Journal of Clinical Neuroscience 94 (2021) 102–106

Contents lists available at ScienceDirect

Journal of Clinical Neuroscience

journal homepage: www.elsevier.com/locate/jocn

Changes in pattern of presentation of patients with unilateral vestibular schwannoma over two decades: Influence of cell phone use in early diagnosis

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ARTICLE INFO

Article history:
Received 16 August 2021
Accepted 3 October 2021

Keywords:
Vestibular schwannoma
Cell phone
Unilateral hearing loss

ABSTRACT

We aimed to study whether the increased use of cell phone in south Asia over the past two decades has impacted presentation of patients with vestibular schwannoma (VS). In this observational cohort study, data on cell phone use and severity of hearing loss and tumor size was collected using a questionnaire through a patient interview (n = 62) in consecutive patients with VS managed between 2017 and 2020. Association between cell phone use and severity of hearing loss and tumor size were studied and compared with our data published earlier when telephone use was not widely prevalent. 71% of the 62 patients (aged between 15 and 81 years) had large or giant VS. Pure tone audiometry showed moderately severe or profound hearing loss in77.4%. Sixty (96.7%) patients used cell phones. 50% of patients complained of difficulty in using their cell phone because of hearing loss. Compared to the earlier era, a higher proportion consulted an ENT surgeon first for hearing loss (59.7% vs 26%; p = 0.0005) and had small or medium sized tumors (29% vs 8%; p = 0.008) with a smaller mean tumor size (3.3 vs 3.9 cm; p = 0.03). Increased cell phone use has led to earlier diagnosis of VS and smaller tumours in recent years when compared to an earlier era. However, the vast majority of patients continue to present with severe to profound hearing loss and large tumors.

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1. Introduction

Unilateral sensorineural hearing loss is the most common initial symptom of patients with vestibular schwannoma (VS) [1–8]. Hearing loss is sensorineural, gradual in onset and mild to profound in degree in the majority of patients with VS, but sudden sensorineural loss has also been reported [2,6]. Despite significant advances in neuroimaging and audiological services, early diagnosis of the disease remains elusive [9,10]. Several patient-related or doctor-related reasons have been postulated for delay in diagnosis [1].

Telephone conversations are usually monaural and provide an opportunity for a patient to recognize mild or moderate unilateral hearing loss. Tumors in the dominant ear may also be diagnosed earlier [1,10]. Contrary to this expectation, Ambett et al [1], from our center, found that telephone use was not associated with early diagnosis of VS. However, their data was from an era of limited landline and cell phone use in India. We hypothesized that the increase in use of cell phones in India since 1995, might lead to early detection of hearing loss and consequently an early diagnosis of VS. In this study, we explore the relationship between cell phone use and diagnosis of VS through assessment of cell phone ownership and use.

2. Materials and methods

2.1. Patients

We performed a retrospective study of 62 consecutive patients admitted to the neurosurgical unit with a diagnosis of unilateral VS, between 2017 and 2020. Patients with Neurofibromatosis II and those with recurrent VS were excluded. Of the 62 patients, 35 (56.5%) patients underwent microsurgery, 14 (22.5%) underwent stereotactic radiosurgery (SRS) and 7 (11.2%) patients underwent planned subtotal excision followed by SRS for the residue. One patient underwent shunt surgery only and another patient

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https://doi.org/10.1016/j.jocn.2021.10.004
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did not consent for surgery. Four patients with intracanalicular tumors were advised yearly follow up.

We compared data obtained in this study with that reported in a study of 50 VS patients from our unit in the years 2003 to 2005 (earlier era) [1]. This enabled us to investigate the impact of cell phone use on diagnosis of VS as only a very small percentage of patients reported using a phone in the earlier era.

The study protocol was approved by the Institutional Review Board of our institution.

2.2. Questionnaire

The following data were gathered: ownership of a cell phone, duration of ownership, duration of cell phone use per day, side and duration of hearing loss, mode of identification of the initial hearing loss (whether by conversation, cell phone use or informed by doctors) and duration of other symptoms. Details regarding specialty of doctor consulted first for hearing loss and the interval between consultation and diagnostic imaging were also recorded.

