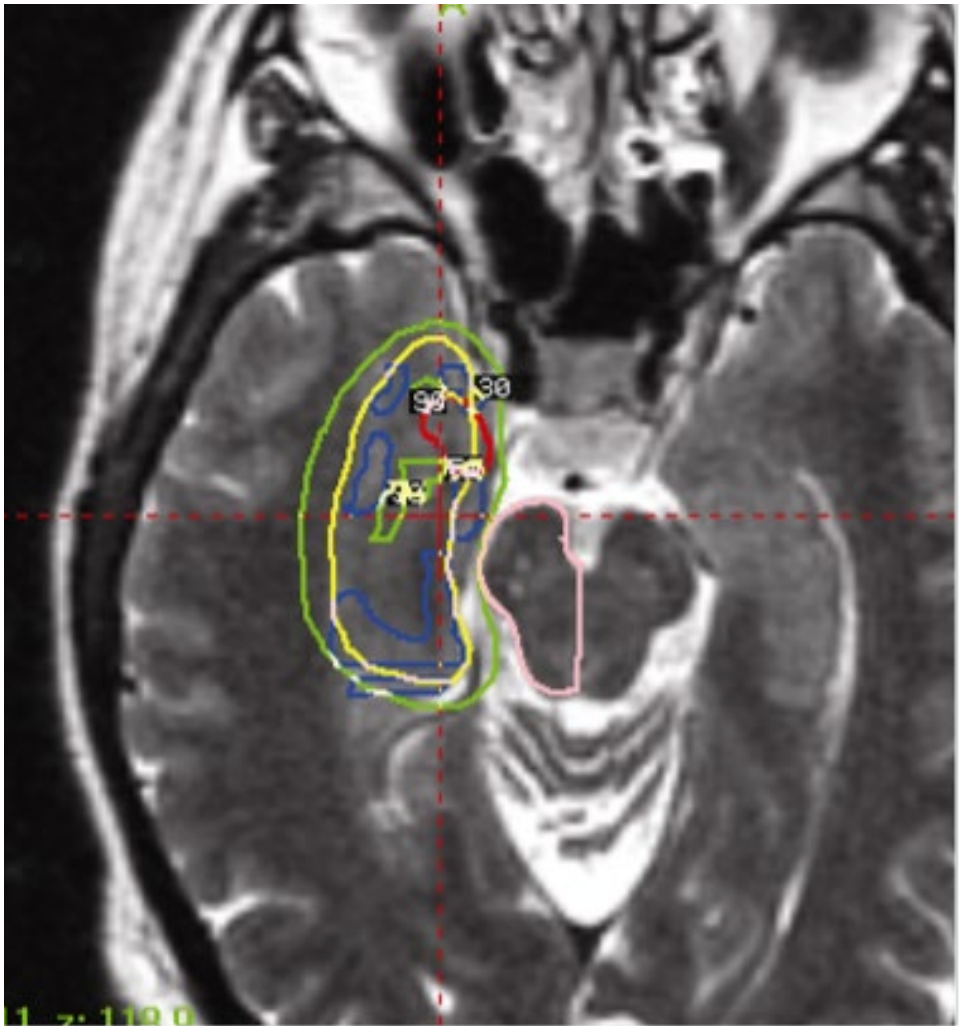
Elekta

Leksell Gamma Knife® SRS for medically refractory tremor



Introduction

Tremor is a common neurological condition and the most prevalent among movement disorders[1-6]. It is characterized by rhythmic oscillations in one or more parts of the body, including the hands, upper and lower limbs, head and vocal cords[3,7]. This can lead to challenges with everyday tasks, such as writing, eating, shaving and dressing, and can cause disability and significant impairment to quality of life[1,3,5-7]. Tremor has also been associated with cognitive abnormalities, anxiety and depression.[3]

Types of tremor include essential tremor (ET) and that caused by an underlying condition, such as Parkinson's disease (PD).[1] The prevalence of ET is estimated to be 0.32% of the global population, affecting around 25 million people worldwide.[3] Tremor tends to worsen with age or with progression of the underlying disease.[1,3,5]

Pharmacological treatments for tremor are available and well tolerated. However, severe and prolonged cases may become refractory to medical treatment.[1,6,7]

