Electrophysiological and Psychological Profiles in Tinnitus Patients

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Introduction
**Tinnitus** is a sensation of noise-like ringing or roaring that is purely subjective.

Lower auditory system affection is usually the cause for the noise, however, higher cerebral structures are also involved (Axelsson & Ringdahl, 1989).

Many tinnitus patients develop several psychiatric symptoms such as: depression, insomnia, problems with auditory perception or poor general & mental health (Folmer et al., 2001).

Tinnitus is associated with reduced cognitive function that affects performance on tasks requiring memory &/or attention (Jacobson et al., 1996).
Electrophysiological studies supported an impaired brain processing in tinnitus patients where abnormal ABR and ERPs findings were recorded (Kehrle et al., 2008).

Dizziness & vertigo are unusual complaints in tinnitus patients. So, vestibular function is not often studied. Some authors suggested a hypothetical possibility of vestibular system impairment in these patients due to close proximity of the vestibular & hearing organs suggesting that they may influence each other.
Abnormal oculomotor findings had been observed in ENG recordings in some tinnitus patients (Shulman and Strashun, 1999; Seabra et al., 1998, Jozefowicz–Krczynska, 2003).

Aims of the Work
Assessment of auditory stimuli processing in tinnitus patients at both brainstem & cortical levels.

Studying different aspects of cognitive & psychological status in those patients through P300 component of ERPs and a series of psychological tests.

Assessing the possibility of central vestibular system affection in cases with tinnitus.

Subjects & Methods
Subjects:

Sixty subjects were included in this study:

Group I:

- 30 healthy subjects with no audiological or vestibular complaints.
- All subjects had bilateral normal peripheral hearing in the frequency range of 250–8000Hz with bilateral normal middle ear function.

Group II

- 30 subjects complaining of tinnitus with no vestibular complaints.
- All subjects had bilateral normal peripheral hearing in the frequency range of 250–8000Hz with bilateral normal middle ear function.
- No history of peripheral or central vestibular disorders, history of CNS or general disease, visual problems, psychiatric disease or functional patients.
Methods:

- Full history.
- Otologic examination.
- Basic audiologic evaluation.
- Auditory brainstem response audiometry (ABR).
- P300.
- Oculomotor test battery of VNG including: smooth pursuit, gaze, saccades as well as optokinetic tests.

Psychiatric evaluations

The first two tests measure the emotional status of patients: Hamilton depression and anxiety scales.

The next two tests assessed cognitive functions:

1. **Mini Mental Status Examination (MMSE).** It is a brief and objective screening test for cognitive impairment.

2. **Trail making test (TMT).** This test has two forms, A and B. Both tests measure a variety of functions including motor speed, visual scanning & visual–motor integration.
Results

Tinnitus Description in Group II

<table>
<thead>
<tr>
<th>Laterality</th>
<th>Unilat</th>
<th>36.6%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bilat.</td>
<td>63.4%</td>
</tr>
<tr>
<td>Course</td>
<td>intermittent</td>
<td>47.7%</td>
</tr>
<tr>
<td></td>
<td>continuous</td>
<td>53.3%</td>
</tr>
<tr>
<td>Cause</td>
<td>traumatic</td>
<td>13.3%</td>
</tr>
<tr>
<td></td>
<td>noise induced</td>
<td>20%</td>
</tr>
<tr>
<td></td>
<td>Idiopathic</td>
<td>66.6%</td>
</tr>
</tbody>
</table>
Both groups showed no significant difference as regard age, sex or PTA results.

**ABR results**

ABR was done and traced down to threshold in all subjects.

