Feasibility of Auditory Cortical Stimulation for the Treatment of Tinnitus

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Outline

- Background
- Materials and Method
- Results
- Discussion & Conclusion

Background

Background

- Recent studies have examined the role of direct and indirect CNS stimulation for the suppression of tinnitus
  - Transcranial magnetic stimulation (TMS)
  - Direct current stimulation of the auditory cortex

Background

- **Objectives**
  - ***To investigate the feasibility and safety of an implantable epidural cortical stimulator for the treatment of severe tinnitus***
    - 2-contact electrode, connected to a fully implantable stimulator, placed over the secondary auditory cortex contralateral to the side of tinnitus percept

Materials and Method

Patients

- **Inclusion criteria:**
  - *Adults (n = 8) with,*
    - constant tinnitus of at least 1 year
    - tinnitus reaction questionnaire score greater than 33
    - tinnitus was predominantly unilateral
    - a frequency less than 8,000 Hz

Patients

- **Exclusion criteria:**
  - Active Me´nie`re's disease
  - Intracranial neoplasm
  - Current substance abuse
  - Medical conditions preventing safe implantation

Setting

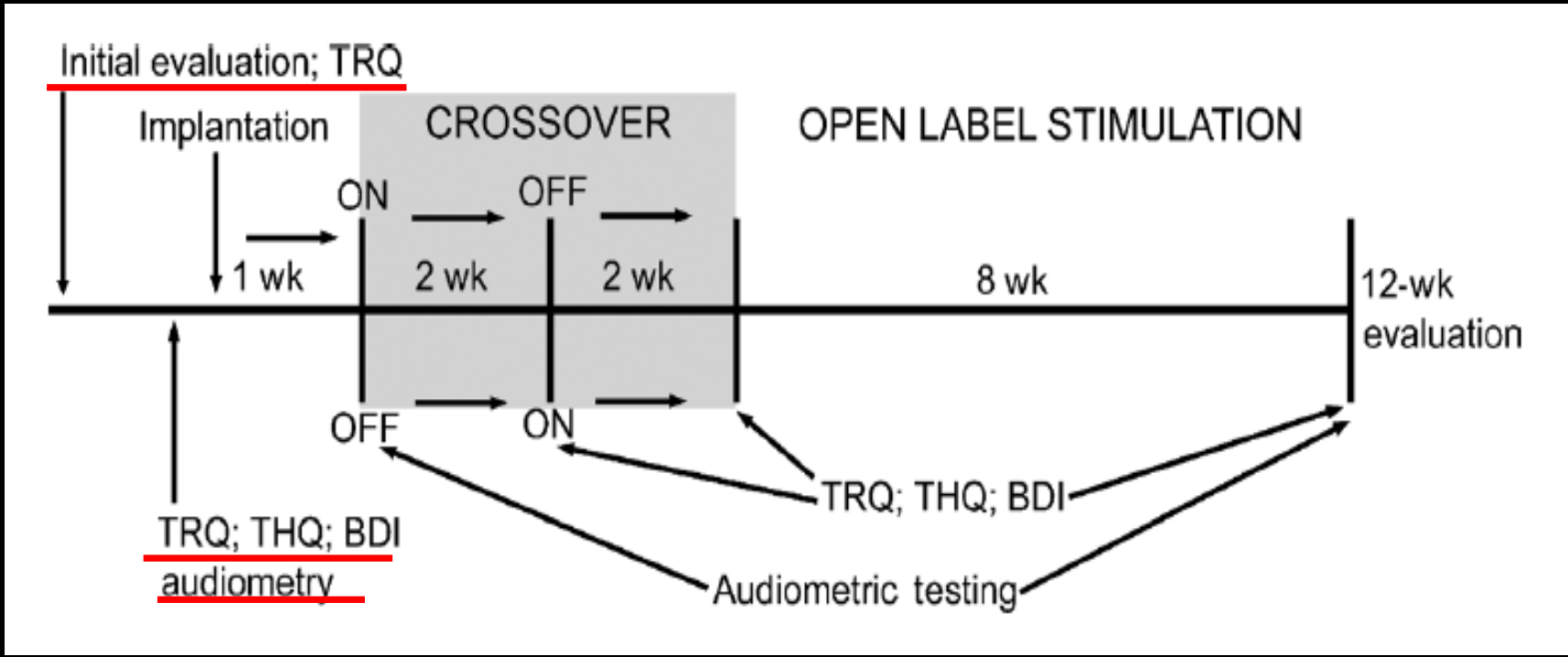
- **Setting:**
  - Tertiary care referral center

Study Design

- **Study design:**
  - **Prospective, controlled, single-blinded study of cortical stimulation for 4 weeks, and then an open-label stimulation period**

