient is set up on the treatment table and all the treatment parameters are verified. Image guidance, and respiratory correlation, if required, may be achieved through a variety of methods, all of which are supervised, corrected and approved in real-time by the physician. The physician assesses and approves all of the ongoing images used for localization, tumor tracking and any gating application, as well as any complementary single (beam's eye) view localization images for any of the fields or arcs that are arranged to deliver a dose. The radiation oncologist remains available throughout SRS treatment to manage the execution of the treatment and make real-time adjustments in response to patient motion, target movement or equipment issues to ensure accuracy and safety. The physician also evaluates the patient post-procedure. All other work generally associated with CPT code 77427 (Radiation treatment management, five treatments) is included and should not be separately coded.

Much of the radiation oncologist's work in establishing the above treatment parameters is performed in conjunction with the qualified medical physicist, who should be present and participate in delivering SRS treatment.

Other Specialist Coding

Usually a radiation oncologist will work with a neurosurgeon to perform SRS. Radiation oncologists and neurosurgeons have separate CPT® billing codes for SRS. CPT codes 61781–61783 or 61796–61800 are reported for the work attributed to the neurosurgeon. These codes are mutually exclusive with the radiation oncology CPT codes 77432 and 77435; therefore, the same physician should not bill for both of these codes.

No one physician may bill both the neurosurgical codes 61781–83 or 61796–61800 and the radiation oncology 77XXX codes. If either the radiation oncologist or the neurosurgeon does not fully participate in the patient's care, that physician must take care to indicate this change by use of the appropriate -54 modifier (followed by any appropriate -55 modifier) on the global procedure(s) submitted. As the services are collegial in nature with different specialties providing individual components of the treatment, surgical assistants will not be reimbursed.

The following codes may be used by the neurosurgeon to code for involvement in the procedure.

CPT® CODE	DESCRIPTION
61796	Stereotactic radiosurgery (particle beam, gamma ray, or linear accelerator); 1 simple cranial lesion
+61797	Each additional cranial lesion, simple (List separately in addition to code for primary procedure)
61798	1 complex cranial lesion
+61799	Additional cranial lesion, complex (List separately in addition to code for primary procedure)
61800	Application of stereotactic headframe for stereotactic radiosurgery (List separately in addition to code for primary procedure)

Additional Information

Coding Guidelines

For Medicare claims, the HCPCS/CPT® code(s) may be subject to Correct Coding Initiative (CCI) edits. This policy does not take precedence over CCI edits. Please refer to the CCI for correct coding guidelines and specific applicable code combinations prior to billing Medicare.

