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Contacts
RARE Journal Secretariat
National Centre for Rare Diseases
Istituto Superiore di Sanità (ISS)
Viale Regina Elena 299
00161 Rome, Italy

Email secretariat@rarejournal.org
http://rarejournal.org/

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ORIGINAL ARTICLE

Use of the incomplete sentences and the 'three wishes' approach in the identification of the subjective perception and impact of cystic fibrosis. The first open methodological experience in Czech voluntary patients: a pilot study

Jan Chrastina
Institute of Special Education Studies, Faculty of Education, Palacký University Olomouc, Czech Republic

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Correspondence to
Jan Chrastina
Institute of Special Education Studies
Faculty of Education
Palacký University Olomouc
Žižkovo náměstí 5
CZ-771 40 Olomouc
Czech Republic
Tel +420 585 635 333
Email jan.chrastina@upol.cz

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Abstract

Aim. Cystic fibrosis (CF) brings numerous limitations and changes in the perception and behaviour. The present study aimed to use a specific qualitative approach to describe the main dimensions and categories in the area of perception/presence of CF in 25 cases. **Methods.** The research (a pilot study) used the open methodological approach of the incomplete sentences (a total of 15) and the 'three wishes' technique in 25 voluntary patients (20 women and 5 men). Two items identified the current condition and sources of support. **Results.** Main dimensions emphasised/signified by cases included particularly health assistance/support and life satisfaction/wishes. The categories of family and patient themselves were the main sources of patients' support. **Conclusions.** The given methodological approach seemed as a highly specific and valuable tool for obtaining the data of subjective nature. The knowledge and understanding of the specifics can help mutual effectiveness in the context of communication, diagnostic and compliance processes in treatment, health/special education and other areas.

Key words

Cystic fibrosis, methodology, impact, subjective perception, incomplete sentences test, three wishes technique.

Background

Cystic fibrosis (CF) is a hereditary disease, which is considered rare. The overall worldwide incidence is between 1:2,500-4,500 of live-borns. In the Czech Republic the incidence is between 1:2,736 (epidemiological and genetic studies) and 1:4,023 (prenatal diagnosis and neonatal screening) of live-borns; in the Czech CF register the current proportion of adults is 39% [1]. At present, the disease can be suppressed, but is not curable. CF is a life-shortening, multisystem genetic disease [2] with the natural course of progressive deterioration in health [3] and leads to respiratory failure and premature death [4]. The dominant symptom is a total failure of the function of the exocrine glands. A typical feature is a high concentration of chlorides in sweat and abnormally viscous mucus in the respiratory, digestive and sexual systems [1, 2]. If the disease is untreated, it often leads to respiratory failure. It should be noted, however, that the treatment and the possibility of a comprehensive approach and interventions are being developed and aim to achieve the highest possible level of the quality of life [3]. The published median survival age indicator is between 30 and 35 years; regarding the progress mentioned above, children born today would probably live up to 40 to 50 years of age [5]. For comparison, the median age of death among individuals suffering from CF followed in the US and UK patients' registries was 27-28 years in 2012 [6, 7]. Although the lifespan for people suffering from CF has markedly improved in recent years [8], CF causes numerous limitations of everyday activities, self-reliance and lifestyle. Last but not least, a very stressful factor is the incurability of the disease and its prognosis. CF is the most common genetically conditioned fatal disease of the Indo-European population [9]. Even in relatively recent times CF was a children's disease and a vast majority of patients died in early childhood [9].

The symptomatology of CF is highly variable. Traditional forms of CF are usually diagnosed at an early age and the symptoms are dominant (together with the presence of two mutations of the CFTR gene) [2]. The most common type of gene mutation is F508del – in more than 66-70% of cases [9, 10]. Atypical forms of CF are often diagnosed in adolescence, or even adulthood. Aggravating conditions and complications include the development of bronchopulmonary disease, often also pulmonary exacerbation [11], pneumothorax, hemoptysis, the so-called cepacia syndrome, pulmonary mykobacteriosis, presence of nasal polyps, insufficiency of external pancreatic secretion, diabetes mellitus, gastroesophageal reflux, chronic metabolic alkalosis, infertility/reduced fertility and many other specific symptoms and syndromes, which depend on the form, severity and presence of complications with the basic disease. In October 2009, nationwide neonatal screening was introduced in the Czech Republic. The immunoreactive trypsin (IRT) in a dry drop of blood was examined. CF patients must adhere to a highly specific hygienic and sanitary-epidemiological regimen, the main purpose of which is to prevent disease transmission (CF itself is not a communicable disease). A very important aspect is the psychosocial support provided to the patients (for deterioration of the health conditions, the issue of terminal conditions, choice and fulfilment of job, disability or partnerships). Psychological and psychiatric support accompanied by medication with anxiolytics and antidepressants are often encountered [12]. Disease progression is reported in infancy and childhood [2]. Finally, adherence to treatment involves a variety of complex behaviours and is time consuming as well, placing a significant treatment burden on the patients [8].