2.3. Examination and investigations

All patients underwent a neurological examination, pure tone audiometry (PTA) and gadolinium enhanced magnetic resonance imaging (MRI). The maximum size of the tumor was measured on the contrast-enhanced MR sequences, recorded in centimeters, and categorized as <1.5 cm (small), 1.5–2.5 cm (moderate), 2.5–4 cm (large), >4 cm (giant). The severity of hearing loss detected on PTA was classified using Goodman's classification [11] as mild hearing loss (26–40 dB), moderate (41–55 dB), moderate to severe (56–70 dB), severe (71–90 dB) and profound (>90 dB).

2.4. Earlier era data

Data sheets from the earlier study, conducted between 2003 and 2005, by Ambett et al [1] were provided to us by the senior investigator (VR) of that study.

2.5. Statistical analysis

Student *t*-test and the Mann-Whitney tests were performed to determine the significance of hearing loss between the different categories of cell phone ownership as well as to compare with the data from the earlier era. Fisher's exact test was performed to compare the categorical variables of the present study and that from the earlier era. A p value of < 0.05 was considered significant.

3. Results

3.1. Patient demographics

There were 62 patients (32 males and 30 females). The mean age was 45.5 ± 15.4 years (range, 15–81 years). Of the 62 patients, 46 (74.2%) were from India and the rest were from Bangladesh (22.6%) or Sri Lanka (3.2%). Sixty one patients were right handed and one patient was left handed.

3.2. Cell phone ownership and use

Sixty (96.8%) patients used a cell phone and 44(71%) patients owned a personal cell phone. Mean duration of daily use of a personal mobile was about four times longer than the use of a shared family phone (Table 1).

Table 1
Cell phone ownership and use.

Feature	
Ownership (%)	
Personal	44 (71)
Family	16 (25.8)
Mean duration of ownership in years (range)	8 (1–18)
Mean daily use in hours (range)	1.3 (0.08–12)
Mean daily use of personal phone in hours (range)	1.3 (0.16–12)
Mean daily use of family phone in hours (range)	0.4 (0.08–1)

3.3. Detection of hearing loss

Unilateral hearing loss was the initial symptom in 46 patients (74.2%) and the only symptom in 7 (11.3%) patients.

Hearing loss was first noted due to difficulty in using their cell phone by 31 (50%) of the 62 patients. In patients with mild hearing loss, this proportion was higher (57%). Severe or profound hearing loss was diagnosed by PTA in nearly three quarters of patients (Table 2). The median duration of hearing loss for patients with severe or profound hearing loss was 24 months (IQR 12–48; range, 2–168 months) while it was 8 months (IQR 3.25–16.5; range, 1–24 months) for patients with mild or moderate hearing loss ($p < 0.001$). Both patients who did not use a cell phone had profound sensorineural hearing loss and had large (3.9 cm) or giant (4.3 cm) sized tumors.

The only left handed patient in our series had right sided hearing loss that was noted through difficulty in conversation. Of the 61 right handed patients, 31 (50.8%) had right sided tumors and the tumor was left sided in the other 30 (49.2%) patients.

3.4. Other symptoms

Along with unilateral hearing loss, 55 patients reported other symptoms on presentation such as headache, tinnitus, dizziness, imbalance while walking, facial weakness and numbness of face, each with varying frequency. Among these 55 patients, 48 (87.2%) presented with involvement of at least one other cranial nerve and 41 (74.5%) had cerebellar dysfunction. Overall, 32 (51.6%) of the 62 patients had features of raised intracranial pressure.

The median duration of these symptoms (excluding hearing loss) was 15 months (range 3–60 months). In 7 patients, symptoms

Table 2
Features of hearing loss.

Mean duration in months (range)	29 (2–168)		
Side (%)			
Right	31 (50)		
Left	30 (48.4)		
Bilateral	1 (1.6)		
Identification (%)			
Conversation	21 (33.8)		
Cell phone use	31 (50)		
Told by doctors	4 (6.5)		
Others	6 (9.7)		
Grading by pure tone audiometry			
	Right (%)	**Left (%)**	**Total (%)**
Mild	4 (12.5)	7 (23.3)	11 (17.8)
Moderate	2 (6.3)	1 (3.3)	3 (5)
Moderately severe	1 (3.1)	1 (3.3)	2 (3)
Mild to moderate	*7 (21.9)*	*9 (30)*	*16 (25.8)*
Severe	6 (6.3)	7 (23.3)	13 (21)
Profound	19 (59.4)	14 (46.6)	33 (53.2)
Severe to profound	*25 (78.1)*	*21 (69.9)*	*46 (74.2)*
Total	32 (100)	30 (100)	62 (100)

unrelated to hearing preceded and were of longer duration than that for hearing loss (headache in 4 patients and tinnitus, gait ataxia and trigeminal nerve related sensory symptoms in one patient each). In the other 48 patients, these symptoms were present for the same duration as the hearing loss or followed the development of hearing loss.

