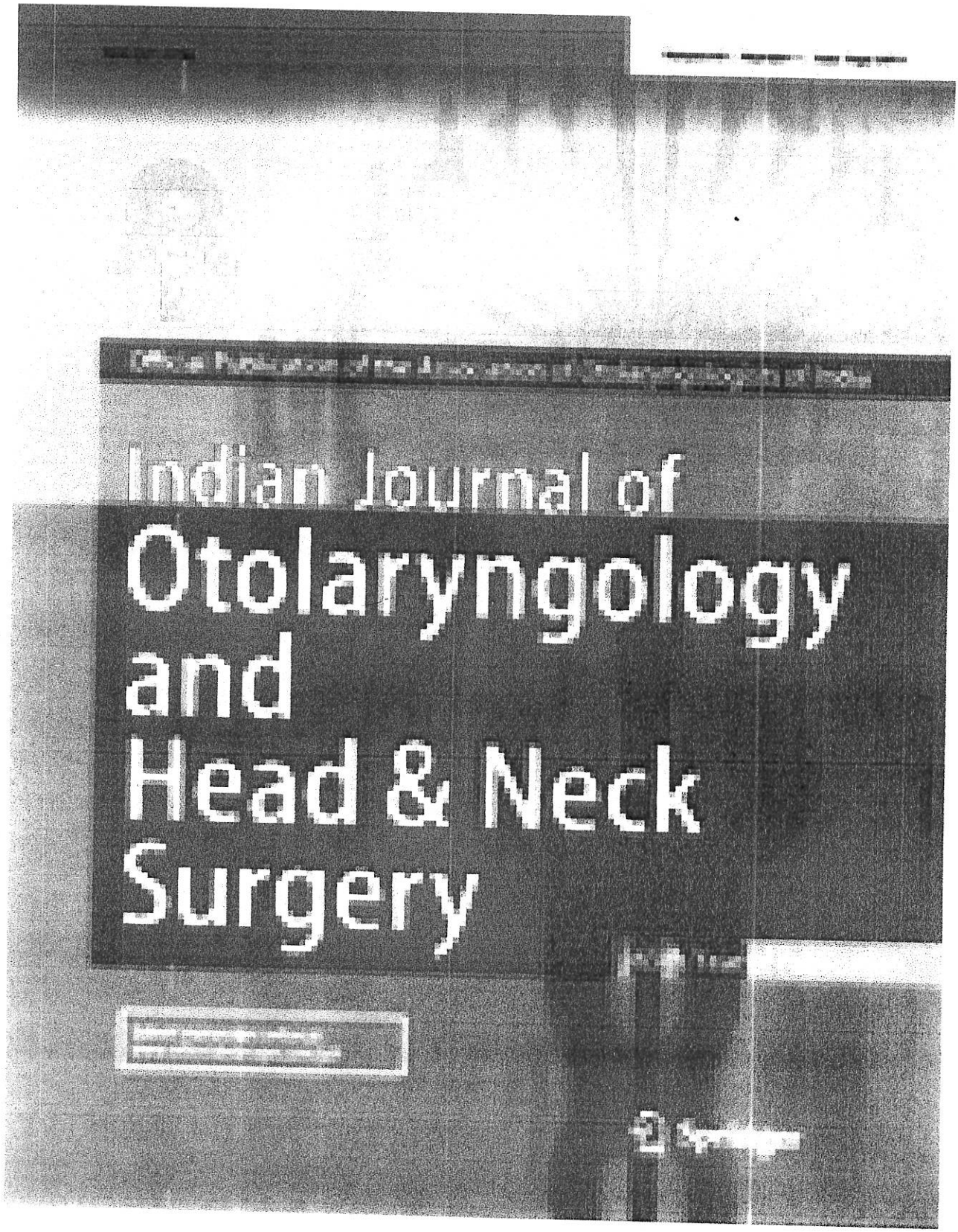
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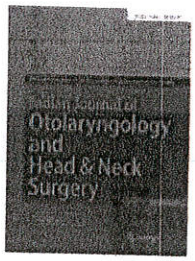

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ORIGINAL ARTICLE

The Association Between Cochlear and Retrocochlear Disorders with Tinnitus with Normal Hearing Thresholds

