Gamma Knife thalamotomy for essential tremor and Parkinson’s Disease
I have no personal or financial interests to declare: I have no financial support from an industry source at the current presentation.
Functional radiosurgery...destruction of precisely selected areas of tissue using ionizing radiation

Lars Leksell, 1951
Tremor | Gamma Knife thalamotomy
Pharmacology
(propranolol, primidone)

Stereotactic RF thalamotomy

DBS

Radiosurgery?
To evaluate the effectiveness and safety of VIM gamma thalamotomy usage for the treatment of disabling parkinsonian and essential tremor.

The additional aim of the study was to review the radiological findings of radiosurgical lesioning as well as the assessment of the risk of complications.
From November 2011, to October 2015, 106 patients underwent unilateral VIM GKT for essential tremor and Parkinson’s disease tremor at our center.  

106 patients completed at least 6 months follow-up

<table>
<thead>
<tr>
<th></th>
<th>ET</th>
<th>PD</th>
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<tbody>
<tr>
<td><strong>Number of pts.</strong></td>
<td>58 (34 men, 24 women)</td>
<td>48 (26 men, 22 women)</td>
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<td><strong>Age</strong></td>
<td>56.2 (18-86)</td>
<td>74.1 (51-91)</td>
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<tr>
<td><strong>Symptoms duration</strong></td>
<td>28.4 (8-50) months</td>
<td>20.8 (6-30) months</td>
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<td><strong>Side of irradiation</strong></td>
<td>44-left 14-right</td>
<td>28-left 20-right</td>
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Frame 1  Gamma Knife thalamotomy
Axial T₁-weighted MRI 1 mm
Axial T₂-weighted 1 mm
Coronal T₁-weighted 1 mm
Coronal T₂-weighted 1 mm

DTI 25 directions

Distortion check! → CT and repeat MR
A dose of 120 or 130 Gy was preferred

- 1 shot 4 mm collimator

- A gamma angle of 90 degrees, no blocking

- Standard VIM coordinates:
  \[x = 14-16 \text{ mm (11 mm lateral to wall of IIIrd ventricle)}\]
  \[y = 6-8 \text{ mm anterior to the PC point}\]
  \[z = 2-3 \text{ mm superior to the AC-PC line}\]
In order to lower the risk of complications (PLIC damage) and improve the results we used multiple strategies in final shot placement.
VIM localisation was not the same in every case and individually changed

\[ X = \pm 1.1 \text{ mm} \quad Z = +0.9 \text{ mm} \]

DTI and fibertracking software StealthViz (Medtronic)
Treatment plan: Gamma Knife thalamotomy

Z = +1.4 mm
Treatment plan | Gamma Knife thalamotomy

18 Gy to the margin of IC
Clinical follow-up evaluation indicated that 74% of patients who underwent thalamotomy became tremor free or nearly tremor free.

Results

Gamma Knife thalamotomy

Excelent 29%
Good 45%
Mild 18%
No improvement 8%

Tremor cessation time: 7-30 weeks
Independent neurological evaluation of tremor was based in all cases on the Fahn-Tolosa-Marin tremor scale. Patients were videotaped before and after GKT.

FTMtrs baseline vs last follow-up

- Resting tremor
- Postural tremor
- Action tremor
- Head tremor
- Handwriting
- Drawing

Legend:
- Before GKT ET
- After GKT ET
- Before GK PD
- After GKT PD
Comparing to DBS... GKT offers similar response rate.

### High Frequency Thalamic Stimulation For Parkinsonian Tremor

<table>
<thead>
<tr>
<th>Investigator (Year)</th>
<th>Follow-up</th>
<th># of implants</th>
<th>% Tremor Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blond et al. (1992)</td>
<td>17 mos</td>
<td>10</td>
<td>70</td>
</tr>
<tr>
<td>Benabid et al. (1996)</td>
<td>6 mos</td>
<td>111</td>
<td>63</td>
</tr>
<tr>
<td>Koller et al (1997)</td>
<td>12 mos</td>
<td>24</td>
<td>91</td>
</tr>
<tr>
<td>Ondo et al. (1998)</td>
<td>3 mos</td>
<td>19</td>
<td>95</td>
</tr>
<tr>
<td>Limousin et al (1999)</td>
<td>12 mos</td>
<td>74</td>
<td>85</td>
</tr>
<tr>
<td>Albanese et al (1999)</td>
<td>9 mos</td>
<td>27</td>
<td>92</td>
</tr>
<tr>
<td>Lyons et al (2001)</td>
<td>40 mos</td>
<td>9</td>
<td>87</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td><strong>14 months</strong></td>
<td><strong>83%</strong></td>
<td></td>
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</table>
In FOUR cases there was unstable tissue response (hyper responder) with thalamotomy lesion size bigger than planned 5-6mm. In TWO cases it produced severe hemiparesis of contralateral limbs that did not resolve over time.
Characteristic qualities on MR FLAIR / T2 imaging suggesting cerebral perfusion instability.

In order to reduce the risk of complications we LOWER the maximal dose to 120 Gy in patients at risk:

- Diabetes type I and II
- Chronic unstable hypertension
- Heavy smokers
Gamma Knife VIM thalamotomy offers good tremor control for patient suffering from PD and essential tremor with minimal risk to patients unwilling to undergo DBS implantation or unsuited for open surgery.

DTI fibertracking plays important role in final shot placement.

Gamma Knife VIM thalamotomy may be also especially harmful in a selected group of patients that are showing characteristic clinical and imagin features suggesting cerebral perfusion instability. Further studies with careful neurologic and neuroimaging evaluations are needed.
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