3.5. Tumor side and size

The tumors were almost equally distributed between the two sides and the mean tumor size was 3.3 cm (range, 0.4–6.2 cm). Large and giant tumors were diagnosed in 24 patients (38.7%) and 20 patients (32.3%) respectively with only 18 (29%) patients having small or medium- sized tumors.

3.6. Tumor size and hearing loss

The median duration of hearing loss in the 7 patients with a small-sized tumor (<1.5 cm) was almost five times more than that of medium to giant tumors (72 months vs. 14 months; p = 0.006).

3.7. Doctors consulted

Over half of the patients (37/62, 59.7 %) initially consulted an ENT surgeon and about a quarter (15/62, 24.3 %) consulted a general practitioner.

However, eight patients either ignored or did not notice their hearing loss and developed symptoms associated with a large tumor which required them to consult either a neurologist or neurosurgeon. One other patient with a 4.3 cm sized tumor initially consulted an ophthalmologist for blurring of vision. Five of these 9 patients used a cell phone for <30 min daily, two for 60 min daily and the remaining two patients for two hours or more daily.

3.8. Delay in diagnosis

The median duration of hearing loss was 18 months (range, 2–128 months). Among the 46 patients who presented with hearing loss as the first symptom, the median duration of hearing loss was 24 months. In comparison, in patients who presented with other symptoms initially, the median duration of hearing unrelated symptom was only half of that of hearing loss (12 months).

3.9. Impact of cell phone use (Table 3)

The median duration of hearing loss in patients who did not use a cell phone or using a shared family phone was nearly double that of patients using a personal phone (24 months vs. 13 months; p = 0.23). There was no significant difference in the side or size of tumor or degree of hearing loss in patients in whom hearing loss was noted through use of cell phone versus those in whom hearing loss was discovered through other means (Table 4). In the 61 patients who had right hand dominance, there was no difference in duration of symptoms in those with right sided tumors versus those with left sided tumors.

3.10. Comparison of the two eras

Use of telephone was reported in 24 (48%) of 50 patients in the earlier era compared to 60 (96.8%) of 62 patients in the present era (p < 0.001). The mean tumor size at the time of diagnosis was significantly smaller in the present era (3.3 cm vs. 3.9 cm; p = 0.03), with a larger proportion of small and medium-sized tumors (29% vs. 8%; p = 0.008) The proportion of patients who sought an initial consultation with an ENT surgeon was also much higher than the proportion in the first era (59.7% vs. 26%; p = 0.0005) (Table 5).

Table 3
Impact of cell phone use on severity of hearing loss, side and size of tumor.

	No phone and family phone (n = 18) (%)	Personal phone (n = 44) (%)	p value
Severity of hearing loss			0.35
Mild to moderate	3 (16.7)	13 (29.5)	
Severe to profound	15 (83.3)	31 (71.5)	
Tumor side			0.78
Right	10 (55.5)	22 (50)	
Left	8 (44.5)	22 (50)	
Tumor size			0.54
Small and medium	4 (22.2)	14 (31.8)	
Large and giant	14 (77.8)	30 (68.2)	

Table 4
Hearing loss, tumor characteristics and mode of detection of hearing loss.

Characteristic	Hearing loss detected through cell phone use (n = 31)	Hearing loss detected through other means (n = 31)	p value
Mean age (years)	44.7 ± 14	47.1 ± 16	0.6
Mean duration of phone use (months)	29.8 ± 35.5	28.5 ± 27.1	0.8
Mean duration of hearing loss (months)	27.1 ± 29.4	28.1 ± 28.3	0.7
Total hearing loss			1
Yes (%)	13 (41.9)	13 (41.9)	
No (%)	18 (58.1)	18 (58.1)	
Hearing loss as the only complaint			0.7
Yes (%)	3 (9.7)	4 (12.9)	
No (%)	28 (90.3)	27 (87.1)	
Severity of hearing loss on PTA			0.6
Mild and moderate (%)	9 (29)	7 (22.6)	
Severe and profound (%)	22 (71)	24 (77.4)	
Side of tumor			1
Right (%)	16 (51.6)	16 (51.6)	
Left (%)	15 (48.4)	15 (48.4)	
Size of tumor			
Mean size (cm)	3.6 ± 1.4	3.1 ± 1.2	0.25
Small and medium (%)	6 (19.3)	9 (29)	0.4
Large and giant (%)	25 (80.7)	22 (71)	