Study Design

Preimplantation Testing



Preimplantation Testing

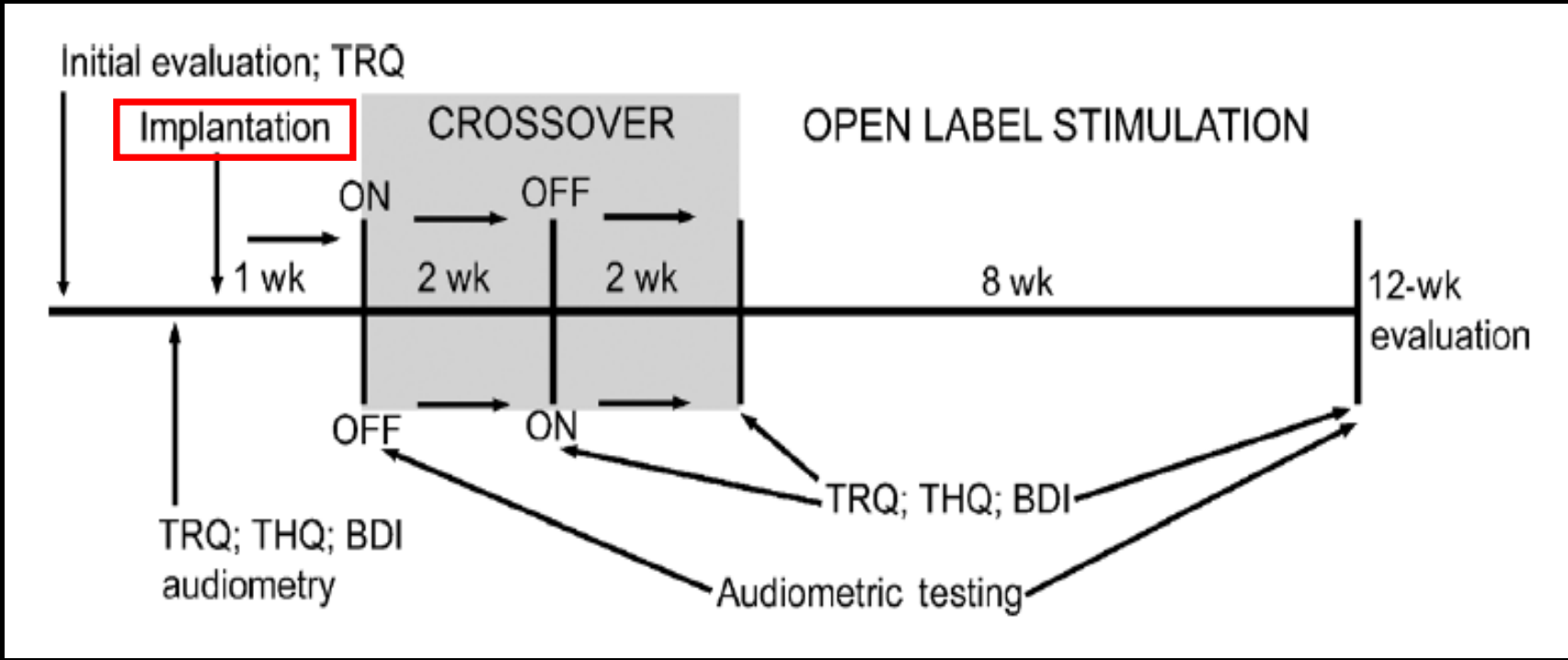
- **Baseline audiometric evaluation:**
  - pure-tone thresholds to bone and air
  - word recognition testing
  - tinnitus loudness matching
  - tinnitus pitch matching
  - determination of minimum masking level
- **Questionnaire evaluation:**
  - TRQ at initial evaluation
  - TRQ, Tinnitus Handicap Questionnaire (THQ) and Beck Depression Inventory before implantation

Preimplantation Testing

- Subjects underwent functional magnetic resonance imaging (fMRI) scanning to localize the site of maximal response to the tinnitus frequency in the auditory cortex

- The target region was merged with a 3-dimensional anatomic MR image and uploaded onto the surgical navigation system

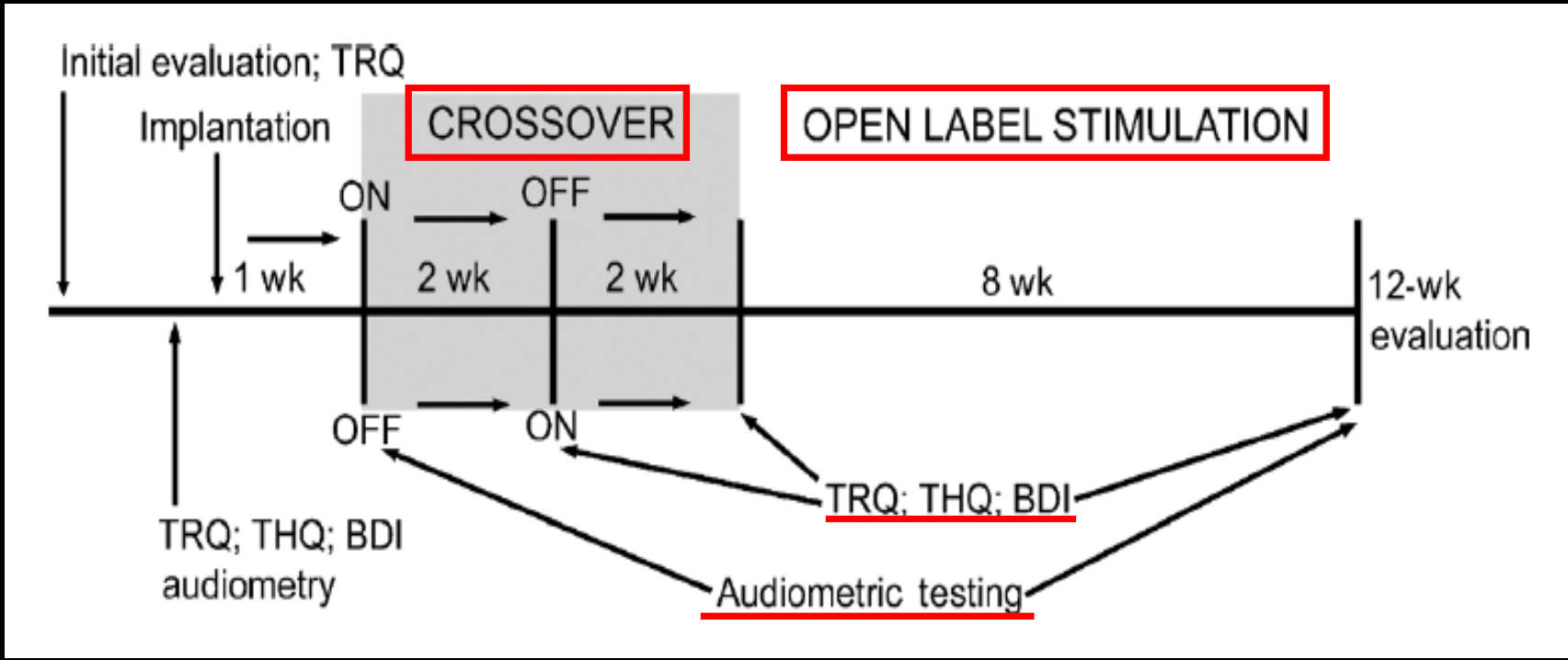
Study Design



Surgical Implantation

- Surgical implantation of an investigational epidural electrode over the posterior superior temporal gyrus using fMRI targeting