Absolute and interpeak latencies (IPL) of wave I, III and V were calculated and compared between both groups.
### ABR results in both groups:

<table>
<thead>
<tr>
<th>ABR</th>
<th>Group I</th>
<th>Group II</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wave I</td>
<td>1.67±0.08</td>
<td>1.95±0.16</td>
<td>0.017*</td>
</tr>
<tr>
<td>Wave III</td>
<td>3.68±0.11</td>
<td>3.93±0.33</td>
<td>0.001*</td>
</tr>
<tr>
<td>Wave V</td>
<td>5.70±0.11</td>
<td>6.16±0.41</td>
<td>0.005*</td>
</tr>
<tr>
<td>IPL I-III</td>
<td>2.05±0.15</td>
<td>2.14±0.23</td>
<td>0.01*</td>
</tr>
<tr>
<td>IPL III-V</td>
<td>1.96±0.14</td>
<td>2.23±0.26</td>
<td>0.374</td>
</tr>
<tr>
<td>IPL I-V</td>
<td>4.03±0.14</td>
<td>4.21±.53</td>
<td>.027*</td>
</tr>
</tbody>
</table>

### Results of ABR absolute latency in both groups.
Group II had significantly delayed latency when compared with group I (p<0.05).

Results of ABR IPL latency in both groups.

Results of P300 latency in both groups.
P300 delayed latency was significantly correlated with prolonged I–V IPL of ABR.

<table>
<thead>
<tr>
<th></th>
<th>IPL I-V</th>
<th>IPL III-V</th>
<th>IPL I-III</th>
<th>P300</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPL I-V</td>
<td>P. Correlation</td>
<td>1</td>
<td>.731</td>
<td>.274</td>
</tr>
<tr>
<td></td>
<td>Sig.</td>
<td></td>
<td>.000*</td>
<td>.060</td>
</tr>
<tr>
<td>IPL III-V</td>
<td>P. Correlation</td>
<td>.731</td>
<td>1</td>
<td>.302</td>
</tr>
<tr>
<td></td>
<td>Sig.</td>
<td></td>
<td>.000*</td>
<td>.037*</td>
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<td>.274</td>
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<td>1</td>
</tr>
<tr>
<td></td>
<td>Sig.</td>
<td></td>
<td>.060</td>
<td>.037*</td>
</tr>
<tr>
<td>P300</td>
<td>P. Correlation</td>
<td>.427</td>
<td>.112</td>
<td>.332</td>
</tr>
<tr>
<td></td>
<td>Sig.</td>
<td></td>
<td>.033*</td>
<td>.593</td>
</tr>
</tbody>
</table>

**Correlation between P300 & IPL of ABR**
Psychiatric assessment revealed significant higher scores on HAM-D in group II with 20% of cases had major depressive disorder.

Moreover, group II had significantly higher scores on HAM-A than control with 24% of cases had generalized anxiety disorder.

As regards TM-A and B, both were significantly higher in tinnitus patients (group II) than control (group I).

MMSE was found to be normal in both groups, though tinnitus patients had significantly lower scores than controls.
Results of HAM-D & HAM-A in both groups

Results of psychological tests in both groups.
Correlation between P300 & HAM-A Test.

Correlation between P300 & MMS Test.
Oculomotor test battery of VNG showed abnormal recordings in 66.6% of subjects of group II as the following:

10%: SP only (↓ gain).

40%: saccades only (either ↑ latency, ↑ velocity, ↓ accuracy or any combination)

30%: OPK only (with asymmetry).

Furthermore, 20% of subjects had abnormalities in more than one test.

Gaze–evoked nystagmus were absent in all cases.

Discussion
Tinnitus may be associated with perceptual impairments at various levels of the auditory system.

Researchers tried to support this assumption with electrophysiological evidence.

In this work, ABR & P300 were used to evaluate the auditory pathway.

ABR showed significant prolonged absolute latencies of waves I, III & V and significant prolonged IPL I–III & I–V in tinnitus group when compared with the control.

This was consistent with Rosenhall & Axelsson (1995) who reported the presence of two patterns of ABR abnormalities.
• The first was prolonged waves I, III & V. Findings which are consistent with a lesion in the peripheral auditory system.

• The other was prolonged III–V IPL, indicating a dysfunction in the brainstem.

• Both patterns occurred most often in tinnitus cases with normal hearing or slight hearing loss.