The objective of this study was (i) to use specific methodological qualitative based approach in a target group of CF patients, and (ii) to identify, analyse and describe the current status of subjective perception and impact of CF. The research question was compiled as follows: "What are the specifics/aspects of the main dimensions/categories in the perception/description of the presence of disease in Czech adult (15 years and older) voluntary CF patients participating in an on-line survey (a pilot study)?"

Materials and methods

Participants

The research included a total of 25 voluntary CF patients (closed group of patients on a social network – no further details provided for anonymity reasons) anywhere from Czech Republic (it was not important for the purpose of the research). The research sample included 20 women (80%) and 5 men (20%). The advantage is the fact that no direct meeting took place (the cases had an opportunity to be much more open and give true responses), which eliminated any shyness or greater age differences between the researcher and the case. The researcher (the author of the paper) became a member of that group, but is not a patient himself. The mean age of the research sample was 26.52 years (range 15-37 years; med = 27; mode = 36; SD = 7.51). Individuals were eligible for participation if they were 15 years of age or older, had a confirmed diagnosis of CF (expressed by own consent obtained prior to the testing – in the first part of testing battery). Attributes of gender, socioeconomic status, religion, and so on were not investigated because of their non-significance of the saturation of the research question. According to physician diagnosis of the disease the values were as follows: range 1-35 years; average value = 13.29 years; med = 15; mode = 1; SD = 11.70.

Research design and procedures

The research (a pilot study) used a qualitative approach. The reason is the intent of this approach (i.e. descriptive nature), as well as the investigated phenomenon, which is subjective in nature (i.e. perception/projection). Another reason is an effort to understand the investigated phenomenon in all its depth, and to present the uniqueness of perception of reality by the cases. The research was of an exploratory-descriptive nature and used incomplete sentences and 'three wishes' techniques. The incomplete sentences approach (also published as a separate research method [13]) is based on a principle of completing incomplete sentences according to own opinions, beliefs and health condition. The method provides a high degree of freedom and independence in completing the sentences.

An advantage of this method is also the fact that incomplete sentences evoke a kind of initial stimulation to comment on issues that could be omitted in free writing or interview.

The incomplete sentences and 'three wishes' approach was used to obtain the responses from patients with CF. Data collection was anonymous and performed by means of a closed group of patients on a social network. The data were collected in July 2015 by electronic means and the transcribed version was qualitatively analysed using thematic analysis [14]. From thematic analysis approach, searching for themes, reviewing themes, defining and refining themes, and describing findings were used [14]. All data materials were collected by the author. The test battery consisted of several parts: the first part (introduction of the research plan, request for cooperation, instructions for completion) was followed by 15 incomplete sentences, formulation of three wishes and socio-demographic characteristics (sex, age, presence of CF according to the initial symptoms and physician diagnosis), including one scale item (Likert type) that identified the current condition (*At the moment: I feel: (1) poorly – (5) great*). One item was focused on identification of the current sources of support for the patients. The incomplete sentences focused on: (i) limitations/contributions of CF; (ii) area of responsibilities; (iii) area of joy; (iv) area of sadness;

(v) area of possible suffering; (vi) area of opinions of the society/people in the surroundings; (vii) area of near future and (viii) area of wishes in the time to come. The three wishes technique was designed in a way that the cases were asked to complete three wishes according to the assignment (*If I had 3 magic wishes that would come true, I would go for*). The numerical data were classified and subjected to a basic statistical description, the non-numerical data were analysed by a qualitative approach. Regarding the fact that we chose an approach capturing the highest possible degree of subjectivity (i.e. very short beginnings of incomplete sentences), the responses were coded (open coding), classified and categorized into semantic units. An additional approach was the application of a selective and summary protocol in order to abstract the similar/same semantic dimension while maintaining the original meaning due to thematic analysis. Moreover, regarding the fact that all items (incomplete sentences) had to be completed with a response, it was possible to obtain only a complete data set for further analyses. Prior to application, the incomplete sentences used in the research were subject to semantic and syntactic review (consultation with a methodologist and a psychologist - one patient did not participated in research). The participants' statements were analysed by means of coding and categorization. The results included only those responses whose significance matched the concept of the research and the research question. By means of triangulation (of perspectives) the interpreted dimensions were consulted with two professionals-clinical psychologists and a special education teacher (from two different institutions to ensure objectiveness of opinions). According to the conformity requirement, the statements were formally adjusted, only in terms of categories but not of codes, which were saturated by fragments of direct quotes. There were no changes in terms of content, but only in terms of identification in order to make the areas clear.

Results

Qualitative analysis protocol

The results are arranged in a selective protocol table for simplicity of presentation (Table 1). The results included only valid and complete information with response relevance to the presence of CF and saturation of the research question.