There were other differences that were not statistically significant. These include the mean duration of hearing loss which was almost half of that of the earlier era (p = 0.09) and the proportion of patients with severe and profound hearing loss (77.4% versus 86%, p = 0.3).

4. Discussion

4.1. Delay in diagnosis of VS causing unilateral hearing loss

Unilateral sensorineural hearing loss, the most common symptom of VS, is very often neglected as it does not cause functional impairment in most patients. The prevalence of unilateral hearing loss in a large study from USA was 7.2%, and it was 4.7% for unilat-

Table 5
Telephone use, hearing loss, tumor size and first consultation in the two eras.

Feature	Ambett et al (2003–05) (n = 50)(%)	Present study (2017–2020) (n = 62)(%)	p value
Telephone use	24 (48%)	60 (96.7%)	<0.0001
Mean (±SD) duration of hearing loss (months)	47.4 ± 73.3	29 ± 31.1	0.09
Median duration of hearing loss (months)	18 (1–360)	18 (2–168)	0.86
Severity of hearing lossMild-moderateModerately severe-profound	7 (14)43 (86)	14 (22.6)48 (77.4)	0.33
Tumor sizeSmall - mediumLarge –giant	4 (8)46 (92)	18 (29)44 (71)	0.008
First consultationENT surgeonNon ENT surgeon	13 (26)37 (74)	37 (59.7)25 (40.3)	0.0005

eral hearing loss without tympanometric or otoscopic abnormality [12]. In a study on patients from USA with unilateral hearing loss, almost two-thirds with mild unilateral hearing loss reported excellent or good function and only around a third of patients with moderate unilateral hearing loss reported significant functional disability due to the same [12]. Augustine et al [13] reported that most patients with unilateral sensorineural hearing loss did not report significant psychosocial or auditory handicap. Only mild or moderate handicap was present in a third of their patients. In patients with VS, hearing loss does not affect the quality of life in patients significantly unlike other symptoms like vertigo, dizziness or tinnitus [14,15].

In the absence of functional limitation due to unilateral hearing loss, there is a delay in the diagnosis of VS presenting with hearing loss as the only symptom [1,4,16]. In a series of 1000 patients with VS, those with hearing loss as the initial presenting complaint were reported to have symptom duration of 3.7 years, compared to those with facial paresis (1.9 years) or trigeminal nerve involvement (1.3 years) [4]. In a study of VS patients managed between 1973 and 1999, Rosenberg identified the mean delay in diagnosis to be 7.3 years [6]. In our study, patients presenting with hearing loss as initial symptom had a mean duration of hearing loss which was almost twice that in those presenting with other symptoms.

Twelve of 18 patients with tumors <2.5 cm, in our study, had severe to profound hearing loss at presentation, despite hearing loss being the initial symptom in 15 of them. In six of these 18 patients, hearing loss was the only symptom. This is probably attributable to the lack of functional impairment noted with unilateral mild or moderate hearing loss. Those with larger tumors are likely to consult a doctor for symptoms other than hearing loss (present in 43 of these 44 patients). These findings also highlight the fact that there is probable lack of awareness of the need to investigate asymmetrical hearing loss to exclude retrocochlear pathology among the general population. In a study from our institution, of 90 patients with asymmetrical hearing loss who were evaluated with auditory brainstem response testing and contrast MRI of the brain, 6 patients with VS were picked up. Early detection (VS < 2 cm) was possible in 3 of these patients who had a mild or moderate hearing loss [17].