REFERENCES

General

1. ACR-ASTRO Practice Guideline for the performance of Stereotactic Radiosurgery. http://www.acr.org/~/media/ACR/Documents/PGTS/guidelines/Stereo_body_radiation.pdf Revised 2009. Accessed May 2014.
2. Adler JR Jr, Gibbs IC, Puataweepong P, Chang SD. Visual field preservation after multisession cyberknife radiosurgery for perioptic lesions. *Neurosurgery.* 2006; 59(2): 244-254.
3. American Society for Therapeutic Radiation and Oncology (ASTRO). The ASTRO/ACR Guide to Radiation Oncology Coding 2010. Fairfax, VA: ASTRO; 2010.
4. Barnett GH, Linskey ME, Adler JR, et al. American Association of Neurological Surgeons; Congress of Neurolofical Surgeons Washington Committee Stereotactic Radiosurgery Task Force. Stereotactic radiosurgery--an organized neurosurgery-sanctioned definition. *J Neurosurg.* 2007; 106(1):1-5.
5. Coverage with Evidence Development Requirements Position Statement. American Society for Radiation Oncology Web site. https://www.astro.org/Practice-Management/Reimbursement/Coverage-Position-Statement.aspx Published November 15, 2013. Accessed August 15, 2014.
6. Karnofsky DA, Burchenal JH. (1949). "The Clinical Evaluation of Chemotherapeutic Agents in Cancer." In: MacLeod CM (Ed), Evaluation of Chemotherapeutic Agents. *Columbia Univ Press*. Page 196.
7. National Comprehensive Cancer Network (NCCN).Web site. Clinical Practice Guidelines in Oncology. Central Nervous System Cancers V.1.2014. http://www.nccn.org/professionals/physician_gls/pdf/cns.pdf Accessed May 2014.
8. Oken MM, Creech RH, Tormey DC, et al. Toxicity And Response Criteria of The Eastern Cooperative Oncology Group. *Am J Clin Oncol.* 1982; 5(6):649-655.
9. Seung SK, Mehta MP, Larson DA, Galvin JM, et al. American College of Radiology (ACR) and American Society for Radiation Oncology (ASTRO) Practice Guideline for the Performance of Stereotactic Radiosurgery (SRS). *Am J Clin Oncol.* 2013 Jun;36(3):310-5
10. Solberg TD, Balter JM, Benedict SH, et al. Quality and safety considerations in stereotactic radiosurgery and stereotactic body radiation therapy: Executive summary. *Pract Radiat Oncol.* 2012; 2(1): 2-9.
11. Stereotactic Body Radiation Therapy (SBRT) Model Policy. American Society for Radiation Oncology Web site. https://www.astro.org/uploadedFiles/Main_Site/Practice_Management/Reimbursement/2013HPcoding%20guidelines_SBRT_Final.pdf Published March 30, 2015.

Brain Metastases

12. American College of Radiology ACR Appropriateness Criteria Brain Metastasis. http://www.acr.org/Quality-Safety/Appropriateness-Criteria/Oncology/Brain-Metastases Updated 2011-2012. Accessed May 2014.
13. Andrews DW, Scott CB, Sperduto PW, et al. Whole brain radiation therapy with or without stereotactic radiosurgery boost for patients with one to three brain metastases: phase III results of the RTOG 9508 randomised trial. *Lancet.* 2004; 363(9422): 1665-1672.
14. Aoyama H, Shirato H, Tago M, et al. Stereotactic radiosurgery plus whole-brain radiation therapy vs stereotactic radiosurgery alone for treatment of brain metastases: a randomized controlled trial. *JAMA.* 2006; 295(21): 2483-2491.
15. Bhatnagar AK, Flickinger JC, Kondziolka D, et al. Stereotactic radiosurgery for four or more intracranial metastases. *Int J Radiat Oncol Biol Phys*. 2006; 64(3): 898-903.
16. Davey P, Schwartz ML, Scora D, et al. Fractionated (split dose) radiosurgery in patients with recurrent brain metastases: implications for survival. *Br J Neurosurg.* 2007; 21: 491-495.
17. Flannery T, Kano H, Niranjan A, et al. Gamma knife radiosurgery as a therapeutic strategy for intracranial sarcomatous metastases. *Int J Radiat Oncol Biol Phys.* 2010; 76(2): 513-519.
18. Flannery TW, Suntharalingam M, Regine WF, et al. Long-term survival in patients with synchronous, solitary brain metastasis from non-small cell carcinoma of lung treated with radiosurgery. *Int J Radiat Oncol Biol Phys.* 2008; 72: 19-23.
19. Higuchi Y, Serizawa T, Nagano O, et al. Three-staged radiotherapy without whole brain irradiation for large metastatic brain tumors. *Int J Radiat Oncol Biol Phys.* 2009; 74: 1543-1548.
20. Hunter GK, Suh JH, Reuther AM, et al. Treatment of Five or More Brain Metastases with stereotactic radiosurgery. *Int J Radiat Oncol Biol Phys.* 2012; 83: 1394-1398.
21. Kim SH, Weil RJ, Chao ST, et al. Stereotactic radiosurgical treatment of brain metastases in older patients. *Cancer.* 2008; 113(4): 834-840.
22. Mehta MP, Tsao MN, Whelan TJ, et al. The American Society for Therapeutic Radiology and Oncology (ASTRO) evidence-based review of the role of radiosurgery for brain metastasis. *Int J Radiat Oncol Biol Phys.* 2005; 63: 37-46.
23. Muacevic A, Wowra B, Siefert A, et al. Microsurgery plus whole brain irradiation versus Gamma Knife surgery alone for treatment of single metastases to the brain: a randomized controlled multicentre phase III trial. *J Neurooncol.* 2008; 87(3): 299-307.