Treatment options for refractory tremor

Effective neurosurgical options exist for the treatment of medically refractory tremor. These include deep brain stimulation (DBS) of the ventralis intermedius (VIM) nucleus, thalamus, and subthalamic nucleus, and unilateral thalamotomy by Gamma Knife stereotactic radiosurgery (GKSRS), high-intensity focused ultrasound (HIFU) or radiofrequency thermocoagulation (RFT).[1,2,4-7] The VIM nucleus is the most common target for neurosurgical procedures aiming to control tremor,[2,4,5] although additional structures along the dentato-rubro-thalamic tract (DRT), namely the caudal zona incerta (cZI) and the subthalamic area (STA), have also been proposed for DBS.[8]

Invasive procedures, while effective, carry known risks, such as cerebral hemorrhage and surgical wound infection.[1,7]

Unilateral thalamotomy using stereotactic radiosurgery (SRS) is a safe, effective and minimally invasive option for refractory tremor patients when surgical procedures are contraindicated due to advanced age, ischemic brain lesions or another comorbidity.[1,4,6,7] It can also be considered for patients who decline or are unresponsive to more invasive surgical options.[4]

Gamma Knife radiosurgery for refractory tremor

GKSRS has been used to treat refractory tremor, including ET and tremor associated with PD, for over 30 years.[1,9] It is also effective in the treatment of tremor associated with multiple sclerosis.[9,10]

Gamma Knife thalamotomy is an ablative, non-incisional procedure that targets the VIM nucleus of the thalamus (figure 1).[1,4,5,11] Included in ISRS recommendations,[5,9] it is considered safe and effective,[5,7,9] particularly with the development of sophisticated MR imaging techniques to improve localization of the VIM nucleus.[9] The ability to use very small (4 mm) collimators and its sharp dose gradients give Leksell Gamma Knife the targeting accuracy and precision required for functional neurosurgery.[5]

Unilateral GK thalamotomy is well-established for the treatment of patients with medically refractory tremor.[1,4,12,13] Simultaneous bilateral GK thalamotomy is not recommended,[7] but staged bilateral GK thalamotomy may provide relief for disabling refractory bilateral tremor in selected cases.[4,14]

Maximum radiation doses used to perform unilateral GK thalamotomy range from 130-150 Gy,[1,2,4-7,12-14] using a collimator size of 4 mm.[1,5,7,12-14] Constraints used include minimizing dose (≤18 Gy) to the posterior limb of the internal capsule.[7]

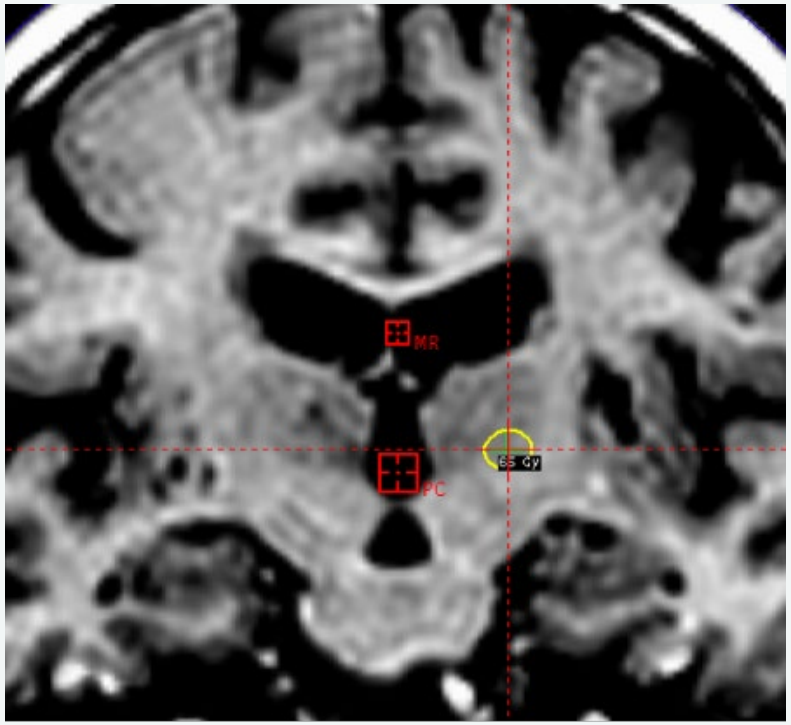


Figure 1. T1-weighted MRI scan showing 50% isodose line (yellow) in the VIM region of the thalamus (with permission from Elisabeth-Tweesteden Hospital, Tilburg, the Netherlands).