• ABR abnormalities could be explained by abnormal elevation in "spontaneous" neural activity at the level of the IC (Adams 1979; Osen 1972).

• Alternatively, they could be due to intrinsic abnormalities (e.g., ↑ the resting potential of IC neurons) (Melcher et al., 2000).

• Moreover, they could be due to possible efferent systems impairment (Lemaire and Beutter, 1995).
P300 component of ERPs depends primarily on the cognitive evaluation of the stimuli and its latency can be used as a measure of the relative timing of this evaluation process (Coles et al., 1995).

This work showed that tinnitus patients have prolonged P300 latency and this agreed with the work of Attias et al., (1993).

Jastreboff (1996) reported that limbic system is responsible for the impairment felt in tinnitus as it has a role in affecting subject’s attention, memory, detection & processing of auditory stimuli.

This could explain abnormal P300 findings in tinnitus patients since the limbic system had been suggested as one of the multiple generators of P300 (McCarthy et al., 1982).
Moreover, there was a significant correlation between prolonged IPL of ABR & P300 delayed latency indicating that affection of subcortical processing of auditory stimuli might influence cortical one.

This also might indicate that auditory pathway affection at different levels may be involved in the sensation of tinnitus (Chery–Croze et al., 1993).

Tinnitus is associated with depression, anxiety, ↓ cognitive function, ↓ selective or divided attention.

This study revealed that tinnitus patients suffered depressive and anxiety symptoms which is consistent with several studies (Holgers et al., 2000; Folmer et al., 2001; Andersson and Vretblad, 2000).
MMSE & TM tests indicated cognitive disturbance in tinnitus patients. This may stem from the depressive & anxiety symptoms or due to central mechanism (McKenna et al., 1996).

Hallam (1986) suggested that tinnitus affect cognition through two mechanisms:

1–Interference with, or reduced capacity for strategic voluntary control or

2–Disrupted or depleted attention resources due to negative thoughts, continuous orienting to tinnitus or increased self-focused and somatic attention
Dizziness and vertigo are unusual complaints in tinnitus patients.
In this work, oculomotor tests were used to evaluate the central vestibular system.
Results showed abnormal recordings in 2/3 of cases despite of absent vestibular complaints.
Moreover, 20% of subjects had abnormalities in more than one test.

These findings are consistent with several authors who suggested a hypothetical possibility of central vestibular system impairment in tinnitus sufferers.
These abnormalities were either gain reduction in SP, incorrect OPK or saccades.
These abnormalities could be due to microorganic lesions or functional disorders like anxiety & emotional distress (Takagi, 2000; Jozefowicz-Korczynska and Pajor, 2003; Mezzalira, 2007; Kapoula et al., 2009).
All these findings could support a hypothesis of central mechanism of tinnitus perception. In this concept, the perceived tinnitus is transformed into affective component like moods, emotions, disturbed sleep, stress, or anxiety that take place in the CNS (Shulman and Strashun, 1999; Lockwood et al., 1998; Jozefowicz–Korczynska et al., 2005).
Tinnitus sound is simply a body signal, to which too much attention is paid.

Lack of habituation to this repeating and non-informative signal led to the development of tinnitus complaints.

This study provides evidences that different pathological mechanisms are involved in tinnitus generation which are more extensive than we thought.

These mechanisms include abnormal neuronal activity at the brainstem level as reflected in abnormal ABR or more central mechanisms as reflected in P300 or oculomotor findings.

Cognitive and psychological conditions in tinnitus patients are matters that deserve attention in their evaluation and management.
This study suggested that tinnitus reduces cognitive capacity.

This was evident at both behavioral and electrophysiologic levels.

Our study also showed that there is a possibility of subclinical central vestibular system impairment.

However, results should be interpreted carefully to avoid overestimation of VNG test results.

Further studying of tinnitus based on its severity, laterality, course & its impact on patients using different diagnostic tools is required for further analysis of pathology associated with tinnitus.
Thank You