Degree of estimation of the current condition

We also analysed the degree of estimation of the current condition (Likert type scale *At the moment: I feel poorly (1) – great (5)*). The average value was 3.44, which may indicate a sort of "neutrality" in the responses of the subjects (central value). An interesting finding was that none of the participants indicated the current perceived condition as "poor". As a result, higher scaled responses were used. A total of three participants indicated the highest degree ("great"), the largest proportion of the research sample (10 cases) indicated value 4 on the Likert scale. The reason might be various health conditions of the participants (CF progression, disability of organs, etc.), as well as selecting "getting used to the fact that I am unwell and at other times it can be even worse," which could have affected the estimates on the Likert scale. At the time of data collection another influence could have been the degree of social support. This provides space for another research survey that could address only this specific phenomenon with a subsequent secondary analysis. In a study by Abbott et al [15], a total of 50 patients (83% of a sample of 60 adult patients with CF) rated their health as "above/well above average". The responses are shown in Figure 1.

Main dimensions and its categories: the three wishes approach

The methodological approach also included the three wishes technique. Table 2 summarizes the results of this approach. Given that all three wishes had to be completed, we obtained a complete set of valid responses.

Main sources of support

One specific question, in the test battery, examined the main resources providing support expressed by the patients themselves. After analysing the obtained data, the main areas of support are: "family", "patient himself/herself and (less frequently mentioned) "close persons" and "animal". The content of individual sources (unquantified) are indicated in Table 3. Surprisingly, the second source of support was "patient himself/herself", despite the incurable nature of the disease.

Discussion

To our knowledge this was the first qualitative study (using given methodological approach) that identified and described subjective perception and impact of CF in adult (15 years and older) patients. The realised qualitative study brought high valuable data. The findings revealed everyday perceptions of own health condition, wishes and needs towards the own person, as well as people around, or other people (society). We have not identified any publications/studies that would use the same research design. A qualitative research of wishes and concerns (in 15 young adults with CF) using the embedded theory was performed by Higham et al [16]. A frequently discussed issue in adults with CF is also the area of employment [17-19]. Regarding the nature of CF and the time of onset/dominance of symptoms, psycho-social aspects are most often addressed in childhood [20]. The cases repeatedly mentioned the need for regularity, regimen and supervision. This finding is in direct agreement with a study by Hunter [21]. Regarding the fact that the research included only few children (<15 years of age), the findings could not be compared with

Table 1. Main dimensions and categories of incomplete sentences – summary protocol (expressed by patients with cystic fibrosis (n = 25), participating in an on-line survey (a pilot study)

Incomplete sentence	Dimension	Category
CF means to me... (1)	Neutrality	• life; disease; "my life"
	Negativity	• poisoning; difference from the others; restrictions; burden; complication; "bad luck but also motivation"
	Self-perception	• self-denial; challenge and (lifelong, eternal) fight; discipline; "not to give up"; fear; fear of the future
	Vis major	• life control and management
	Relationship with CF	• inhalation; medication; rehabilitation
CF gave me... (2)	Approach to life and own health	• humility; respect for life; enjoying today (uncertainty of the future); faith; strength; to change (a different style); detachment; emphasis on substantial matters; power to fight; another view of the world
	Life complications	• difficulties; "lesson"
	Social support	• friends; "new good people"; learning
	Neutrality/benefit	• "nothing"; "apologize in school for falling behind"; experience; "a lot"
CF took away from me... (3)	Life attributes	• freedom; "a lot of friends"; carelessness; friendship; right to a normal life; superficiality; independence; ideas about life; joy; possibilities
	Family aspect	• "possibility to have a child in a natural way"; have another child
	Time	• "prospects for survival up to 90 years"; future; time; "a piece of life of a normal person"; plans for the future
	Interests	• sport; dancing; travelling; flying; restrictions of lifestyle
	Work related activities	• work in my field of expertise; work with children
	Health	• "my health"
	Loss	• "it took everything"; taste for life
I am usually sad when... (4)	Comparison, failure	• I'm not doing well; I'm not successful in working with horses • "I understand things in context"; "what others can do and I can't"; people around me are concerned about me; people around me are sad because of my disease; I don't want to hurt people around me; I envy healthy people
	Disease	• disease (as a complication of CF); poor prognosis; I'm sick; I'm not well
	Time/finiteness	• "I know that my time is running out"; "how long will I be here with my children"; thoughts about the future; I think about death; death of a sick friend (with CF)
	Neutrality	• "I'm not sad – I believe"
My greatest wish is... (5)	Relationship with the disease	• find a cure/(available) medication; "get close to a kind of life that other (healthy) people have"; live;
	Relationship with health	• recover; stay healthy; never lose control over CF; "live as long as possible (I'm 37 years old)"
	Relationship with the health and life of others	• "I wish my children were healthy"; health for all; "I wish everybody was happy"
	Relationship with the family	• to have and raise a child; "to be here as long as possible for my children and grow old with my husband"; live to senior age, see my grandchildren; have a happy family
	Vis major	• "I wish I wasn't forgotten"; "to achieve something in life and be a known person in the Czech Republic"; already accomplished
It bothers me that... (6)	Other people/society	• misunderstanding of the health condition/disease; physicians in the Czech Republic are not at such level of development as abroad; people do not know much about CF; the media focus on CF mostly in the children's population
	Other qualities	• inability
	Disease	• new drugs are very expensive; searching for a cure is very slow; the need to inhale, taking Creon, sometimes being excluded from a group of people; there is no individualized institutional care in the Czech Republic; poor-quality medical equipment/material; there is still no cure; "I hate inhaling"; often I can't breathe
	Life aspects	• life is not fair; I don't know what to expect in the future; "CF takes so much time (also future time) of my life"; "spend a lot of time with CF"; loss of energy; "CF reminds me of how different I am"; "because of cepacia I can't go for transplantation"
	People around me	• "It's not just my affliction – I also bring suffering to the family, friends, etc."
	Family	• I'm not going to have my own child; "I won't see my son grow"
I would praise myself for... (7)	Success	• marks in school; endurance; effort to help others; good mood; I don't succumb to depression as a result of CF; "how do I manage"; "the fact that I still haven't terminated my life"; "as a female CF patient I gave birth to a healthy child"; psyche; persistence and stubbornness; strong will; detachment; "the fact that I haven't gone crazy after being on oxygen for three years"
	Mask	• "the fact that I'm a good actress and I can conceal things"
	Perspective of others	• "the smiling girl"; "the fact that my mother has taken care of me – this extended my life"
	Life	• previous way of life; attitude to treatment; the fact that I live – regarding my condition – very actively; strength to undergo daily treatment; activity; positivity; "I praise myself for everything"