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Abstract Tinnitus is the perception of hearing the sound without any sound stimulus. It is a symptom of abnormality in a form of conductive disorder when it comes from the outer ear canal and middle ear. A tinnitus complaint has a normal hearing threshold but it has been not fully recognized its causes. Thus, an objective evaluation is needed to locate the abnormality by using OAE and BERA test. To analyze the association of TEOAE, DPOAE, and BERA to locate cochlear and retrocochlear disorders in tinnitus patients with normal hearing threshold. The study was conducted from August to November 2010 until the number of samples was fulfilled in Outpatient Clinic and Audiology Unit in Department of Otolaryngology-Head and Neck Surgery, Dr. Soetomo General Hospital Surabaya. The inclusion criteria in this study included: patients aged 20–50 years old, hearing threshold of ≤ 25 dB, type A tympanogram. The comparison and the association test of TEOAE, DPOAE and BERA in tinnitus group were: TEOAE–BERA analysis result using Mc Nemar obtained $p = 0.006$, Kappa $p = 0.047$, likelihood ratio $p = 0.066$, and the result of DPOAE–BERA analysis using Mc Nemar obtained $p = 0.008$, Kappa $p = 0.439$, likelihood ratio $p = 0.336$. There was a difference in the results of DPOAE examination between tinnitus patients with normal hearing threshold and the control group. There was no difference in TEOAE and BERA test results between tinnitus patients with normal hearing threshold and the control group. This indicates an abnormality in the cochlear.

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Keywords Tinnitus · Mc Nemar test · Kappa test · Cochlear

Background

Tinnitus is the perception of hearing the sound without any sound stimulus [1, 2]. In daily life, tinnitus causes hearing loss which can degrade the quality of life. This is what causes the patient to visit a specialist doctor of Otolaryngology, to evaluate the auditory function with audiometry. It is revealed that there are conductive hearing loss, sensorineural hearing loss and mixed hearing loss. However, in 30% of patients with tinnitus, there is a normal threshold (audiogram within normal limits), providing an impression that there is no hearing loss problem in tinnitus and is often overlooked [3].

The complaint of tinnitus with normal hearing threshold with normal limit audiogram results requires further evaluation as the cause of tinnitus is not known clearly. Tinnitus itself is presummed to have abnormalities in the peripheral hearing pathways, cochlea, retrocochlea to the central, and the possibility of lesions in more than one place. The evaluation on the basis of audiogram alone was not enough to describe the abnormality/location of the cause of tinnitus. The association between the presence or absence of cochlear and retrocochlear abnormalities with normal hearing threshold is still not widely known [1, 4].

A study in tinnitus patients with normal hearing threshold using TEOAE test obtained the pass results of 64%, while the DPOAE obtained the pass result of 90% [5]. The same study conducted by Ami et al. in 2007 using DPOAE test obtained that the amplitude values of tinnitus patients with normal hearing threshold decreased about

Table 1 Age distribution

Age (years)	Tinnitus group	Control group
20–35	6 (42.86%)	9 (81.81%)
36–45	4 (28.57%)	1 (9.09%)
46–55	4 (28.57%)	1 (9.09%)
Total	14	11

Table 2 Gender distribution

Gender	Tinnitus group	Control group	Total
Female	10 (71.43%)	8 (72.72%)	18
Male	4 (28.57%)	3 (27.27%)	7
Total	14 (100%)	11 (100%)	25

Based on the Fisher's Exact test, the gender distribution in both groups obtained $p = 1.000$. There was no significant difference in gender distribution in tinnitus and control group ($p > 0.05$) (Table 2).

Based on the occupation distribution in tinnitus and control group, the most occupation in tinnitus group was housewife as many as 5 subjects (35.71%), while there were 9 subjects (81.81%) in the control group who worked as doctor/paramedic (Table 3). Based on the distribution of educational level in tinnitus group, there were 5 subjects (35.71%) that had attained their undergraduate degree, whereas there were 8 subjects (72.73%) educated undergraduate in the control group. Based on the Mann–Whitney test, the education level of both groups obtained $p = 0.120$. There was no significant difference in the distribution of education level between the two groups ($p > 0.05$) (Table 4). The frequency of the location of tinnitus in the right ear was 5 (35.71%), the left ear was 3 (21.43%), and the left and right ear was 6 (42.86%) (Table 5). In the tinnitus group, the complaint can appear on one side or both sides at the same time (bilateral).