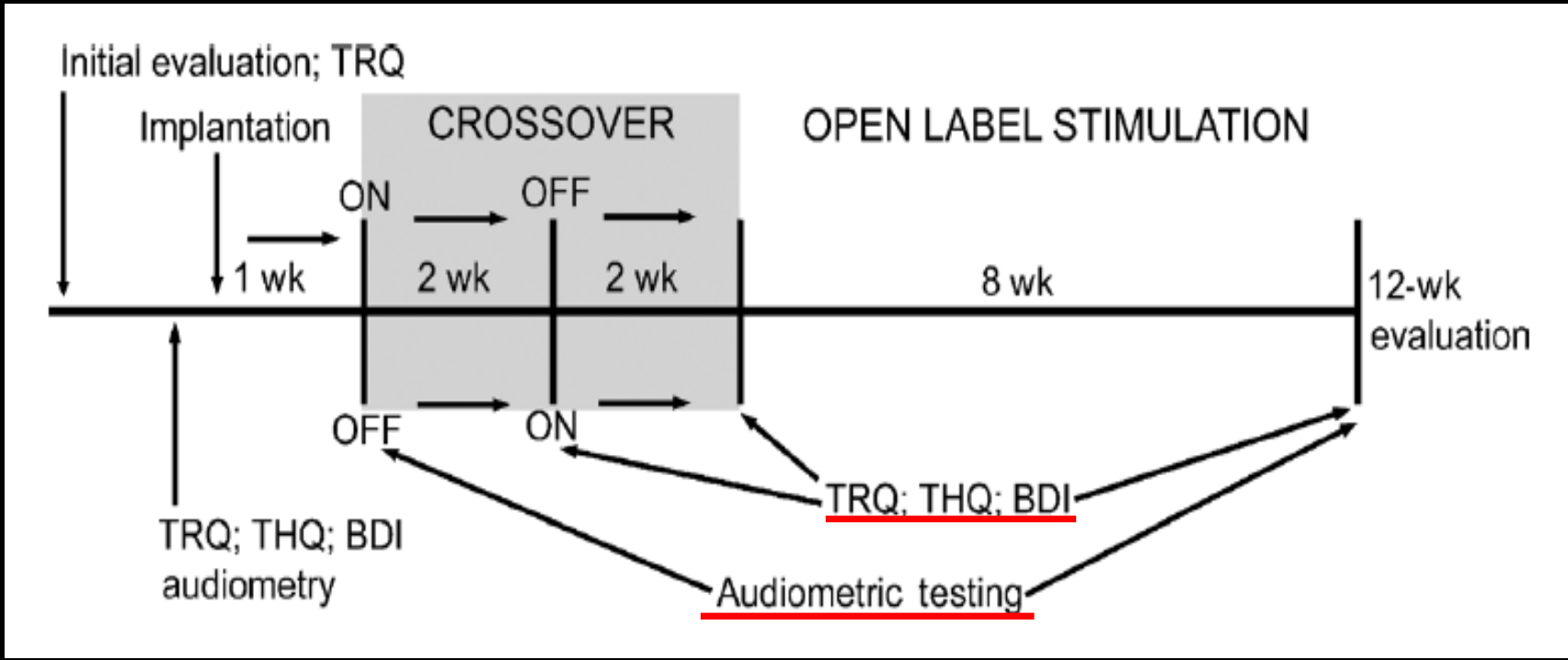
Study Design



Stimulation

- **4-week crossover control period**
  - a 2-week stimulation period alternated with a 2-week sham period in random order to which subjects were blinded
- **Open-label stimulation period**
  - continuous stimulation with parameter adjustments to maximize tinnitus suppression

Study Design



Postimplant Evaluation

- **Main Outcome Measure:**
  - *Subjective measures*
    - rating of tinnitus severity, loudness, and device efficacy
  - *Objective measures*
    - Hearing thresholds, tinnitus frequency, loudness, and minimum masking levels
    - Outcome measures using the THQ, TRQ, BDI

Results

Results

Subject Characteristics

Results

Subject Characteristics

					Tinnitus characteristics			
Subject	Age	M/F	PTA (dB)	Side	Duration (yr)	Frequency (Hz)	Loudness (dB)	Minimum masking level (dB)
1	32	M	87	R	14	4,700	102	65
2	56	F	33	L	13	2,150	41	59
3	58	F	62	R	3	2,600	29	74
4	54	M	17	L	12	6,400	52	72
5	42	M	68	R	10	2,000	66	69
6	57	M	17	B (L>R)	17	6,400	21	18
7	67	F	53	L	48	3,400	62	51
8	67	M	NR	L	9	6,400	41	64

