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CASE REPORT

Acquired auditory neuropathy spectrum disorder after an attack of chikungunya: case study

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Abstract Auditory neuropathy spectrum disorder (ANSD) is a retrocochlear disorder in which the cochlear functioning is normal but the transmission in the auditory neural pathway is affected. The present study reports of a 14-year-old teenager with acquired ANSD after an attack of chikungunya. He reported symptoms of difficulty in understanding speech, tinnitus and vertigo when exposed to loud sounds. The audiological characteristics suggested auditory neuropathy spectrum disorder with raising audiogram configuration. The results of tinnitus evaluation showed low-pitched tinnitus and it was persistent causing significant handicap to him based on self report tinnitus handicap questionnaire results. The results of depression, anxiety and stress scale also suggested symptoms of mild depression and anxiety. Chikungunya virus is suspected to be neurotropic in nature which can damage auditory nerve cells and may have caused ANSD. The result also shows presence of tullio's phenomenon and absence of cervical vestibular evoked myogenic potentials suggesting damage to the vestibular neuronal system. The possible pathophysiology of chikungunya virus causing ANSD and vestibular symptoms needs to be explored further in future studies.

Keywords Chikungunya · Auditory neuropathy spectrum disorder · Tinnitus · Tullio's phenomenon · Depression · Anxiety

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Introduction

Chikungunya is a form of viral fever caused by alphavirus which spreads by the bite of mosquito *Aedes aegypti* [1]. The fever was first reported by Robinson in 1955 in Africa. Chikungunya epidemic has been reported in several parts of Southeast Asia, like India, Pakistan, Sri Lanka, Myanmar, Thailand, Indonesia, the Philippines, Cambodia, Vietnam, Hong Kong, and Malaysia [2]. The outbreak of chikungunya in India in 2006 was suspected in 13,91,165 patients across India according to the Ministry of Health and Family Welfare, Government of India [1, 2]. The social and economic impact of chikungunya fever has also been tremendous especially in India [2]. The spread of chikungunya virus varies across geographical locations which include the West-African; the East, Central, Southern African (ECSA) phylogroups that have contributed to epidemics in Africa; and the Asian phylogroup [2]. In Asia, chikungunya is maintained in a mosquito–human–mosquito cycle, while in Africa the virus is maintained in a sylvatic cycle involving wild non-human primates and forest-dwelling *Aedes* mosquitoes [3, 4]. In Asia, it is reported to be transmitted by the same mosquitoes as dengue, *A. aegypti* and *Ae. albopictus*. The gold standard for diagnosis of chikungunya fever is by viral culture. Other methods like reverse transcription polymerase chain reaction and real-time loop-mediated isothermal amplification have also been found to be useful. However, serodiagnostic methods for the detection of immunoglobulin M and immunoglobulin G antibodies against chikungunya virus are more frequently used methods [4].

Chikungunya is manifested with triad symptoms namely—fever, severe joint pain and rashes. Chikungunya fever can affect individuals with all age groups. It is reported that the fever can affect males and females equally and the

period of incubation ranges from 2 to 7 days [5, 6]. The individuals suffering from chikungunya exhibit neurological complications such as Encephalitis, myelopathy, peripheral neuropathy, myeloneuropathy, and myopathy [7]. Other complications such as Guillain–Barre Syndrome, ophthalmic problems, hypokalemic paralysis, and acute flaccid paralysis and also deaths were also reported in individuals suffering from chikungunya [8, 9]. Thus, chikungunya fever can lead to lots of neurological complications affecting different sensory organs and can be fatal.

However, the symptoms related to hearing are rarely reported by individuals suffering with chikungunya. Bhavana, Tyagi and Kapila [10] reported a clinical case study with chikungunya who had sudden sensorineural hearing loss. They reported a 15-year-old female who had complaints of unilateral sudden hearing loss after the episode of fever, joint pain and rashes. She was diagnosed as having chikungunya using serological tests and the hearing loss was attributed to chikungunya. However, detailed audiometric results were not reported in the study. The degree of hearing loss was not mentioned and tests like Immittance evaluation, otoacoustic emissions and auditory brainstem response were not done. Hence, there is only one documented report of hearing loss in individuals with chikungunya fever and the study lacks detailed audiological evaluation details. The literature review suggests that chikungunya fever may cause neurological complications and thus it may cause neuropathy of the auditory nerve as well.