Table 5 The ear location frequency of tinnitus complaints

Ear	Quantity	%
Right	5	35.71
Left	3	21.43
Right and left	6	42.86
Total	14	100

Table 6 The recurrence time in tinnitus complaints

Recurrence time	Quantity	%
Noon	2	14.28
Night	6	42.86
Throughout the day	6	42.86
Total	14	100

The recurrence time of tinnitus complaints were divided into three: during the day, night and throughout the day. The results of recurrence time during the day were 2 subjects (14.28%), 6 subjects at night (42.86%) and 6 subjects all day (42.86%) (Table 6). Based on the period of tinnitus complaint, the fastest patient who came for examination in 2 months was 1 subject (7.14%), the longest 1 subject in

Table 3 Occupation distribution

Occupation	Tinnitus group	Control group	Total
Housewives	5 (35.71%)	0 (0%)	5 (20%)
Machine operator	2 (14.29%)	0 (0%)	2 (8%)
Civil servant	3 (21.43%)	2 (18.18%)	5 (20%)
Doctor/paramedic	1 (7.14%)	9 (81.81%)	10 (40%)
Entreupreneur	1 (7.14%)	0 (0%)	1 (4%)
Baby sitter	2 (14.29%)	0 (0%)	2 (8%)
Total	14 (100%)	11 (100%)	25 (100%)

Table 4 Education level distribution

Group	Uneducated	ES	SHS	Diploma	Undergraduate	Total
Tinnitus	1 (7.14%)	2 (14.29%)	3 (21.43%)	3 (21.43%)	5 (35.71%)	14 (100%)
Control	0 (0%)	0 (0%)	3 (27.27%)	0 (0%)	8 (72.73%)	11 (100%)
Total	1 (4%)	2 (8%)	6 (24%)	3 (12%)	13 (52%)	25 (100%)

Table 10 The DPOAE test results of each frequency in tinnitus and control groups

DPOAOE frequency (kHz)	Tinnitus		Control		*p*
	Pass	Refer	Pass	Refer	
1	6 (42.85%)	8 (57.14%)	11 (100%)	0 (0%)	0.003*
2	10 (71.42%)	4 (28.57%)	11 (100%)	0 (0%)	0.105
3	10 (71.42%)	4 (28.57%)	11 (100%)	0 (0%)	0.105
4	8 (57.14%)	6 (42.85%)	11 (100%)	0 (0%)	0.020*
6	7 (50%)	7 (50%)	11 (100%)	0 (0%)	0.008*

* indicates significant correlation ($p < 0.05$)

Table 11 The correlation of DPOAE results of each frequency in tinnitus and control groups

DPOAOE frequency (kHz)	Tinnitus		Control		*p*
	Pass	Refer	Pass	Refer	
1	6 (42.85%)	8 (57.14%)	11 (100%)	0 (0%)	0.002*
2	10 (71.42%)	4 (28.57%)	11 (100%)	0 (0%)	0.053
3	10 (71.42%)	4 (28.57%)	11 (100%)	0 (0%)	0.053
4	8 (57.14%)	6 (42.85%)	11 (100%)	0 (0%)	0.013
6	7 (50%)	7 (50%)	11 (100%)	0 (0%)	0.006

* indicates significant correlation ($p < 0.05$)

Table 12 The results of BERA test in tinnitus and control group

BERA wave	Tinnitus		Control		*p*
	Mean (ms)	SD	Mean (ms)	SD	
I	1.43	0.13	1.35	0.04	0.044*
III	3.62	0.34	3.42	0.17	0.088
V	5.53	0.33	5.36	0.17	0.119
I–III	2.19	0.33	2.09	0.16	0.332
III–V	1.90	0.13	1.91	0.16	0.819
I–V	4.09	0.31	3.85	0.66	0.219

* indicates significant correlation ($p < 0.05$)

using Mc Nemar obtained $p = 0.008$, Kappa $p = 0.439$, likelihood ratio $p = 0.336$ (Table 13).

Discussion

There was no correlation between TEOAE, DPOAE and BERA to locate the abnormality in tinnitus patients with normal hearing threshold. TEOAE, DPOAE and BERA tests can not replace each other.

In this study, the tinnitus group obtained ear frequency that had tinnitus complaint in right ear of 5 subjects, 3 subjects in left ear and 6 subjects in bilateral ears. This is in contrast to a research in Canada that the location of the left ear is 1.5 times more frequent than the right [13].

Table 13 The comparison test between TEOAE, DPOAE and BERA results in the tinnitus group

Tests	Statistical test	*p*
TEOAE–DPOAE	Mc Nemar	0.688
	Kappa	0.538
	Likelihood Ratio	0.560
TEOAE–BERA	Mc Nemar	0.006
	Kappa	0.047
	Likelihood Ratio	0.066
DPOAE–BERA	Mc Nemar	0.008
	Kappa	0.439
	Likelihood Ratio	0.336