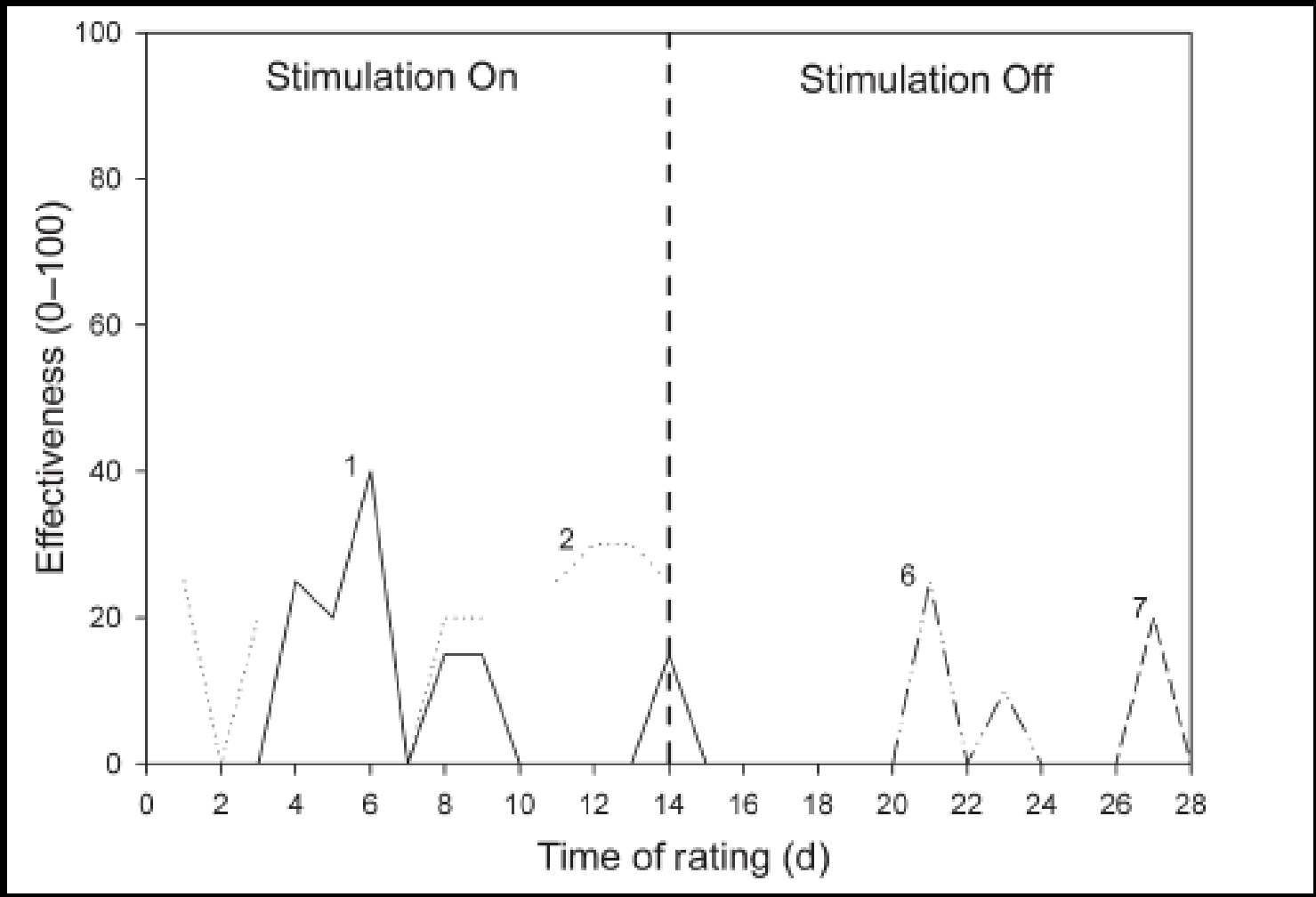
54y/o **15.7yr** **<8000Hz**

B indicates both; F, female; L, left; M, male; R, right.

Results

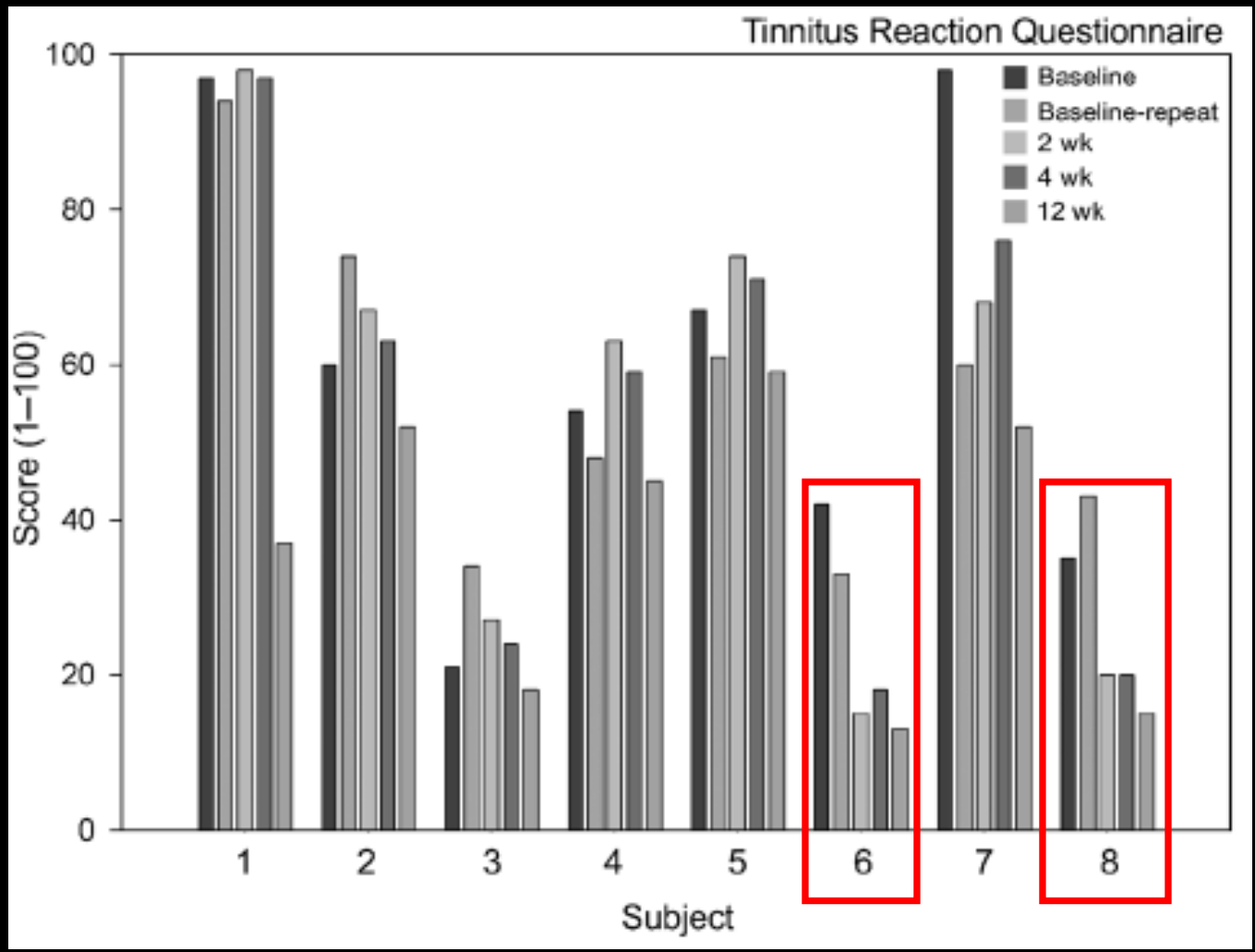
Crossover Control Period

Subjective rating of device effectiveness during the 4-week blinded crossover period

