Radiosurgery for the Treatment of Psychiatric Disorders: A Review

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Key words
- Cingulotomy
- Gamma capsulotomy
- Gamma cingulotomy
- Gamma knife radiosurgery
- Literature review
- Obsessive-compulsive disorders
- Psychiatric disorder

Abbreviations and Acronyms
CKRS: Cyberknife radiosurgery
MRI: Magnetic resonance imaging
OCD: Obsessive-compulsive disorder
Y-BOCS: Yale-Brown Obsessive Compulsive Scale

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Radiosurgery for psychiatric disorders has been performed for more than 50 years. The use of deep brain stimulation has recently been expanded to the investigational treatment of specific psychiatric disorders. A literature review of past studies incorporating radiosurgical stereotactic lesions for psychiatric disorders was performed to provide historic context and possible guidance for current and future attempts at treating psychiatric disorders, especially by gamma capsulotomy. The anatomic target localization, dose selection, and the outcome of the radiosurgical procedures were reviewed, and the evolutions of lesioning strategies were analyzed with particular emphasis on the dose selection. Large-scale prospective studies with strict inclusion and well-defined, objective outcome criteria are necessary for defining the role of radiosurgery for the treatment of psychiatric disorders.

INTRODUCTION

There is current interest in the use of gamma capsulotomy for patients with psychiatric disorders, especially in patients with medically refractory obsessive-compulsive disorders (OCD). An OCD is marked by recurrent unwanted and intrusive thoughts or repetitive behaviors. These "rituals" reflect the patient's anxiety or attempts to control it and can be greatly exacerbated in stressful situations and, in some cases, prove very incapacitating (4). In 1949, the French neurosurgeon Jean Talairach, Saint-Anne Hospital in Paris, was the first to selectively lesion the anterior limb of the internal capsule for the treatment of psychiatric disorders (22). Talairach developed the technique of anterior capsulotomy with a view to obtaining the same benefits as those provided by extensive procedures like transorbital lobotomy or prefrontal lobotomy, but by creating a much smaller lesion and incurring fewer side effects. Initially, he reported good results in patients with anxiety disorders and soon the procedure was tested by other neurosurgeons around the world. The original reason for targeting the internal capsule was that fibers connecting the orbitofrontal cortex to the limbic system pass through the anterior limb of the internal capsule. As the cingulotomy or subcaudate tractotomy, the results were poor among patients with psychosis but better among patients with anxiety and OCD. The Swedish neurosurgeon Lars Leksell modernized the anterior capsulotomy, which he co-developed in the 1950s with Talairach, with the invention of a procedure to produce radiofrequency thermocoagulative lesions and gamma knife radiosurgery (9). The first radiosurgical capsulotomy was performed in 1953 using 300 kV X-rays (11). At present, these lesions are generated by gamma radiation (**Figure 1**). This involves the focusing of 192–201 beams of ^{60}Co γ-radiation from a stereotactic gamma unit onto the lesion site of the fibers that pass through the anterior portion of the internal capsule. Our literature review aims at reporting the efficacy and adverse events of radiosurgery for the treatment of psychiatric disorders.

METHODS

We performed a PubMed search of the literature by using the terms gamma capsulotomy, psychiatric disorders, radiosurgery and obsessive-compulsive disorder. Articles published in languages other than English were excluded from our study. Of the included articles, there were no limitations with regard to the indications for radiosurgery, length of follow-up, or outcome assessment. All articles were studied irrespective of the year of publication and the journal. We were particularly interested in the evolution of the radiosurgical technique with time, including the dose, the target, the neuropsychological evaluation, and the outcome criteria. We believe that this review will help neurosurgeons understand the concept of gamma capsulotomy and identify the pitfalls of this procedure and also to recognize its future clinical utility.

RESULTS

Leksell was the first to publish his experience with gamma capsulotomy from two case reports in 1955 and in 1985 (**Table 1**)