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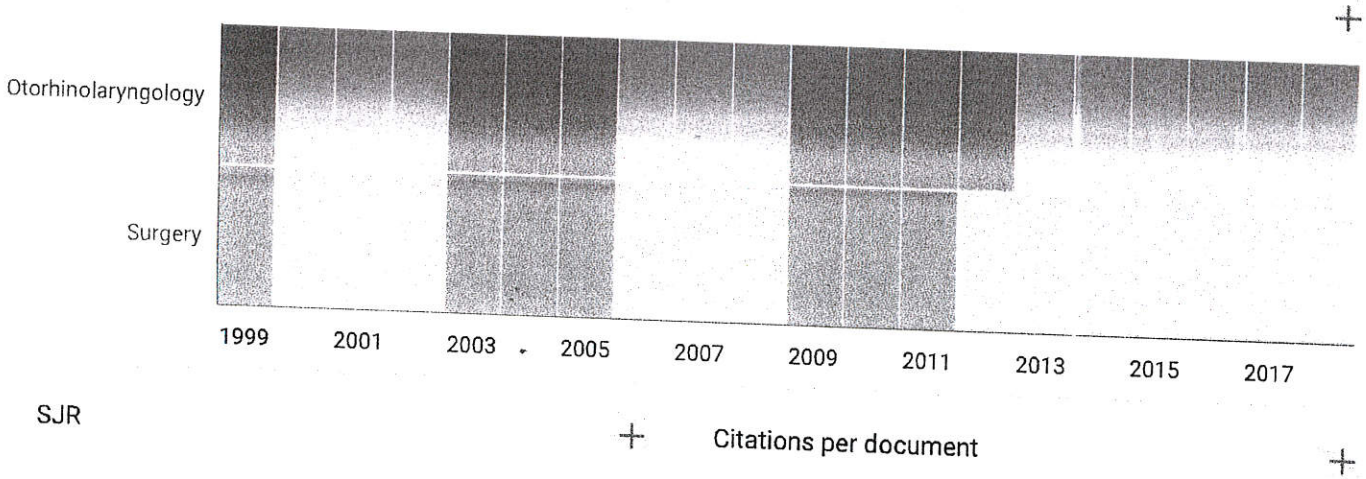

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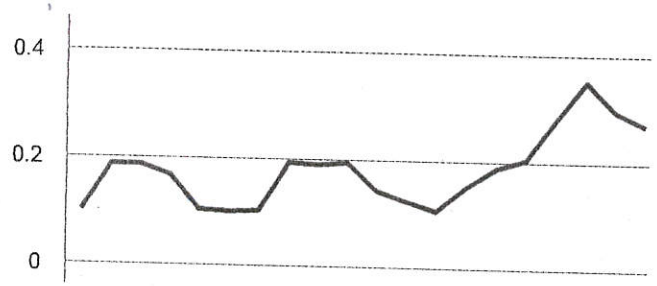