Targeting the VIM nucleus

Targeting of the VIM nucleus has been achieved using MRI,[1,2,5,7] localization systems (such as the Taillerach system modified by Regis and Ohye,[1] and Guiot's targeting system[2]), atlases (such as the Wahren and Schaltenbrand atlases),[1,5] and involvement of multidisciplinary expertise, including neuroradiologists, medical physicists, neurologists and neurosurgeons.[1,4]

Imaging techniques used for target localization include structural and resting-state functional MRI (T1-, T2- and diffusion weighted; FLAIR), and 18F-fluorodeoxyglucose-positron emission tomography.[1,2,5] Recent advances in MRI, such as state-of-the-art tractography[5,15] and the fast gray matter acquisition T1 inversion recovery (FGATIR) MRI sequence,[16] have helped to further improve anatomical identification. Small shifts or blocking may be required to protect the internal capsule.[5,7]

Although the VIM nucleus is most commonly targeted for the treatment of tremor, the ventralis oralis anterior (VOA) has also been used effectively as a treatment target for some uncommon movement disorders.[7]

GKSRS treatment response rates

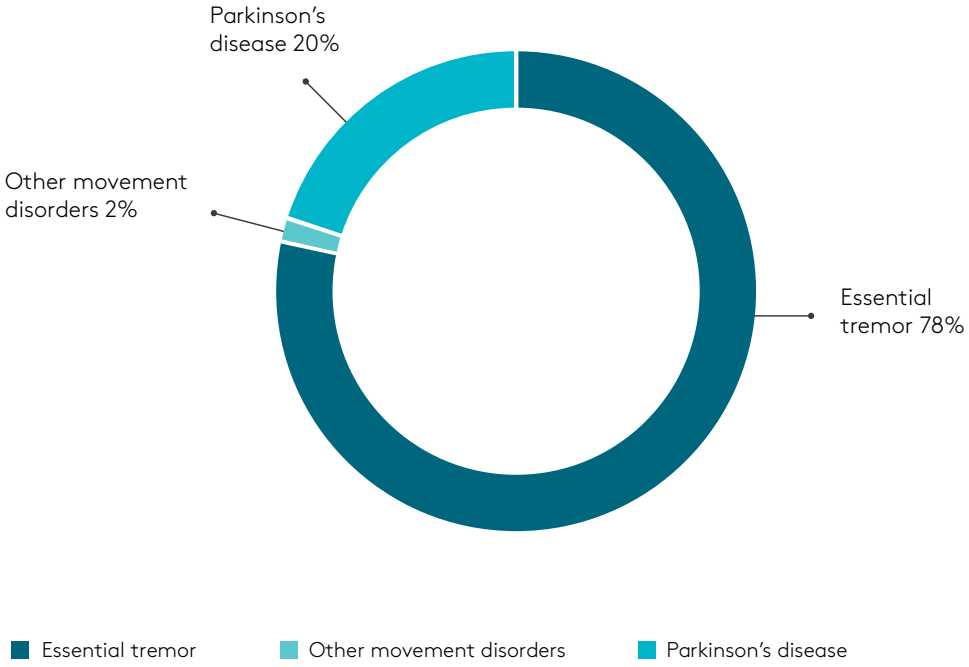
A variety of methods have been used to measure response in the treatment of tremor, including the Fahn-Tolosa-Marin (FTM) scale and the Movement Disorders Society-Unified Parkinson's Disease Rating Scale (MDS-UPDRS), as well as the Karnofsky Performance Status (KPS) and the VAS EuroQoL-5D quality of life scales.[1,6,13,17]

Improvement rates of 70-93% have been observed in studies following SRS for the treatment of tremor,[5,6,13] and symptoms disappeared or were minimal in around 61% of cases.[1,6] 82-90% of individuals experienced an improved quality of life,[1,4,5] with patients able to return to independent living.[7]

Mean times to response reported range from 4.8-5.3 months.[5,12] The treatment is well tolerated, and clinical complications are rare, usually mild and transient.[1,4-7,12,13]

In a retrospective comparative study, comparing DBS, RFT and SRS, similar tremor control rates were reported for each method. A longer latency period was noted for SRS, while more permanent complications were observed following DBS and RFT.[5]

Distribution of movement disorders treated on Leksell Gamma Knife between 2018 and 2024



Conclusions

GK thalamotomy is an efficient, effective and well-tolerated treatment option for patients with medically refractory tremor. [1,5,11,12,17] It provides a safe, non-invasive alternative for patients, including those who are elderly or where more invasive procedures are contraindicated. [1,5-7,10,13] Patients can receive imaging and treatment on the same day, in a convenient outpatient setting, without the trauma or recovery period associated with open surgery.

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