24. Nam TK, Lee JI, Jung YJ, et al. Gamma knife surgery for brain metastases in patients harboring four or more lesions: survival and prognostic factors. *J Neurosurg.* 2005; 102 Supppl: 147-150.
25. Nishizaki T, Saito K, Jimi Y, et al. The role of cyberknife radiosurgery/radiotherapy for brain metastases of multiple or large-size tumors. *Minim Invasive Neurosurg.* 2006; 49(4): 203-209.
26. Rades D, Bohlen G, Pluemer A, et al. Stereotactic radiosurgery alone versus resection plus whole-brain radiotherapy for 1 or 2 brain metastases in recursive partitioning analysis class 1 and 2 patients. *Cancer.* 2007; 109(12): 2515-2521.
27. Serizawa T, Hirai T, Nagano O, et al. Gamma knife surgery for 1-10 brain metastases without prophylactic whole-brain radiation therapy: analysis of cases meeting the Japanese prospective multi-institute study (JLGK0901) inclusion criteria. *J Neurooncol.* 2010; 98(2): 163-167.
28. Suh JH. Stereotactic Radiosurgery for the Management of Brain Metastases. *N Engl J Med.* 2010; 362(12): 1119-1127.

Primary Tumors

29. Chua DT, Sham JS, Hung KN, et al. Predictive factors of tumor control and survival after radiosurgery for local failures of nasopharyngeal carcinoma. *Int J Radiat Oncol Biol Phys.* 2006; 66(5): 1415-1421.
30. Dieckmann K, Georg D, Bogner J, et al. Optimizing LINAC based stereotactic radiotherapy of uveal melanomas: 7 years' clinical experience. *Int J Radiat Oncol Biol Phys.* 2006; 66(4 Suppl): S47-52.
31. Furdova A, Sramka M, Chorvath M, et al. Stereotactic radiosurgery in intraocular malignant melanoma – a retrospective study. *Neuro Endocrinol Lett.* 2014; 35(1):28-36.
32. Giller CA, Berger BD, Fink K, et al. A volumetric study of CyberKnife hypofractionated stereotactic radiotherapy as salvage for progressive malignant brain tumors: initial experience. *Neurol Res.* 2007; 29(6): 563-568.
33. Hara W, Loo BW Jr, Goffinet DR, et al. Excellent Local Control with Stereotactic Radiotherapy Boost After External Beam Radiotherapy in Patients with Nasopharyngeal Carcinoma. *Int J Radiat Oncol Biol Phys.* 2007; 71(2): 393-400.
34. Kano H, Kondziolka D, Lunsford LD, et al. Stereotactic radiosurgery for pilocytic astrocytomas part 1: outcomes in adult patients. *J Neurooncol.* 2009; 95: 211-218.
35. Lipani JD, Jackson PS, Soltys SG, et al. Survival Following CyberKnife Radiosurgery and Hypofractionated Radiotherapy for Newly Diagnosed Glioblastoma Multiforme. *Technol Cancer Res Treat.* 2008; 7(3): 249-256.
36. Romanelli P, Conti A, Pontoriero A, et al. Role of stereotactic radiosurgery and fractionated stereotactic radiotherapy for the treatment of recurrent glioblastoma multiforme. *Neurosurg Focus.* 2009; 27(6): E8.
37. Schwer AL, Damek DM, Kavanagh BD, et al. A phase I dose-escalation study of fractionated stereotactic radiosurgery in combination with gefitinib in patients with recurrent malignant gliomas. *Int J Radiat Oncol Biol Phys.* 2008; 70(4): 993-1001.
38. Simonova G, Novotny J, Liscak R. Low-grade glioma treated by fractionated gamma knife surgery. *J Neurosurg.* 2005; 102 Suppl: 19-24.
39. Souhami L, Seiferheld W, Brachman D, et al. Randomized comparison of stereotactic radiosurgery followed by conventional radiotherapy with carmustine to conventional radiotherapy with carmustine for patients with glioblastoma multiforme: report of Radiation Therapy Oncology Group 93-05 protocol. *Int J Radiat Oncol Biol Phys.* 2004; 60(3): 853-860.
40. Tsao MN, Mehta MP, Whelan TJ, et al. The American Society for Therapeutic Radiology and Oncology (ASTRO) evidence-based review of the role of radiosurgery for malignant glioma. *Int J Radiat Oncol Biol Phys.* 2005; 63: 47-55.
41. Wu SX, Chua DT, Deng ML, et al. Outcome of fractionated stereotactic radiotherapy for 90 patients with locally persistent and recurrent nasopharyngeal carcinoma. *Int J Radiat Oncol Biol Phys.* 2007; 69(3): 761-769.
42. Yoshikawa K, Saito K, Kajiwara K, Nomura S, Ishihara H, Suzuki M. CyberKnife stereotactic radiotherapy for patients with malignant glioma. *Minim Invasive Neurosurg.* 2006; 49(2): 110-115.