4.2. Changes in duration of hearing loss

Reports from developed countries indicate that the duration of hearing loss at the time of presentation among patients with VS has reduced in recent years. In a recent study from South Korea, the duration of hearing loss was 18 months prior to diagnosis of VS [18]. Routine use of MRI since the late 1990s has resulted in a higher number of smaller tumors being detected, several of them being detected incidentally [5,9,19–24]. However, the authors of these studies did not report whether the duration of hearing loss had also reduced over time. In contrast, even recent studies conducted in developing and underdeveloped countries reveal a long mean duration of hearing loss. The duration of hearing loss ranges from around 1.5 years to nearly 12 years [7,5–28]. The mean duration of hearing loss at presentation in our study was about half of that reported in the earlier era, though this was not statistically significant. Patients with severe or profound hearing loss had significantly longer duration of symptom prior to diagnosis compared to those with mild or moderate hearing loss.

4.3. Size of tumor and severity of hearing loss

Although, tumor growth during observation has been associated with deterioration in hearing, no correlation has been reported between size of VS and severity of hearing loss [4,6,29–31]. While an increase in tumor size was correlated in deterioration in pure tone audiometry, no significant change in speech discrimination was reported in one study [6]. Our study also did not show a correlation between the tumor size and severity of hearing loss.

4.4. Causes for delay in diagnosis

Ambett et al [1] documented the causes for delay in diagnosis of VS among patients from south Asia who presented between 2003 and 2005. Doctor-related causes were mainly due to misdiagnosis of the disease, especially in the older patients, where hearing loss was attributed to presbyacusis. The mean time to presentation from the time hearing loss was noticed was 47 months. The delay in diagnosis after consulting a doctor was almost 32 months. Additional factors reported by other authors [2,15,19,21] include poor awareness about VS as a cause of unilateral or hearing loss among the doctor community and patients, reluctance in using expensive neuroimaging for the investigation of otologic symptoms and a poor referral system, especially in developing countries [6,7,10,16].

In our study, 59.7% of patients visited an ENT surgeon in their first visit as opposed to only a 26% in the earlier era (p = 0.0005). There was also a significant increase in proportion of small and medium sized tumors in the present study compared to the earlier era, indicating an increased awareness among the medical community towards evaluating patients with unilateral hearing loss with MRI in order to arrive at an early diagnosis.

4.5. Role of cell phones

Cell phones may aid in early identification of unilateral hearing loss as loss of speech discrimination in the affected ear may be detected earlier, particularly if it corresponds to the side of the dominant hand [32]. Cell phone applications are also presently freely available for self-assessment of hearing loss, although awareness of this facility may not be widespread in the community [33].

Seidman et al [32] studied the impact of dominant hand-ear combination on detection of unilateral hearing loss. Their data suggests that patients with right sided tumors are more likely to notice their hearing loss with the use of cell phone. But this was not noted in our findings wherein nearly 50% of patients with right hand dominance had left sided tumors. Similar to our findings, handedness did not significantly correlate with side of hearing loss in a series of patients with otosclerosis [34].

Ambett et al [1] investigated the frequency of telephone use and awareness of hearing loss. They found that a greater percentage of regular telephone users (68%) were aware of hearing loss than non-regular/non-telephone users (54%), but this was not statistically

significant. Our findings are similar in that while a greater proportion of patients who owned cell phones had mild to moderate sensorineural hearing loss and small/medium tumours compared to those who did not own a cell phone, the difference was not statistically significant. Previous studies have shown that screening patients with asymmetrical hearing loss (with a PTA threshold difference of $\geq$15 dB between ears) using audiological tests and neuroimaging will help to identify these tumours early and is ultimately cost-effective [17].

Although there have been some gains in the diagnosis of VS during the present era with higher proportion of patients presenting with mild to moderate hearing loss and smaller tumors, >75% still have severe to profound hearing loss and >70% still present with large or giant sized tumors.

There are several incentives to diagnose VS when it is small. Tator [10] observed that the outcome and cost of treatment were related directly to the tumor size and hence early diagnosis and treatment was invaluable. Additionally, smaller tumor size at the time of diagnosis was associated with better hearing and facial nerve outcome after surgery [18].

5. Conclusions

Increased cell phone use has led to earlier diagnosis of VS and smaller tumours in recent years when compared to data from the same institution published 15 years back. A greater proportion of patients now present with mild to moderate hearing loss, have smaller tumours and consult an otolaryngologist for their problem. However, the vast majority of patients continue to present with severe to profound hearing loss and large tumors necessitating patient and physician education to further improve awareness regarding the need for early screening of patients with unilateral/asymmetrical sensorineural hearing loss with PTA and neuroimaging.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Sources of support: This work did not receive any financial support.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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