Continues

Table 1. Continued

Incomplete sentence	Dimension	Category
I am most happy when... (8)	Disease	• when I don't cough too much; good results of medical examination; better spirometry results; when I feel good; when CF does not show symptoms
	Myself - success	• when I'm doing well; when my plans come true; when I do sports
	Joy	• when I'm with animals (they're not bad as people); when I can be with the family and friends; when I see people around me happy; when I see the family happy
	Myself - values	• "when I can be somewhere on my own and think about life – somewhere where no one can hear me coughing and crying, somewhere where I'm free"
At home I have to... (9)	CF symptoms	• depression; when I cough; when I can't breathe very well; fatigue
	Duties	• clean up; do everything as normal people do (sometimes even more than my peers)
	Time	• "manage a lot of things which I'm not good at"; often be home for inhalations
	Care/health	• "fortunately I no longer have to care for anybody else but me"; to follow the treatment/hygienic regimen; get up too early; inhale; take medication; listen to prohibitions and orders – my parents are concerned about me; have the fridge full of high-calorie healthy food
	Neutrality	• common things; it depends; I don't have to do anything – my wife takes care of everything
Sometimes bothers me ... (10)	CF symptoms	• diarrhoea; insomnia; vomiting; mucous blockage; fear; anxiety; depression; cough; constipation
	Time	• falling behind with things; "the older I am the more the disease progresses"; thoughts about what is going to come;
	Questions	• "why me?"; "how long will my insides last and how long will I be strong enough to start the fight with my body every morning"
	Duties	• be dependent on electricity and hygiene; ordinary worries; concerns about what is going to come
	Other people	• "no one understands me and nobody knows what it's like to live with CF"
	Myself	• •carelessness; my helplessness; bad thoughts; inability to do more sports
I am weakest... (11)	CF symptoms	• depression; when I cough; when I can't breathe very well; fatigue
	Duties	• cleaning up; physical work
	Myself	• "I'm overwhelmed by my own matters"; when I admit that the health condition of my child may deteriorate irreversibly any time; I don't have enough time to fulfil my own wishes
	Complications	• flu; when it's very hot; when my son is ill; when there is a problem; when I'm sick; when I'm lying in the Motol hospital and think about what is going to come...; when I'm in hospital on oxygen; I don't want to eat and everything is exhausting
	Neutrality/strength	• "I'm not – I live and fight"; I'm not the weakest; I don't know
	Other people/other	• when people laugh at me; compare me with those without CF; autumn period
I believe that many people... (12)	Relationship with CF	• concerns of others about infection; there are other people in a worse condition (compared with CF)
	Other people	• "they're checking me out"; they don't know about CF; they don't know what is important in life; they don't think as a sick person; "they're wasting time"; they deal with stupid things; they don't appreciate life and health
	Neutrality	• "he has a lot of ideas"; they're idiots
I wish I... (13)	Disease	• recover; live a normal life; "be here as long as possible"; "to wake up in the morning"; extend my life by a new drug; "wake up and find out that CF was just a bad dream"
	Other people	• "be healthy for the family"; "give my son a normal childhood without restrictions"; have a normal family; eradicate diseases; have strength for other people
	Myself	• be happy and be of benefit to others; ability to show others that it is possible to live with CF; finish all planned things; not to feel sorry for myself at the end of my life
	Finiteness	• die; "live at least to 30 years – I'm 16"
If only I could... (14)	Possibilities	• have supernatural abilities; have more money; have millions to find a cure
	Health/relationship with CF	• healthy; I wish CF was curable; be helpful in finding a cure; to win the jackpot and buy equipment for other patients; have quality physicians; be able to meet other patients with CF
	Time	• have many years of life ahead; have more time; see a happy and full life of my children; to be able to control time
	Wishes	• know what it's like to breathe normally; fulfil my own dreams; be happy and contented; have a better physical condition; be able to travel; have a family and be able to take care of them; have more strength and function better
	Neutrality	• I can't think of anything; have a magic ring; have one magic wish
Sometimes I think about... (15)	Priority	• the value of life; CF makes me a better person; about the meaning of life
	Finiteness	• about death; "about death, quite often. Everybody has to die, but perhaps it won't be tomorrow for me"; about dying
	Cure to CF	• when a cure is finally found
	Future	• "live to 50 years"; what will come; about the future; "about what will be then" (after death)
	Myself	• "what would it be like to have a child"; "what would it be like if I didn't know anything about CF"; about why I?; "why cannot I be a normal-healthy person"
	Other	• about how I and my CF is actually perceived by others; about people who are in a worse condition
	Neutrality	• about everything