Benign Tumors

43. Barajas MA, Ramirez-Guzman MG, Rodriguez-Vazquez C, et al. G. Gamma Knife surgery for hypothalamic hamartomas accompanied by medically intractable epilepsy and precocious puberty: experience in Mexico. *J Neurosurg.* 2005; 102 Suppl: 53-55.
44. Chang SD, Gibbs IC, Sakamoto GT, et al. Staged stereotactic irradiation for acoustic neuroma. *Neurosurgery.* 2005; 56(6):1254-1261; discussion 1261-1263.
45. Chopra R, Kondziolka D, Niranjan A, et al. Long-term follow-up of acoustic schwannoma radiosurgery with marginal tumor dose of 12 to 13 Gy. *Int J Radiat Oncol Biol Phys.* 2007; 68:845-851.
46. Drees C, Chapman K, Prenger E, et al. Seizure outcome and complications following hypothalamic hamartoma treatment in adults: endoscopic, open, and Gamma Knife procedures. *J Neurosurg.* 2012; 117(2): 255-261.
47. Elia AE, Shih HA, Loeffler JS. Stereotactic radiation treatment for benign meningiomas. *Neurosurg Focus.* 2007; 23(4):E5.
48. Ferraro DJ, Funk RK, Blackett JW, et al. A retrospective analysis of survival and prognostic factors after stereotactic radiosurgery for aggressive meningiomas. *Radiat Oncol.* 2014; 9: 38.
49. Gande A, Kano H, Bowden G, et al. Gamma Knife radiosurgery of olfactory groove meningiomas provides a method to preserve subjective olfactory function. *J Neurooncol.* 2014; 116(3): 577-583.
50. Gopalan R, Dassoulas K, Rainey J, et al. Evaluation of the role of Gamma Knife surgery in the treatment of craniopharyngiomas. *Neurosurg Focus.* 2008; 24(5): E5.
51. Gottfried ON, Liu JK, Couldwell WT. Comparison of radiosurgery and conventional surgery for the treatment of glomus jugulare tumors. *Neurosurg Focus.* 2004; 17(2): E4.