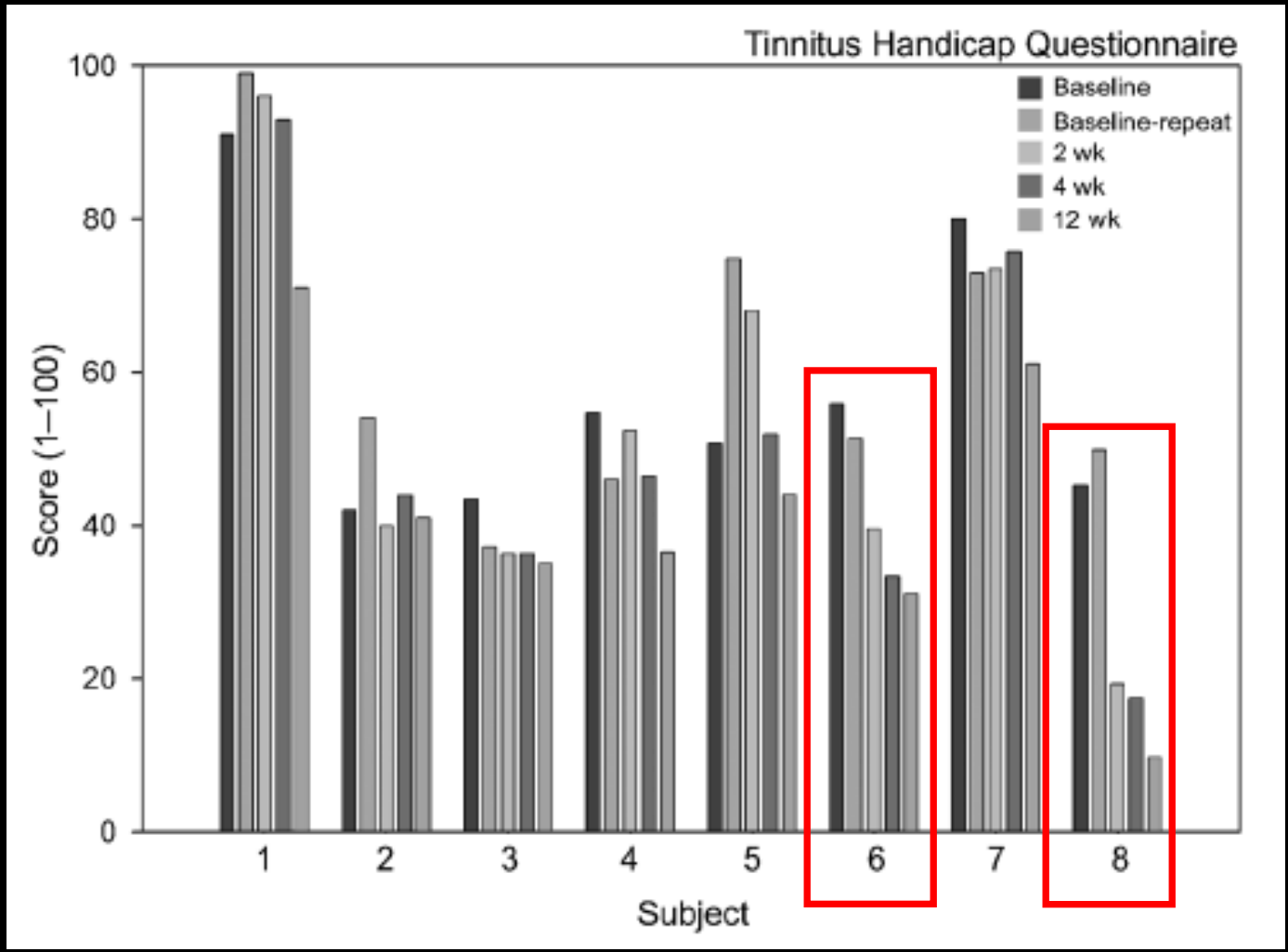


(0-100 numeric rating scale)

Graphic representation of performance on the TRQ at baseline and treatment Weeks 2, 4, and 12



Graphic representation of performance on the THQ at baseline and treatment Weeks 2, 4, and 12