Auditory neuropathy spectrum disorder (ANSD) is defined as a retrocochlear disorder in which patient has normal outer hair cells functioning (represented by normal otoacoustic emissions/cochlear microphonics) and an absent/abnormal auditory brainstem response (ABR) [11]. In Indian population, Kumar and Jayaram [12] reported a prevalence of ANSD as 1 in 183 in clients diagnosed as having sensorineural hearing loss. Prabhu et al. [13] studied the risk factors reported in adolescents and young adults with auditory dyssynchrony and reported that factors such as low socioeconomic status, exposure to toxic chemicals, family history of the condition, and onset at the pubertal age could be the possible predisposing factors of late-onset auditory dyssynchrony. Narne et al. [14] studied 198 patients with ANSD and reported that in adolescents and adults with ANSD, 8 of them had onset of the condition which was preceded by high fever. In addition, acquired ANSD is also reported after an attack of high fever, traumatic injury, post mumps and post seizures [14]. Thus, the literature review shows that there is no report of acquired ANSD after an attack of chikungunya. Thus, the present clinical case study attempts to report a unique cause for acquired ANSD followed by an attack of chikungunya fever. The study also attempts to describe the audiological and psychoemotional status of a teenager providing a holistic viewpoint of the clinical scenario.

Materials and methods

A 14-year-old boy reported to audiology clinic with a complaint of reduced hearing sensitivity in both ears. He reported bilateral humming continuous tinnitus in both ears. He reported of difficulty in understanding speech. The client also reported of vertigo (subjective) which lasted for 5–10 min whenever he hears a loud sound (Tullio's phenomenon). He had a history of attack of chikungunya at the age of 13.6 years and auditory symptoms were reported to manifest after the fever because of chikungunya. He experienced symptoms of pain in the joints of fingers and knee joint with high fever and rashes with the onset of auditory symptoms. The IgM ELISA with chikungunya antigen revealed positive results for chikungunya. Thus, based on the symptoms and serological results he was diagnosed as having chikungunya fever. His hearing was reported to be normal with no otological symptoms before the onset of fever. After, recovery from fever through appropriate medications, client reported of continuous tinnitus and difficulty understanding speech in both ears. He reported that sudden continuous tinnitus caused lots of discomfort, anxiety and affected his daily life functioning. He reported that the sudden loss of ability to understand speech and tinnitus caused difficulty in his academics and affected his communication. As time elapsed, he stopped talking to his peer group because of humiliation and was emotionally disturbed.

He underwent detailed audiological evaluation which included pure tone audiometry, speech audiometry, Immittance evaluation, otoacoustic emissions (OAE), auditory brainstem response (ABR) and cervical vestibular evoked myogenic potentials (C-VEMP) was recorded using standard protocols. Pure tone average was determined by averaging thresholds obtained at 500 Hz, 1000 Hz and 2000 Hz. The speech identification scores were determined using monitored live voice presentation of phonemically balanced word list in Kannada at 40 dB SL (re: Speech Recognition Threshold). Clinical neurological examination and CT scan were done to identify any space occupying lesion in the auditory nerve.

Procedure for tinnitus evaluation

He had binaural tinnitus with equal tinnitus loudness and thus, the right ear was chosen. For pitch matching, frequencies were tested between 125 and 8000 Hz. The

frequency at which the pitch was matched by him, loudness of tinnitus was estimated. For loudness matching, the test tone was below his threshold and only an ascending series of intensity levels was employed to minimize residual inhibition. The sound level was increased in small steps until he reported that the external tone is just equal to the loudness of the tinnitus. White noise was presented at 50 dB SPL for 1 min to determine residual inhibition.

Procedure for administration of self report tinnitus handicap questionnaire (SR-THQ)

Self report tinnitus handicap questionnaire (SR-THQ) [15] was administered on him to determine the functional, emotional and catastrophic reactions because of tinnitus. 25 questions of SR-THQ were administered and he was asked to answer the questions as 'Yes', 'Sometimes' or 'No'. The questions in SR-THQ are grouped under 3 subscales namely Functional, Emotional and Catastrophic. The functional subscale has 17 questions, emotional subscale includes 6 questions and catastrophic subscale includes 2 questions. Each 'yes' response was awarded four points, 'sometimes' responses were awarded 2 points and 'no' response was awarded 0 point. The total sum of the scores obtained for SR-THQ is 100. In addition, the scores obtained for all the three subscales of SR-THQ are divided by the maximum possible scores for each scale, respectively, and it is converted to percentage and interpreted.