52. Inoue HK. Low-dose radiosurgery for large vestibular schwannomas: long-term results of functional preservation. *J Neurosurg.* 2005; 102 Suppl: 111-113
53. International RadioSurgery Association. Radiosurgery practice guideline initiative: stereotactic radiosurgery for patients with vestibular schwannomas. http://www.irsa.org/AN%20Guideline.pdf Issued May 2006. Accessed April 2009.
54. Ishihara H, Saito K, Nishizaki T, et al. CyberKnife radiosurgery for vestibular schwannoma. *Minin Invasive Neurosurg.* 2004; 47(5): 290-293.
55. Kajiwara K, Saito K, Yoshikawa K, et al. Image-guided stereotactic radiosurgery with the CyberKnife for pituitary adenomas. *Minim Invasive Neurosurg.* 2005; 48(2): 91-96.
56. Kano H, Lunsford LD. Stereotactic radiosurgery of intracranial chordomas, chondrosarcomas, and glomus tumors. *Neurosurg Clin N Am.* 2013; 24(4): 553-560.
57. Kano H, Niranjan A, Lunsford LD, et al. Adjuvant Stereotactic Radiosurgery after resection of Intracranial Hemangiopericytomas. *Int J Radiat Oncol Biol Phys.* 2008; 72: 1333-1339
58. Kano H, Niranjan A, Mongia S, et al. The Role of Stereotactic Radiosurgery for Intracranial Hemangioblastomas. *Neurosurgery.* 2008; 63: 443-451.
59. Kaul D, Budach V, Wurm R, et al. Linac-based stereotactic radiotherapy and radiosurgery in patients with meningioma. *Radiat Oncol.* 2014;9(1):78. [Epub ahead of print]
60. Kondziolka D, Patel AD, Kano H, et al. Long-term Outcomes After Gamma Knife Radiosurgery for Meningiomas. *Am J Clin Oncol.* 2014 Apr 21. [Epub ahead of print]
61. Kong DS, Lee JI, Lim do H, et al. The efficacy of fractionated radiotherapy and stereotactic radiosurgery for pituitary adenomas: long-term results of 125 consecutive patients treated in a single institution. *Cancer.* 2007; 110(4): 854-860.
62. Lee M, Kalani MY, Cheshier S, et al. Radiation therapy and CyberKnife radiosurgery in the management of craniopharyngiomas. *Neurosurg Focus.* 2008; 24(5):E4.
63. Lee JY, Kondziolka D, Flickinger JC, et al. Radiosurgery for intracranial meningiomas. *Prog Neurol Surg.* 2007; 20: 142-149.
64. Lim M, Bower R, Nangiana JS, et al. Radiosurgery for glomus jugulare tumors. *Technol Cancer Res Treat.* 2007; 6(5): 419-423.
65. Linskey ME, Davis SA, Ratanatharathorn V. Relative roles of microsurgery and stereotactic radiosurgery for the treatment of patients with cranial meningiomas: a single-surgeon 4-year integrated experience with both modalities. *J Neurosurg.* 2005; 102 Suppl: 59-70.
66. Lunsford LD, Niranjan A, Flickinger JC,et al. Radiosurgery of vestibular schwannomas: summary of experience in 829 cases. *J Neurosurg.* 2005; 102 Suppl: 195-199.
67. Mathieu D, Kondziolka D, Niranjan A, et al. Gamma knife radiosurgery for refractory epilepsy caused by hypothalamic hamartomas. *Stereotact Funct Neurosurg.* 2006; 84(2-3): 82-87.
68. McClelland S 3rd, Gerbi BJ, Higgins PD, et al. Safety and efficacy of fractionated stereotactic radiotherapy for acoustic neuromas. *J Neurooncol.* 2008; 86(2): 191-194.
69. Myrseth E, MP, Pedersen PH, Vassbotn FS, et al. Vestibular schwannomas: clinical results and quality of life after microsurgery or Gamma Knife radiosurgery. *Neurosurgery.* 2005; 56(5): 927-935.
70. Park SH, Kano H, Niranjan A, et al. Stereotactic radiosurgery for cerebellopontine angle meningiomas. *J Neurosurg.* 2014; 120(3): 708-715.
71. Picozzi P, Losa M, Mortini P, et al. Radiosurgery and the prevention of regrowth of incompletely removed nonfunctioning pituitary adenomas. *J Neurosurg.* 2005; 102 Suppl: 71-74.
72. Pollock BE. Stereotactic radiosurgery in patients with glomus jugulare tumors. *Neurosurg Focus.* 2004; 17(2):E10.
73. Regis J, Scavarda D, Tamura M, et al. Epilepsy related to hypothalamic hamartomas: Surgical management with special reference to Gamma Knife surgery. *Childs Nerv Syst*. 2006; 22(8):881-895.
74. Selch MT, Gorgulho A, Mattozo C, et al. Linear accelerator stereotactic radiosurgery for the treatment of gelastic seizures due to hypothalamic hamartoma. *Minim Invasive Neurosurg.* 2005; 48(5): 310-314.
75. Wilson DA, Awad AW, Brachman D, et al. Long-term radiosurgical control of subtotally resected adult pineocytomas. *J Neurosurg.* 2012; 117(2): 212-217.
76. Wowra B, Muacevic A, Jess-Hempen A, et al. Outpatient Gammaknife surgery for vestibular schwannoma: definition of the therapeutic profile based on a 10-year experience. *J Neurosurg.* 2005; 102 Suppl: 114-118.
77. Yianni J, Rowe J, Khandanpour N, et al. Stereotactic radiosurgery for pineal tumours. *Br J Neurosurg.* 2012; 26(3): 361-366.