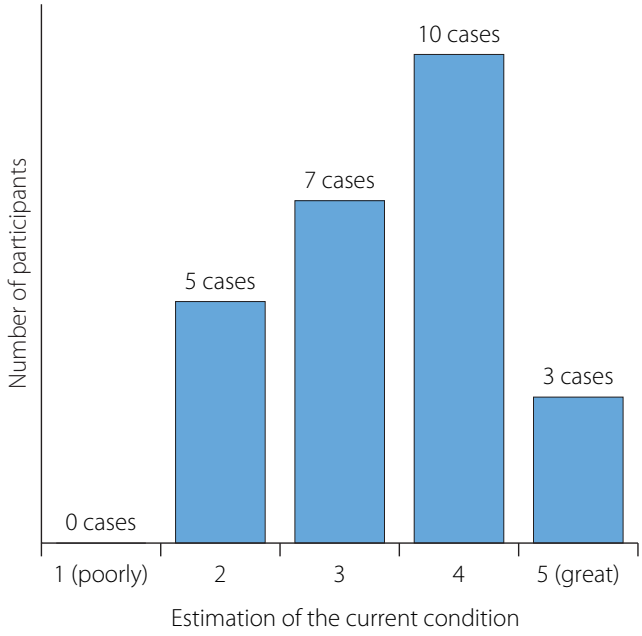

Figure 1. Degree of subjective estimation of the current condition (Likert scale) expressed by patients with cystic fibrosis (n = 25), participating in an on-line survey (a pilot study).

the two main problems of the health condition: diabetes with CF and growth disorders [22]; accordingly, it is not necessary to investigate the association with the quality of life [3, 23-25], including close relatives [26]. The issue of perception of the illness by patients with CF was addressed in a study by Cepuch et al [27]; however, this study included those who have undergone, or are waiting for lung transplantation. The importance of social support, which was often emphasised by the patients participating in the research, was pointed out by Barker et al [28] in the age category of adolescents. A serious problem – stigmatization of CF patients – was highlighted in a research study by Pakhale et al [29]. The perceptions of adults suffering from CF were qualitatively analysed by Abbott et al [11], regarding pulmonary exacerbation. Another study on a similar research topic was conducted by Gee et al [3]. The perception was captured in a view of "general health perceptions" in combination with the impact of gender and disease severity connected with a concept of quality of life. A qualitative analysis similar to author´s topic was used by Filigno et al [30], but in a view of parent experiences with achieving CF nutrition recommendations; and experiences, perceptions and assessments (but of different topic: medical treatment) among patients with CF were discussed by Grotenborg et al [31]. In the socio-cultural context of the Czech Republic, Hodková et al [32] bring interesting findings of coping with CF, but using a quantitative approach (the Cystic Fibrosis Coping Scale). Finally, one similar study focused on perceptions of barriers and facilitators in older adolescents and adults with CF was made by George et al [8], but in a view of self-management decisions.

Partial results suggest a correlation between the severity of the disease (type and progression of CF) and performance of everyday activities. These are limited by the current health condition. The results of our study are in

Table 2. Results of the 'three wishes' (W) technique (main dimensions – categories) expressed by patients with cystic fibrosis (n = 25), participating in an on-line survey (a pilot study)

(W)	Dimension	Category
1st W	CF	• health; possibility to recover; cure; live as long as possible (after lung transplantation); live my life as best as I can; "new lungs"
	Other people	• medications for diseases; good health for all people; "I wish my parents and my brother (also with CF) lived as long as possible"
	Other	• have an own apartment/house; meadow behind the house
2nd W	Values	• happiness; no wars; "make people around me happy"
	Family	• have a family; to have a healthy child; have a happy marriage; health for my family; "have a happy family without everyday concerns about somebody"; I wish nothing happened to my children
	Improvement	• "live a luxurious lifestyle"; be rich; higher pension; fulfil the wishes of people around me
	CF	• cure to CF
	Finiteness	• "I wish I was here a little longer"; "I wish people took me seriously and remembered the good of me"
	Miscellaneous	• visit America
3rd W	People around me	• "I wish I could give my son a childhood that he deserves. Because he is the most amazing and brave child in the world"; have a family with children
	Unused wish	• "I'll leave it to someone else"
	CF	• medicine to cure CF; health; not have CF
	Time/future	• "live to at least 60 years of age"; "be here for many years"; grow old with my family
	Other wishes	• some other wishes; have good luck in my life; "avoid disasters"; world peace; "I wish all people loved each other and were nice"; be smarter; "it's impossible to live without CF, so nothing"
	Miscellaneous	• house by the sea; own a farm; go to Iceland; respect from other people