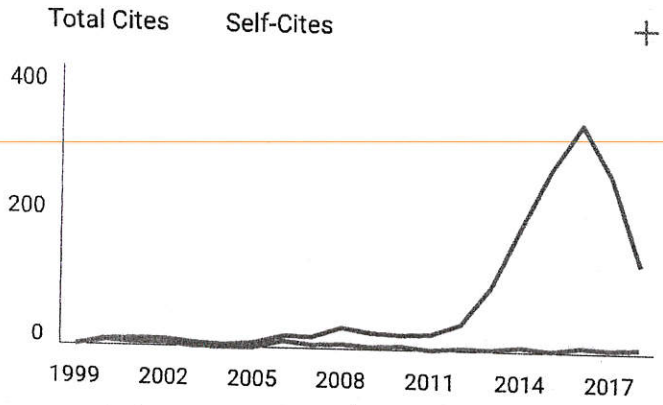

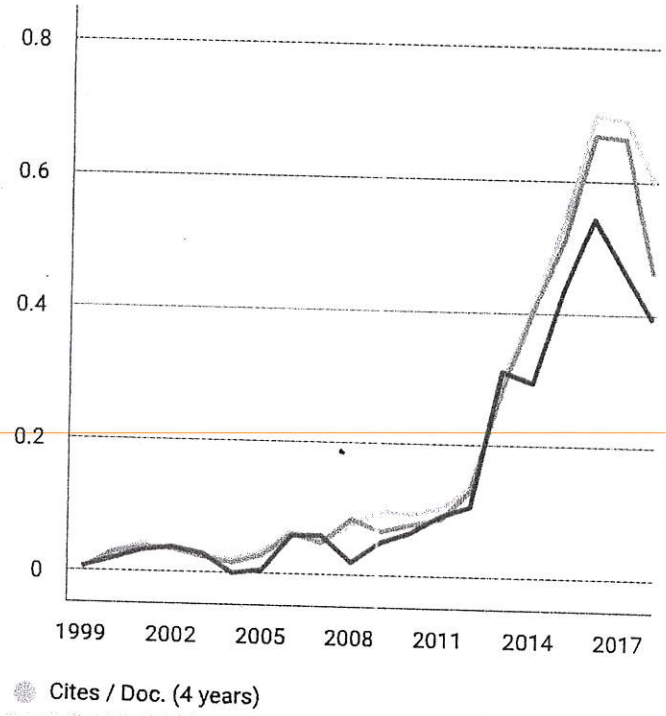

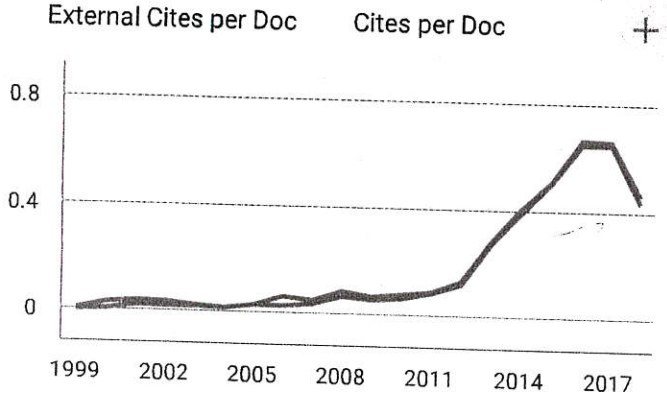

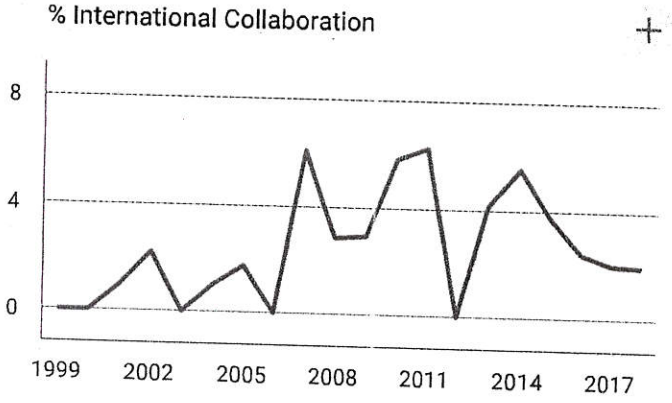

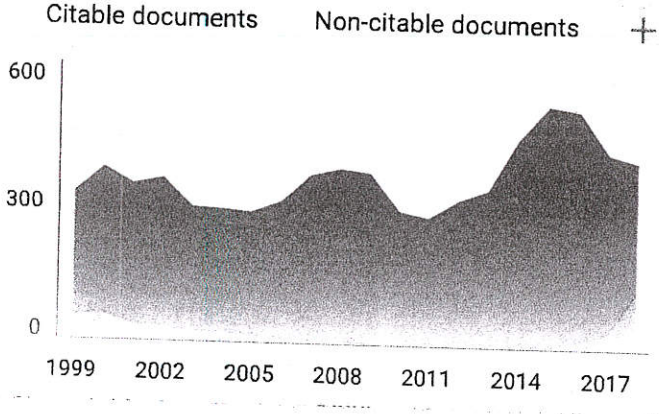

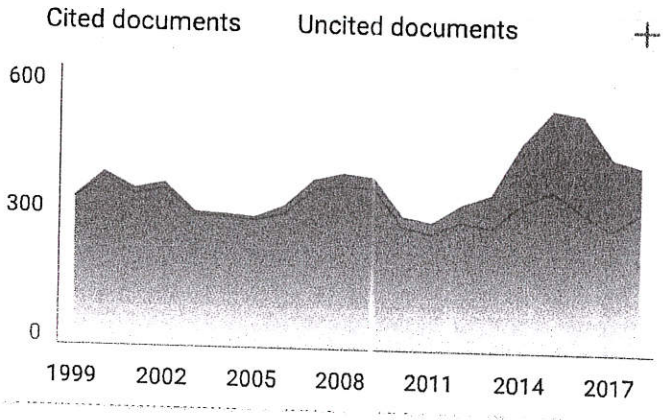

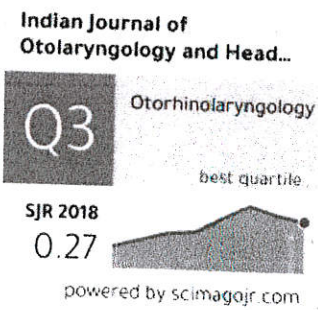

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