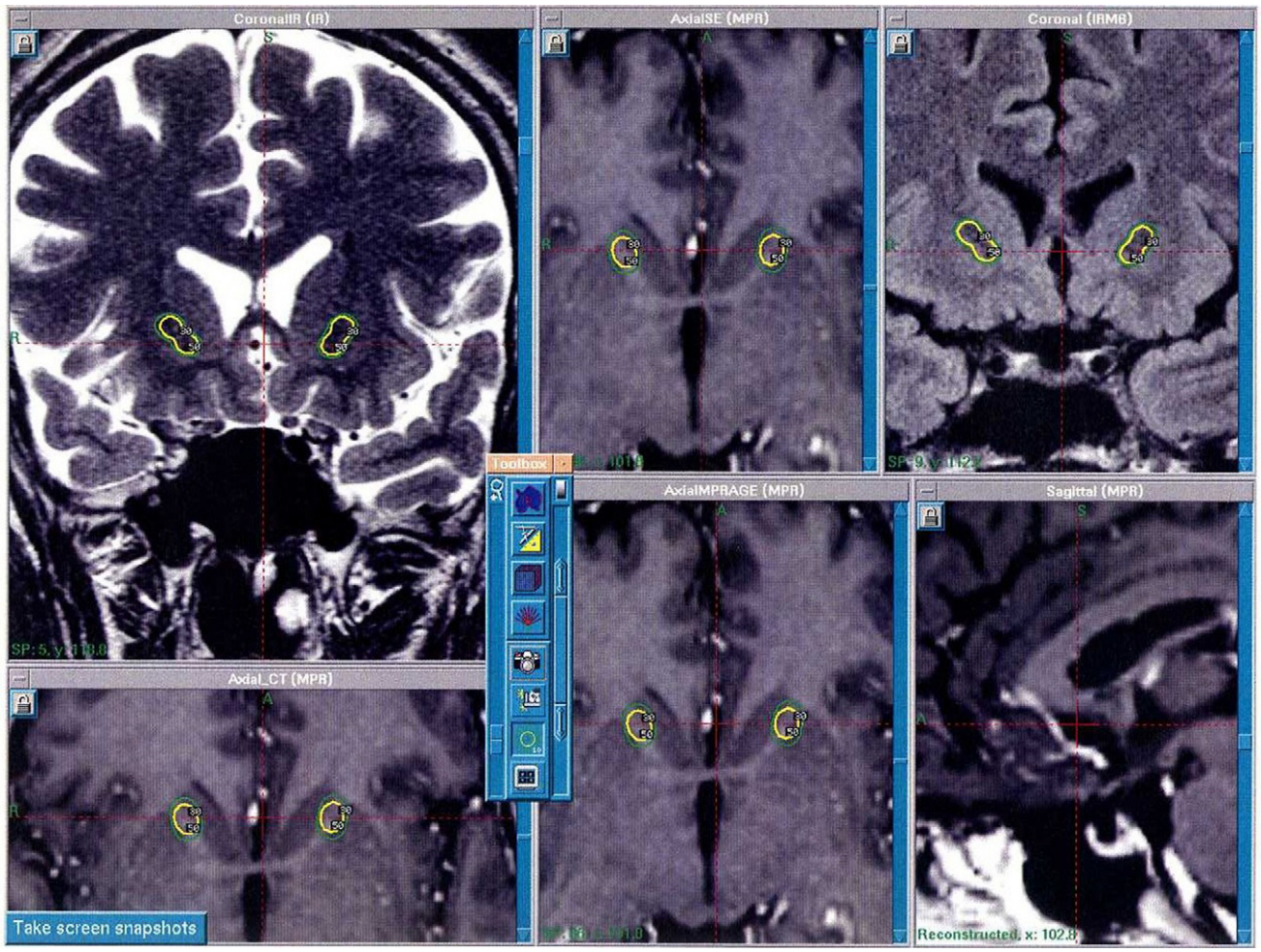

Figure 1. Magnetic resonance imaging axial and coronal gamma knife radiosurgical dose plan for anterior capsulotomy for a patient with severe intractable obsessive-compulsive disorder from the Gamma-Plan (Elekta Instruments AB, Stockholm, Sweden). The yellow outline indicates the 50% isodose line of 180 Gy maximum dose delivered bilaterally with two shots of the 4-mm collimator.

(10, 11). The first involved a 29-year-old man with intractable OCD. Operation stereotactic radiosurgery was performed in two stages: anterior gamma capsulotomy on the right side was performed with a collimator helmet with an 8-mm diameter and a maximum dose of 100 Gy to the most anterior part of the internal capsule. Pneumoencephalography was used for target definition in the placement of the shot. One month later, the same procedure was performed with 120 Gy (maximum dose) on the left side. We have no information about the follow-up.

Mindus et al. (15) in Stockholm continued the tradition started by Leksell and Rylander (20). They published the results of a series of seven patients treated by gamma capsulotomy who had been hospitalized repeatedly for their anxiety disorders, which had proved resistant to conventional treatments. Unfortunately, Mindus et al. (15) gave no details regarding clinical outcomes and adverse effects. We only know that five of the initial seven patients (72%) experienced long-term improvement, after 7 years of follow-up. Magnetic resonance imaging (MRI) could only demonstrate an adequate lesion in white matter in five of seven patients, and those were the patients who benefitted from the procedure. A strong correlation was found between the adequacy of the lesion and the postoperative level of social functioning. The lowest effective target dose was 160 Gy, whereas 100, 120, and 152 Gy failed to produce identifiable lesions. The main conclusion of this article is that MRI may facilitate the determination of a clinically effective radiation threshold estimate for radiosurgical lesions, which should be of value for the planning of studies of gamma capsulotomy. The same team, with approximately the same series of patients concludes that lower irradiation doses should be used in the future, and the time factor should be taken into account when interpreting computed tomographic and MRI of gamma capsulotomy-induced lesions (5). They also concluded that the initial use of an 8-mm collimator resulted in excessive edema, and recommended the use of 4-mm isocenters (12).

Between 1976 and 1989, Lippitz et al. (13), from the Karolinska Institute, observed 10 patients with otherwise intractable conditions with a chronic clinical course of OCD who underwent bilateral