Table 3. Individual sources supported CF patients (n = 25), participating in an on-line survey (a pilot study)

Family	Patient himself / herself	Close persons	Animal
The family itself; husband/wife; grandmother; boyfriend/girlfriend; brother; parents	Myself ("Sometimes I have to be my own hero")	Friends; My faithful friend (female)	A horse

agreement with those of Abbott et al [33, 34]. They also discovered that daily activities were affected by disease exacerbations, which the patients considered a significant limitation. A frequent requirement indicated by the patients in our study was an adequate and high quality care for all patients with CF. These results are consistent with the partial results of a study by Bucks et al [35] (questionnaire survey in 38 patients with CF) where the patients reported strong doubts about the necessity of chest physiotherapy. The research focused on illness perceptions and treatment beliefs; however, the target group consisted of adolescents with CF. The agreement of our study with the results of a study by Swisher and Erickson [36] can be found in frequent statements of the patients concerning annoying symptoms. Another notable finding of our study was "limitation of freedom" as a result of CF. For comparison reasons, only a single study was found that describes this attribute – this is a research study by Gabatz and Ritter [37] performed only in children with CF. Concerns about the future suggested by the patients in our study are also present in the results of several other studies. In the context of adult persons (i.e. older than 15 years) only a single study was found that highlighted this fact [38], but from the perspective of gender (greater concerns were suggested by women, which is consistent with the women's statement in our study). For patients with long-term chronic and incurable diseases, "their disease" becomes part of their lifestyle and perspective of their own health. This attitude was also suggested in several cases in our study; CF as a 'normal' health state in adult patients with CF was also suggested by Lowton and Gabe [39], and Abbott et al [34]. However, it should be noted that none of the studies discussed above was performed as an online survey in patients with CF, as in the Czech Republic, and using the same (or similar) methodology.

Study limitations

Several limitations should be acknowledged. A limitation of the study might be the absence of a control group. In that case however, the design of the study would be changed, i.e. a case control study or cross-sectional study (quantitative approach). Only after implementation of such type of research the author could identify the specifics of subjective perception typical only for patients with CF (not the objective of this study). Moreover, we are aware of a degree of similarity of the content components of attitudes of patients with CF and attitudes of patients with another disease, including rare diseases. The study was based on the assessment of direct patients' statements; therefore, the findings cannot be generalized. The validity is related only to the specific group of patients studied. Another limitation might be that the researcher did not differentiate the participants' attitudes and experiences by age (i.e. younger and older patients). During the pilot testing the age criterion was set at older than 15 years. The overall concept of the research study – to explore the possibilities of using the specific methodology in the target group of patients with CF – did not include patient differentiation by the criterion of "age".

Information data was analysed as reported by cases with CF, the testimonies should not correspond with actual behaviour and cases may not be aware of or unwilling to discuss some topics that influence their attitudes and behaviour. A certain limit of the study also derives from the current health status of patients, as well as the fact that the study might have involved motivated and talkative patients in a close social network group. A limitation not specific to a qualitative approach was the risk of selection bias, as cases had to be reachable by on-line contact and motivated enough to complete on-line testing via research form (sample size was dependent on participants being sourced from a closed group). Despite these limitations, this research offers the first experiences with highly specific methodological combination, which proved highly sensitive and valuable. It has been able to identify information of a subjective nature that cannot be obtained by quantitative approaches. A novel methodological approach was applied to a target group of CF patients, that can provide essential new opportunity for researchers and clinicians. Further quantitative research is needed for a global statement of valid reality of subjective nature in research action in CF patients.

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ORIGINAL ARTICLE

Audiological profile in osteoporosis

Bhavya M[1], Shashi Kumar Y[2], Deena Priya BJ[3], Rakesh CV[4], Wasim Ahmed[5]

[1]JSS Institute of Speech and Hearing, Mysore, India
[2]Department of Orthopaedics, JSS Hospital, Mysore, India
[3]Dr SR Chandrashekar Institute of Speech and Hearing, Lingarajpuram, Bangalore, India
[4]All India Institute of Speech and Hearing, Mysore, India
[5]JSS Institute of Speech and Hearing, Dharwad, India

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Correspondence to
Bhavya M
Clinical Supervisor
JSS Institute of Speech
and Hearing,
Ooty road, Mysore
Karnataka 570025, India
Email bhavya.j8@gmail.com