Functional Disorders

78. Barbaro NM, Quigg M, Broshek DK, et al. A multicenter, prospective pilot study of gamma knife radiosurgery for mesial temporal lobe epilepsy: seizure response, adverse events, and verbal memory. *Ann Neurol.* 2009; 65(2):167-175.
79. Brisman R. Microvascular decompression vs. Gamma Knife radiosurgery for typical trigeminal neuralgia: preliminary findings. *Stereotact Funct Neurosurg.* 2007; 85(2-3):94-98.
80. Donnet A, Tamura M, Valade D, RJ. Trigeminal nerve radiosurgical treatment in intractable chronic cluster headache: unexpected high toxicity. *Neurosurgery.* 2006; 59(6):1252-1257.
81. Duma CM. Movement disorder radiosurgery--planning, physics and complication avoidance. *Prog Neurol Surg.* 2007; 20:249-266.
82. Friehs GM, Park MC, Goldman MA, et al. Stereotactic radiosurgery for functional disorders. *Neurosurg Focus.* 2007; 23(6):E3.
83. Gronseth G, Cruccu G, Alksne J, et al. Practice parameter: the diagnostic evaluation and treatment of trigeminal neuralgia (an evidence-based review): report of the Quality Standards Subcommittee of the American Academy of Neurology and the European Federation of Neurological Societies. *Neurology.* 2008; 71(15):1183-1190.
84. Kondziolka D, Ong JG, Lee JY, et al. Gamma Knife thalamotomy for essential tremor. *J Neurosurg.* 2008; 108(1):111-117.