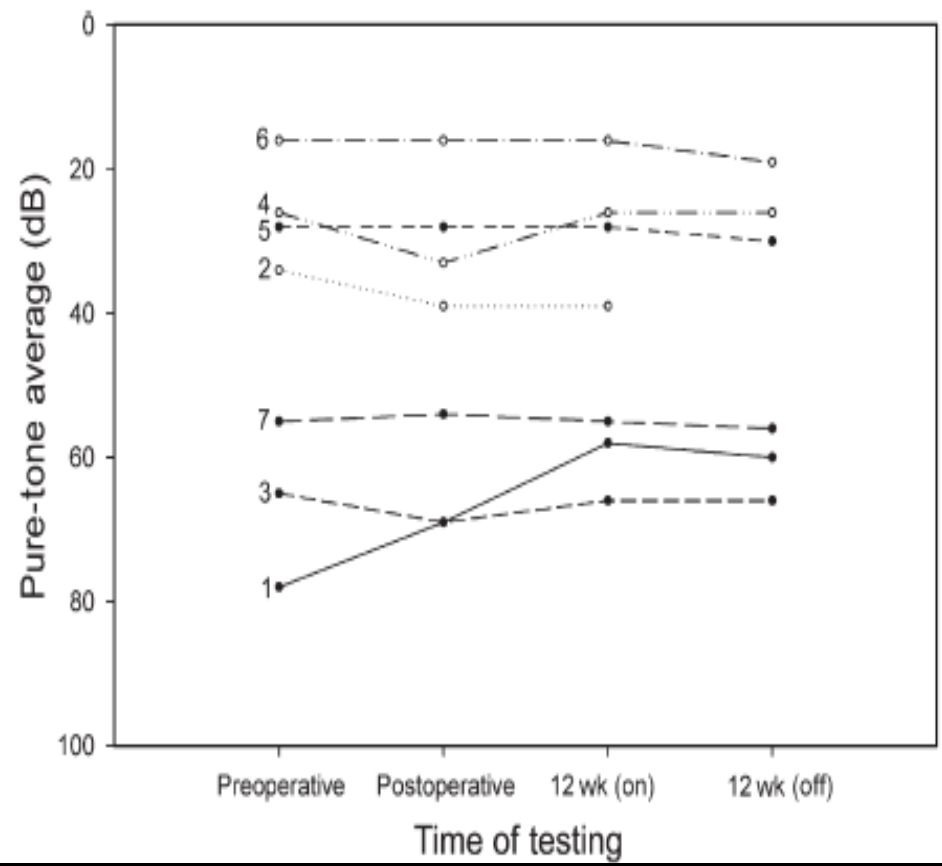
Results Summary

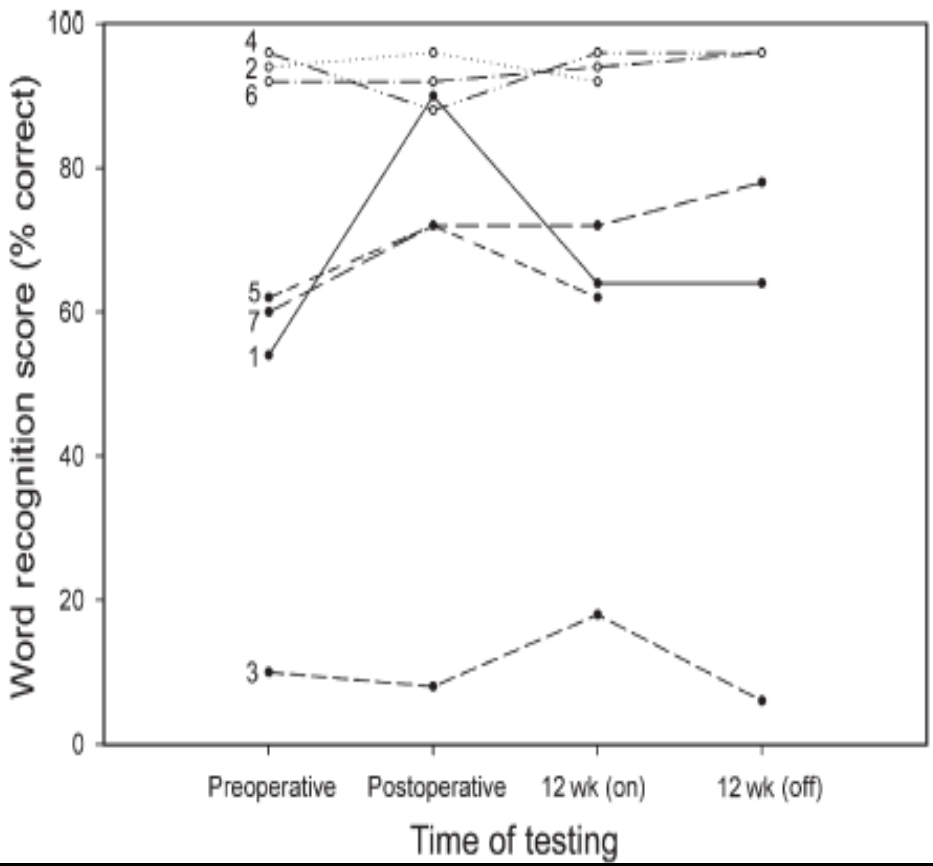
- **4-week blinded period:**
  - No effects of stimulation

Results

Open-Label Stimulation Period

Pure-tone averages, word recognition scores, at baseline and at treatment Week 12