Procedure for administration of depression anxiety stress scales (DASS)

Depression anxiety stress scales (DASS) [16] were administered to determine the depression, anxiety and stress level of the client. It is a questionnaire which has 42 items with three self report scales. The three scales are used to determine the depression, anxiety and stress of the individual. Each subscale has 14 items which are divided into items of 2–5 of for different subscales with similar content. He was asked to answer questions in a 4-point severity scale. He was asked to rate the extent to which he experienced the state in last week. He was instructed that there are no right and wrong answer for the questions.

Ethical considerations

In the present study, all the testing procedures done were using non-invasive technique adhering to conditions of ethical approval committee of the Institute and complied with the declaration of Helsinki. All the test procedures were explained to him and his family members before testing and informed consent has been taken from the patient and his family member for participating in the study.

Results and discussion

The results of the audiological evaluation showed that he had bilateral mild sensorineural hearing loss. The pure tone threshold in right ear was 36.67 dB HL and left ear was 38.34 dB HL. The configuration of hearing loss was raising type in both the ears. The audiogram for both ears is shown in Fig. 1. The speech identification scores were 44 % in right ear and 40 % in left ear. The client had 'A' type tympanogram with absent acoustic reflexes. OAE emissions were normal indicative of normal outer hair cell functioning and ABR was absent indicative of retrocochlear pathology. This raising audiogram is the common type of audiogram configuration reported in individuals with ANSD [11, 12, 14]. The speech perception scores are reduced for a mild sensorineural hearing loss. The speech identification scores are reported to be disproportionate to degree of hearing loss in individuals with ANSD [17]. Clinical neurological evaluation suggested that ANSD and CT scan results showed no space occupying lesion and confirmed the diagnosis of ANSD. All the above findings correlated with the diagnosis of auditory neuropathy spectrum disorder [11, 17].

Chikungunya is reported to have several neurological complications [1, 7, 9]. There are several reports of peripheral neuropathy, myelopathy, myeloneuropathy reported in individuals suffering from chikungunya fever [7, 9]. Other studies reported peripheral neuropathy in 7 out of 49 patients with chikungunya [7] and myelopathy and myeloneuropathy in 26 out of 57 patients with chikungunya fever [9]. Chikungunya virus is suspected to be

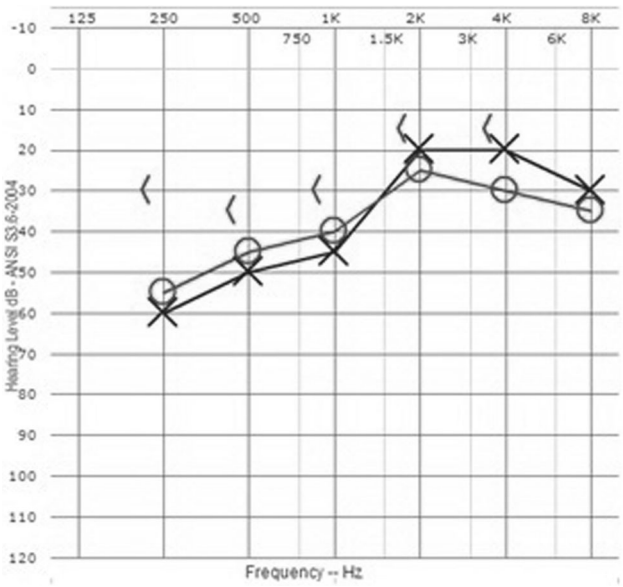

Fig. 1 Audiogram of the client with *right* and *left* ear air conduction thresholds and right bone conduction thresholds