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Abstract

Osteoporosis is a multifactorial disease characterized by decrease in bone mineral density and disruption of bony architecture. This reduction in bone mineral density is measured using T-score. T-score of ≥1 is normal, -1 to -2.5 is in the osteopenic range and ≤2.5 is in the osteoporotic range. Various researchers have found an association between osteoporosis and hearing loss. Yeh et al (2015) found a significant relationship between sudden sensorineural hearing loss and osteoporosis. However, there is lack of studies finding the relationship between osteoporosis and hearing loss in Indian population. The present study was undertaken to find the relation between hearing loss and osteoporosis in postmenopausal Indian women. Thirty-three postmenopausal Indian women in the age range of 38-55 were subjected to bone mineral density (BMD) study and T-scores were obtained. Based on the T-scores, participants were divided into three groups. Group I consisted of 12 normal women, group II consisted of 11 osteopenic women and group III consisted of 10 osteoporotic women. Pure tone audiometry, tympanometry and distortion product otoacoustic emissions (DPOAEs) were carried out. Data obtained were subjected to statistical analysis and was found that the mean threshold at all frequencies from 250 Hz to 8 kHz were better for normal, poorer for both osteopenic and osteoporotic group. At all frequencies the effect of reduced BMD on hearing loss was significant. Results indicated that thresholds at all frequencies and pure tone average thresholds were significantly different between the three groups with $p < 0.05$. 'A' type of tympanogram was present in all the groups. DPOAEs signal to noise ratio were significantly different at 3 kHz and 4 kHz between normal, osteopenic and osteoporotic group with $p < 0.05$. However, there was no significant difference between the groups at 1 kHz and 2 kHz. Both osteopenic and osteoporotic group showed a greater number of individuals with sensorineural hearing loss. The present study indicates a stronger relation between osteoporosis and hearing loss. Effect of osteoporosis on auditory system using this test battery indicated bilateral sensorineural hearing loss.

Key words

Osteoporosis, osteopenia, bone mineral density, hearing loss, signal to noise ratio.

Introduction

Osteoporosis is defined as a progressive systemic skeletal disorder characterized by low bone mineral density (BMD), deterioration of the microarchitecture of bone tissue, and susceptibility to fracture [1]. Our bones are comprised of two major ingredients: minerals (including calcium and phosphorous), and bone cells (consisting of osteoblasts and osteoclasts). Normally bone formation (osteoblastic activity) and bone resorption (osteoclastic activity) are in balance and depend on many factors (age, endocrine function, nutrition and genetics).

There are two major types of bone: cancellous bone (also known as trabecular bone), which is the inner, softer portion of the bone, and cortical bone, which is the outer, harder layer of bone. Cancellous bone undergoes turnover at a faster rate than cortical bone. As a result, if osteoclast and osteoblast activity become mismatched, cancellous bone is affected more rapidly than cortical bone. In osteoporosis the amount of cortical and cancellous bone is decreased, haversian canals are widened, and the rate of bone resorption exceeds the rate of bone formation.

Osteoporosis may be classified as primary osteoporosis and secondary osteoporosis. Primary osteoporosis is a metabolic bone disease characterized by low bone mass and microarchitectural deterioration of bone tissue, leading to enhanced bone fragility and increased fracture risk. It represents bone mass loss that is unassociated with any other illness and is related to aging in women and men. Primary osteoporosis has been most frequently recognized in elderly women. It is further classified into post-menopausal osteoporosis and senile osteoporosis.

Post-menopausal osteoporosis (type I primary osteoporosis) affects postmenopausal women but younger than 70 years. Type I osteoporosis is characterized by increased bone resorption due to osteoclastic activity, which is due to oestrogen deficiency. Vertebral crush fractures and fractures of the distal radius (colles fractures) are the main complications. Senile osteoporosis (type II primary osteoporosis) occurs when there is excessive bone loss manifested after age 70 in both women and men. Type II osteoporosis results from normal aging and is associated with a steady, 1-2% loss of cortical and cancellous bone mass each year. Hip and vertebral fractures are most common in this type of osteoporosis.

Secondary osteoporosis can result from a variety of chronic conditions that significantly contribute to bone mineral loss, or it can result from the effects of treatment regimens that compromise normal bone metabolism, like corticosteroids or chemotherapeutic agents, and nutritional deficiencies. It may arise at any age and affect men and women equal. Most commonly observed osteoporosis is the postmenopausal one which affects the bone metabolism.

Following menopause there is loss of bone mass by about 3-5% per year, and there is decline in collagenous bone matrix resulting in osteoporotic changes, which is primarily due to deficiency of oestrogen. For women, in addition to age, the menopause transition itself causes an extra degree of bone loss. This bone loss is greatest in the first three to six years after menopause. Women can lose up to 20% of the total bone mass during this time. Since women generally have a lower bone mass to begin with in comparison with men, the ultimate result is a higher risk of fracture in postmenopausal women as compared to men of the same age.

Generally, osteoporosis is asymptomatic until a fracture occurs. Tests that measure the bone strength and diagnoses at an early stage are of importance. Bone mineral density (BMD) study has been reported to correlate for more than three quartiles of total bone strength. The reduction in BMD is measured using T-score. WHO criteria defines T-score of more than -1 as normal, -1 to -2.5 as osteopenic and less than -2.5 as osteoporotic. Osteopenia is a milder form of bone loss and it is thought to be a precursor of osteoporosis.