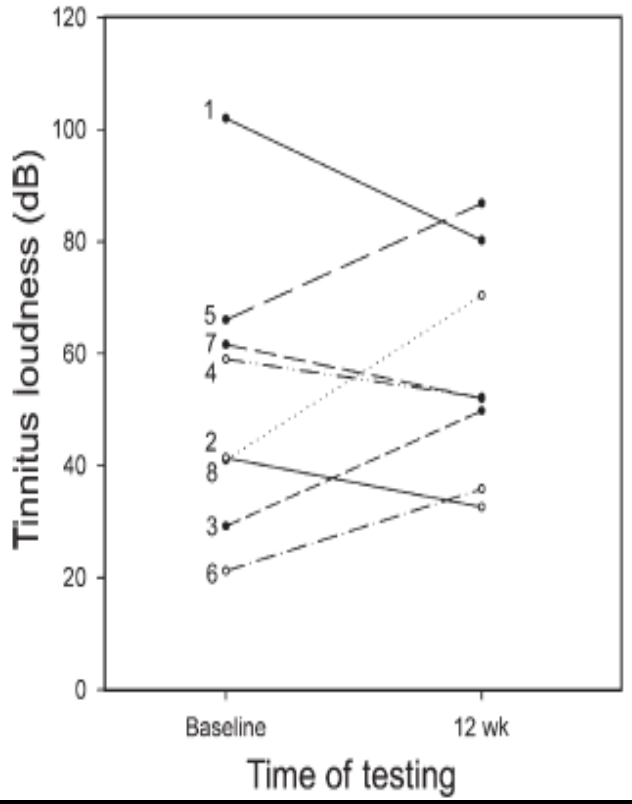


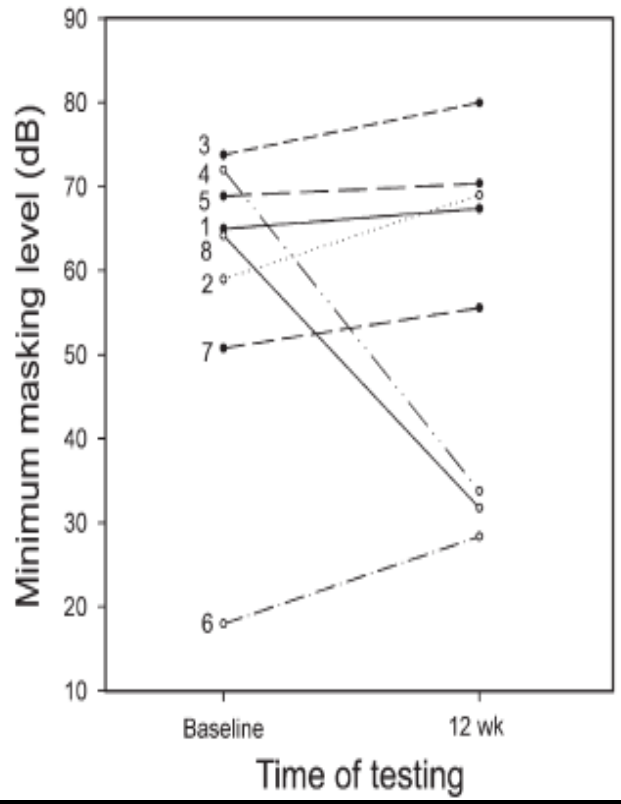


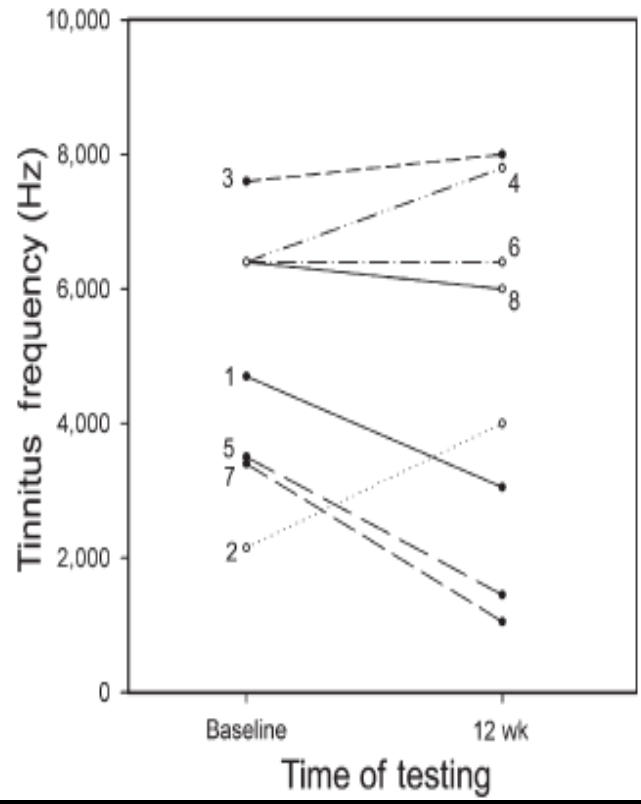
Results Summary

- No change noted in pure-tone average and word recognition score
- No surgical or stimulation-related complications

Objective measures of tinnitus loudness, minimum masking level, and tinnitus frequency scores, at baseline and at treatment Week 12



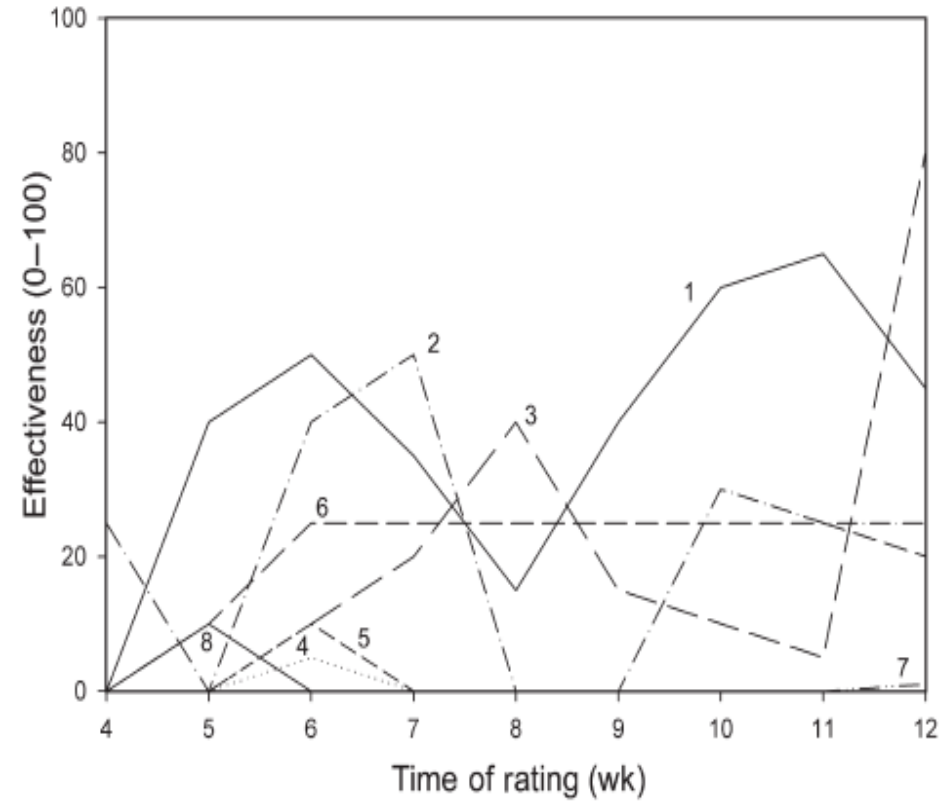


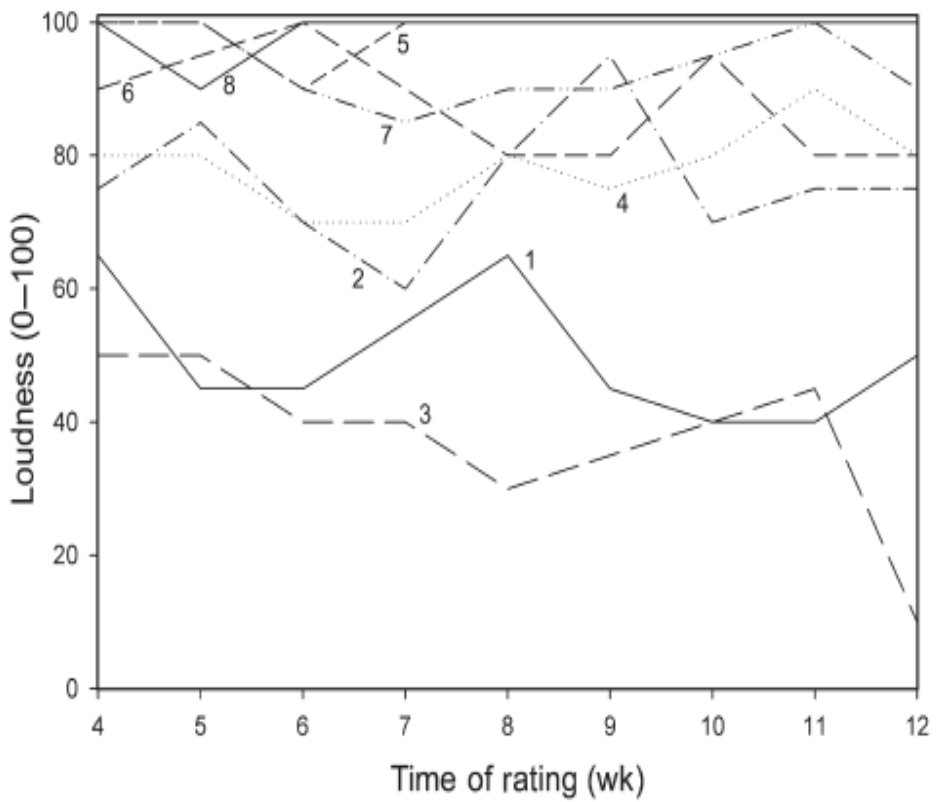


Results Summary

- Objective measures of tinnitus loudness remained **fairly Stable**

Subjective rating of device effectiveness and tinnitus loudness during an 8-week open-label stimulation period