neurotropic in nature which can damage nerve cells [18, 19]. ANSD is reported to occur because of axonal loss, reduction in number of nerve fibers and loss of myelin sheath [20, 21]. Thus, neurovirulence and neuroinvasive nature of chikungunya fever could have damaged auditory nerve fibers leading to auditory neuropathy spectrum disorder. However, the possible mechanism for ANSD because of chikungunya needs to be explored in detail. Cervical VEMP were also absent which suggested an abnormal sacculo-collic pathway. The result is consistent with other studies reported in literature which suggest abnormal vestibular nerve functioning in individuals with ANSD [22, 23]. It has been reported that there are similarities in the vestibular hair cells and cochlear hair cells and the blood supply to both the systems [23]. Thus, the absence of VEMP could be because of the demyelination at the level of inferior vestibular nerve [22]. The presence of Tullio's phenomenon in ANSD is a unique finding and the possible mechanism for the same needs to be determined with other vestibular tests which unfortunately could not be done. All these results suggest that chikungunya virus could have damaged even vestibular portions of eighth cranial nerve or the vestibular pathway. The detailed investigation with vestibular tests would have shed light on the possible site of damage caused because of chikungunya fever.

The results of tinnitus evaluation showed that the pitch of tinnitus was matched to 250 Hz and intensity of tinnitus was 30 dB SL and there was absence of residual inhibition. These results are in consensus with other studies which also report that tinnitus pitch matches with frequency of maximum hearing loss [24]. The result obtained here is also similar to the results obtained by Prabhu and Chandan [25] in ANSD group. Prabhu and Chandan [25] studied psychoacoustic characteristics of tinnitus in individuals with ANSD and reported that majority of individuals with low frequency hearing loss had low-pitched tinnitus. They concluded that frequency of tinnitus matched by the patients with ANSD usually correlates with the degree of maximal hearing loss. The client reported humming type of tinnitus subjectively in the case history which also suggests subjective low frequency tinnitus. The client had raising audiogram configuration with more loss at low frequencies. The subjective estimation of tinnitus is reported to be low pitched in most of the individuals with ANSD [26]. It is also reported in literature that individuals reporting low-pitched tinnitus also had low frequency hearing loss [26].

SR-THQ result showed overall tinnitus handicap of 68 % and emotional, catastrophic and functional handicap score was 66, 75 and 67 %, respectively. The result of SR-THQ is shown in Table 1. Similar result was also obtained by Prabhu and Sneha [27] who reported overall tinnitus handicap of 59.28 % using SR-THQ in 30 individuals with ANSD. The results of subscales of SR-THQ suggested that tinnitus affected the client's functioning in daily life, caused significant emotional problems and it was also found to be catastrophic. However, since SR-THQ is not validated for a teenager, the result can not be easily generalized. The result of DASS showed that the client got scores of 12, 8 and 6 on depression, anxiety and stress scale, respectively. The results are depicted graphically in Table 1. The result shows that depression and anxiety was of mild degree and stress level was normal. The decreased speech identification abilities in the client might have affected his daily life functioning and thus could have lead to depression and anxiety symptoms.

Table 1 The percentage scores of SR-THQ and its subscales and scores on subscales of DASS

SR-THQ (scores in %)		DASS	
Functional scale	67	Depression	12
Emotional scale	66	Anxiety	8
Catastrophic scale	75	Stress	6
Total	68		

Conclusions

The present study reported a teenager with acquired ANSD after an attack of chikungunya. It is a unique clinical condition as there are no reports of chikungunya causing acquired ANSD. The study attempted to explain the audiological characteristics which were similar to any other patient diagnosed with ANSD. It was attempted to determine the possible pathophysiology of chikungunya virus causing ANSD. The chikungunya virus is reported to be neurotropic in nature and may have damaged the neuronal population leading to ANSD. Interestingly, he also reported Tullio's phenomenon which is usually not reported in individuals with ANSD. The abnormal c-VEMP results and Tullio's phenomenon suggest vestibular damage also because of the virus. However, the detailed site of lesion needs to be further explored. He also reported low-pitched tinnitus which worsened his daily life functioning. The result shows that the clinical condition also caused symptoms of anxiety and depression because of sudden difficulty in understanding speech. Hence, the present study tries to explain the audiological and psycho-emotional characteristics of a unique patient with acquired ANSD after an attack of chikungunya. However, the possible mechanism for ANSD after chikungunya fever and the site of lesion and possible pathophysiology of vestibular damage in such patients needs to be explored in detail in future studies.

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Conflict of interest The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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