85. Lim M, Cotrutz C, Romanelli P, et al. Stereotactic radiosurgery using CT cisternography and non-isocentric planning for the treatment of trigeminal neuralgia. *Comput Aided Surg*. 2006; 11(1):11-20.
86. Lim M, Villavicencio AT, Burneikiene S, et al. CyberKnife radiosurgery for idiopathic trigeminal neuralgia. *Neurosurg Focus.* 2005; 18(5):E9.
87. Linskey ME, Ratanatharathorn V, Penagaricano J. A prospective cohort study of microvascular decompression and Gamma Knife surgery in patients with trigeminal neuralgia. *J Neurosurg.* 2008; 109 Suppl:160-172.
88. Little AS, Shetter AG, Rogers CL, et al. Salvage Gammaknife Stereotactic Radiosurgery for Surgically Refractory Trigeminal Neuralgia. *Int J Radiat Oncol Biol Phys.* 2009; 74:522-527.
89. Muragaki Y, Nakamura R, Iseki H, et al. Outcome after pituitary radiosurgery for thalamic pain syndrome. *Int J Radiat Oncol Biol Phys.* 2007; 69(3):852-857.
90. National Institute for Health and Clinical Excellence. Interventional procedure Guidance IPG085 Stereotactic radiosurgery for trigeminal neuralgia using the Gamma Knife - guidance. http://www.nice.org.uk/nicemedia/pdf/ip/IPG085guidance.pdf August 2004. Accessed April 2009.
91. Patil CG, Veeravagu A, Bower RS, et al. CyberKnife radiosurgical rhizotomy for the treatment of atypical trigeminal nerve pain. *Neurosurg Focus.* 2007; 23(6):E9.
92. Quigg M, Barbaro NM. Stereotactic radiosurgery for treatment of epilepsy. *Arch Neurol*. 2008; 65(2):177-183.
93. Regis J, Rey M, Bartolomei F, et al. Gamma knife surgery in mesial temporal lobe epilepsy: a prospective multicenter study. *Epilepsia*. 2004; 45(5):504-515.
94. Romanelli P, Anschel DJ. Radiosurgery for epilepsy. *Lancet Neurol.* 2006; 5(7):613-620.
95. Villavicencio AT, Lim M, Burneikiene S, et al. Cyberknife radiosurgery for trigeminal neuralgia treatment: a preliminary multicenter experience. *Neurosurgery*. 2008; 62(3):647-55.
96. Zesiewicz TA, Elble R, Louis ED, et al. Practice parameter: therapies for essential tremor: report of the Quality Standards Subcommittee of the American Academy of Neurology. *Neurology.* 2005; 64(12):2008-2020.

Vascular

97. Ding D, Yen CP, Sheehan JP, et al. Radiosurgery for ruptured intracranial arteriovenous malformations. *J Neurosurg.* 2014 Mar 21. [Epub ahead of print]
98. Han JH, Kim DG, Chung HT, et al. Clinical and neuroimaging outcome of cerebral arteriovenous malformations after Gamma Knife surgery: analysis of the radiation injury rate depending on the arteriovenous malformation volume. *J Neurosurg.* 2008; 109(2):191-198.
99. Hayes, Inc. HAYES Medical Technology Directory. Stereotactic Radiosurgery for Arteriovenous Malformations and Intracranial Tumors. Lansdale, PA: Hayes, Inc. January 2009.
100. Liscak R, Vladyka V, Simonova G, et al. Gamma knife surgery of brain cavernous hemangiomas. *J Neurosurg.* 2005;102 Suppl:207-213.
101. Potts MB, Sheth SA, Louie J, et al. Stereotactic radiosurgery at a low marginal dose for the treatment of pediatric arteriovenous malformations: obliteration, complications, and functional outcomes. *J Neurosurg Pediatr.* 2014 Apr 25. [Epub ahead of print]
102. Schaeuble B, Cascino GD, Pollock BE, et al. Seizure outcomes after stereotactic radiosurgery for cerebral arteriovenous malformations. *Neurology.* 2004; 63(4):683-687.
103. Sinclair J, Chang SD, Gibbs IC, et al. Multisession CyberKnife radiosurgery for intramedullary spinal cord arteriovenous malformations. *Neurosurgery.* 2006; 58(6):1081-1089.
104. Sun DQ, Carson KA, Raza SM, et al. Radiosurgical Treatment of Arteriovenous Malformations: Obliteration, Morbidities and Performance Status. *Int J Radiat Oncol Biol Phys.* 2011; 80: 354-361.