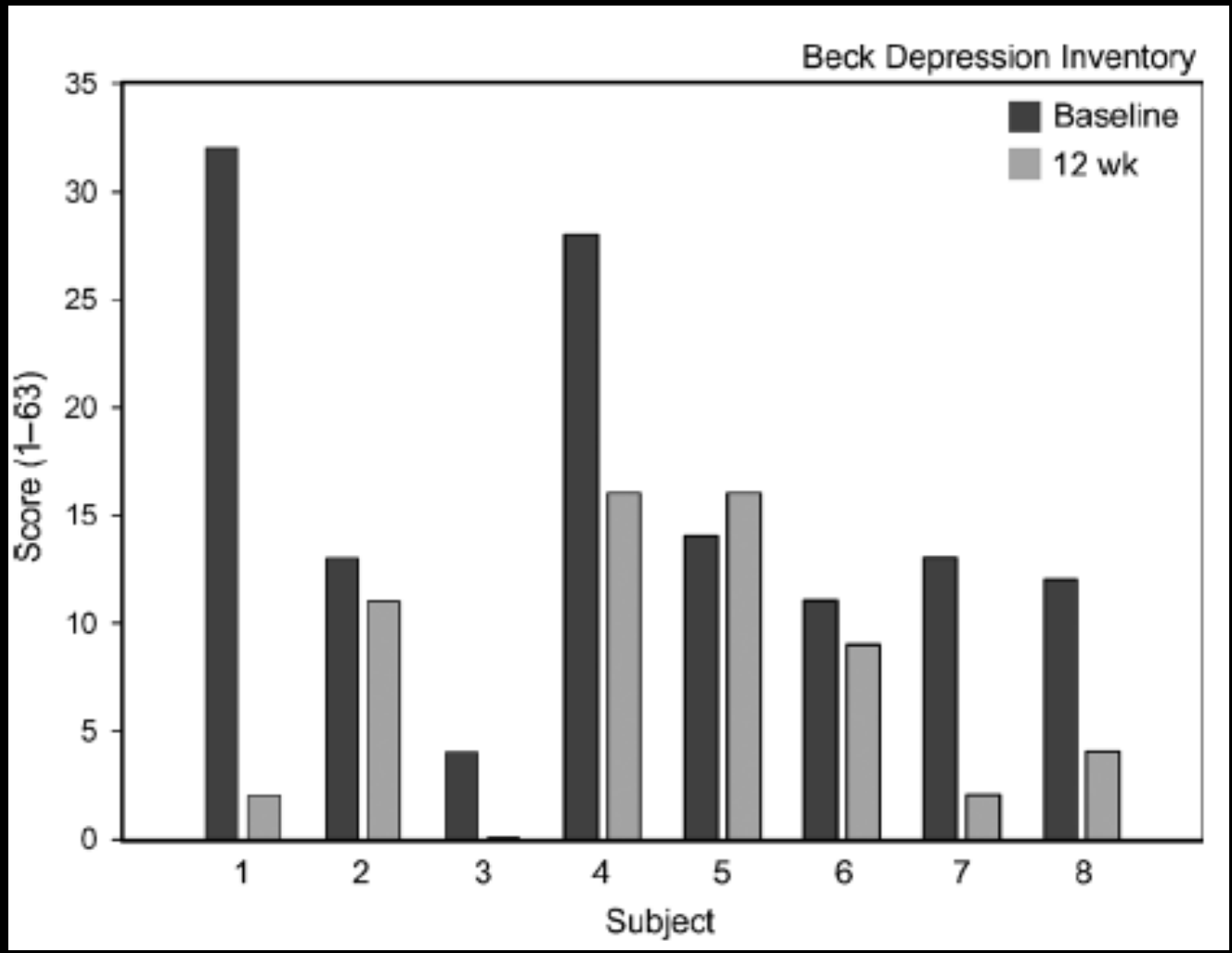


(0-100 numeric rating scale)

Results Summary

- **Continuous chronic stimulation:**
  - 2 patients ⇒ persistent reduction of pure-tone tinnitus
  - 6 patients ⇒ short periods of total tinnitus suppression

Graphic representation of performance on the BDI at baseline and treatment Week 12



Results Summary

- Significant improvements in the BDI and tinnitus questionnaires

Discussion & Conclusion

Discussion & Conclusion

- *This study suggest,*
  - **CNS stimulation is feasible and warrants further investigation as a tinnitus intervention**
  - perception of tinnitus may be multifactorial, involving separate pathways for emotional and auditory perception

Discussion & Conclusion

- **Noticeable improvement in subjective ratings but unchanged objectives measures, due to**
  - cortical stimulation influences emotional centers independent of an effect on the percept
  - Placebo effect related to the surgical intervention or continued physician contact

Thanks for your attention!!

Summary of subject responses to cortical stimulation using objective, subjective, and outcome measures of tinnitus at 12 weeks

Subject	Objective Measures		Subjective Measures		Quality of Life Measures		
	Loudness (dB)	Masking Level (dB)	Effectiveness (0–100)	Loudness (0–100)	TRQ	THQ	BDI
1	–22 –21%	2 –4%	65 (NA)	–10 –20%	–59 –61%	–24 –25%	–30 –94%
2	29 –72%	10 –17%	30 (NA)	–5 –7%	–15 –22%	–7 –15%	–2 –15%
3	21 –71%	6 –8%	5 (NA)	–5 –10%	–10 –35%	–5 –13%	–4 - 100%
4	–7 –12%	–38 –53%	0 0%	10 –13%	–6 –12%	–12 –24%	–12 –43%
5	21 –32%	2 –3%	0 0%	0 0%	–5 –8%	–18 –29%	2 –14%
6	–10 –16%	5 –9%	0 0%	15 –18%	–27 –34%	–15 –20%	–11 –85%
7	15 –69%	10 –58%	20 (NA)	–10 –11%	–25 –65%	–22 –42%	–2 –18%
8	–9 –21%	–32 –50%	0 0%	0 0%	–24 –62%	–39 –80%	–8 67%

Conclusion

- **Additional studies will investigate,**
  - improve current delivery to the auditory cortex
  - identify characteristics predicative of postimplantation efficacy
  - require more robust control periods to distinguish the effects of cortical stimulation from the potential placebo effects of surgical intervention