6 out of 9 patients participated in prospective study:  
- All side effects from stimulation and effectiveness on cardinal disease-effects  
- Retrospective review – Chart review of patients currently treated with DBS

Interleaving is achieved by rhythmic automatic switching of current between two groups of DBS parameters on the same electrode at a maximum frequency of 125Hz. Amplitude and pulse width (PW) can be different between the interleaved programs.

- There is no evidence-based guidelines regarding patient selection for interleaving.

- Study objectives:  
  1. To compare efficacy and side effects of interleaved DBS versus non-interleaved programming.  
  2. To describe characteristics of patients with DBS whom may be candidates for interleaving.

Methods

- Retrospective review – Chart review of patients currently treated with interleaving and those who failed it to analyze the indications for failure.
- Prospective evaluation – Direct comparison of effectiveness of interleaved DBS vs non-interleaved stimulation in the same patients.
- Evaluation / video done in 5 conditions:  
  1) Interleaved DBS ON:  
  2) DBS ON with non-interleaved stimulation (Program 1 of two: monopolar or bipolar)  
  3) DBS ON with non-interleaved Program (2 of two: monopolar or bipolar)  
  4) DBS ON and both contacts used for interleaved stimulation programmed in a double monopolar or bipolar configuration (if applicable).  
  5) DBS OFF (baseline of the disease-specific rating scale).

- All side effects from stimulation and effectiveness on cardinal disease-specific symptoms were documented.

- 9 patients identified in retrospective chart review (Table 1)  
  - 2 were still using interleaving at the time of study  
  - 2 failed and were switched to non-interleaved settings.

- Reason for interleaving failure:  
  - Suboptimal lead position eventually requiring revision (n=3):  
  - Tremor improves with better stimulation frequency (>125 Hz) (n=1)  
  - 6 out of 9 patients participated in prospective study:  
    - 2 patients were excluded (1 had electrode revision and no longer interleaved; 1 had impending IPG failure that required exchange)  
    - 1 lost to follow up.

<table>
<thead>
<tr>
<th>Case Example #1</th>
<th>Case Example #2</th>
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<tbody>
<tr>
<td>Case Example #1</td>
<td>60 yo M with PD L-STN Activa PC</td>
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<tr>
<td></td>
<td>Rapid alternating activation of two programs with the same active electrode provides better symptom control and no side effects as opposed to separate use of both 2 programs</td>
</tr>
<tr>
<td>Monopolar C+2-1, 50, 100</td>
<td>Bipolar T+3-4, 130, 100</td>
</tr>
<tr>
<td>Reasonable improvement of R-sided symptoms (MDS UPDRS: 19 for R side)</td>
<td>Better control of R-sided symptoms (contralateral MDS UPDRS: 17)</td>
</tr>
<tr>
<td>Side effects at 2.0 V (dysarthria) and 2.5 V (slowing) to increase Amp</td>
<td>Side effects (dysarthria) Field too broad</td>
</tr>
<tr>
<td>Field broaden to increase Amp</td>
<td>Field focus</td>
</tr>
</tbody>
</table>

- Case Example #2 | 60 yo F with ET BI VM Activa PC |
|                | Interleaving of bipolar and monopolar programs with different active contacts provides best effect on tremor with no side effects |
| Monopolar C+2-60, 150 | Bipolar T+3-4, 130, 100 |
| Good tremor control | Better control of R-sided symptoms (contralateral MDS UPDRS: 17) |
| Side effects (dysarthria and dizziness) Field too broad | Field too broad |

- Interleaved DBS programming might be a good troubleshooting option (earHy or late post-implant management, initial effect for a device or conversion from older devices) when conventional programming options:  
  - 1. Are not sufficient to control cardinal disease symptoms and / or  
  - 2. Cause intolerable side effects.

- Interleaving might be less successful in cases where:  
  - 1. Adequate symptom control requires higher frequency  
  - 2. Electrode location is suboptimal (however, in some cases interleaving can still improve symptoms better than any other programming option + prevent / delay surgical electrode revision)

- Advantages of interleaving (better effect on disease symptoms and fewer side effects) can be mediated by shaping the field to focus / spread electrical stimuli with different intensity within the field.

- Further studies are needed to define selection criteria for patients who would benefit from interleaved programming:  
  - 1. larger numbers of patients  
  - 2. post-op CT to check electrode location and correlate with effects / side effects of interleaved vs. non-interleaved stimulation fields.

- Interleaved DBS can be used in patients unable to tolerate conventional programming due to side effects, or in whom satisfactory control of disease-specific symptoms could not be achieved.

- Evidence-based guidelines for patient selection and methodology of achieving interleaved programming should be defined to assist clinicians treating patients with DBS.

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References

6. Use of Interleaving in Deep Brain Stimulator Programming in Patients with Movement Disorders

Use of Interleaving in Deep Brain Stimulator Programming in Patients with Movement Disorders

Olga Wain, MD; Jooji Jimenez-Shahed, MD*

Methodological Neurological Institute, Department of Neurology, Houston, TX, USA.

Parkinson’s Disease Center and Movement Disorders Clinic, Department of Neurology, Baylor College of Medicine, Houston, TX, USA.

Results, continued

Patient demographics and clinical data of study patients

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<td>51-60</td>
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