Osteoporosis and osteopenia are systemic illnesses and all bones are affected. Most often hip and spine bones are affected, but ear bones can be damaged too. Demineralization of the temporal bone including otic capsule and internal auditory canal may be one biological factor contributing to hearing loss. Hearing loss may be an under recognized complication of osteoporosis [2-4]. Shafer (2006) studied the relationship between bone loss and dizziness in post-menopausal women, and hypothesized that that bone loss is associated with benign paroxysmal positional vertigo (BPPV) [5]. A research study done by McKenna et al (2004) explored the clinical relationship between osteoporosis and otosclerosis citing a common gene COL1A1 associated with both conditions [6]. Henkin et al (1972) indicated increased sclerosis of cochlear and vestibular labyrinths in four of seven patients with idiopathic osteoporosis [7]. Horner (2009) suggested a possible relationship between recurrent BPPV and a decreased fixation of calcium in bone in postmenopausal women [8]. Yeh et al (2015) found a significant relationship between sudden sensorineural hearing loss and osteoporosis [9]. On the contrary, Babich et al (2009) reported conductive hearing loss in osteoporosis [10]. These findings suggest that there may be a pathology in the middle and/or inner ear of the patients with osteoporosis. In our clinical practice we observed that sensorineural hearing loss was more frequent than conductive hearing loss in patients with osteoporosis. There was lack of studies finding the relationship between osteoporosis and hearing loss in Indian population. Hence the present study was undertaken to find the relation between hearing loss and osteoporosis in postmenopausal Indian women.

The aim of the study was to profile the bilateral audiological findings including pure tone average, type of tympanogram, otoacoustic emissions in osteoporotic and osteopenic patients and to see if it varies with that of age matched controls.

Materials and methods

Thirty-three post-menopausal Indian women in the age range of 38-55 were included in the study. Women were eligible to participate if they did not have a prior history of ear surgery, otosclerosis and excessive exposure to noise.

Instrumentation for the present study included 4 instruments. Omnisense instrument was used for assessment of BMD. This instrument consists of a desktop system and small handheld probes of differing sizes to measure the different sites. The probe includes both the transmitter and the receiver. A two channel clinical audiometer consisting of supra-aural headphones with ear cushions was used for obtaining pure tone audiogram. The audiometer was calibrated to conform to ANSI standards. Calibrated middle ear analyzer GSI-Tympstar was used for doing tympanometry. Calibrated Otoread was used for measurement of distortion product otoacoustic emissions (DPOAEs). All the audiological testing was carried in a sound treated room and noise levels were within the permissible limits as per ANSI (1991) [11].

All the participants underwent a BMD assessment by quantitative ultrasound method. BMD is simple non-in-

vasive procedure and was performed by an orthopedician. Bone mineral density test measures the absolute amount of bone which generally correlates with bone strength and its ability to bear weight. BMD was measured in the participants using Omnisense (Sunlight) instrument and the T-scores were obtained in the distal radius bone by measuring the speed of the sound along a fixed distance of bone parallel to its axis. Thrice the measurements were done and a graph was displayed with the T-score. Based on the T-scores, participants were divided into three groups. Group I consisted of 12 normal women with T-score of ≥1. Group II consisted of 11 osteopenic women with T-score between -1to -2.5. Group III consisted of 10 osteoporotic women with T-score ≤2.5.

Case history was taken for the participants and questions were asked regarding subjective hearing loss, dizziness, tinnitus, and prior ear trauma or surgery. The following categories of information were obtained: demographics (age, phone number), medical history [age at menopause, medical disorders (thyroid disease, diabetes)], and medication used (chemotherapy, diuretics, oestrogen for hormone replacement therapy (HRT)], nutritional status (use of calcium supplementation).

Initially pure tone audiometry was done. Air conduction thresholds were determined across octave frequencies from 250 Hz to 8000 Hz and bone conduction thresholds were obtained from 250 Hz to 4000 Hz for both the ears. The thresholds were obtained using modified version of Hughson and Westlake procedure [12]. Tympanometry was obtained for 226 Hz probe tone to evaluate the middle ear status for all the subjects. An otoacoustic emission test was done. DPOAE SNR were measured using 2 primary tones with frequencies of f1 and f2. The ratio of frequencies of the 2 primaries (f1/f2) was constant at 1.2. The f2 frequency varied from 1.5kHz to 4kHz and the intensity levels of primaries was maintained at 65dBSPL and 55dBSPL respectively for f1 and f2 [13] to produce optimum results.

The data collected from participants was tabulated. A commercially available statistical package for social sciences (SPSS-version 15.0) was used for statistical analysis.

Results and discussion

Data obtained were analyzed using generalized linear model statistical analysis to compare the thresholds across frequencies, pure tone average (PTA) and SNRs of otoacoustic emissions across frequencies between normal hearing individuals, osteopenic and osteoporotic individuals and to evaluate ear difference.

Pure tone audiometry

Results of mean threshold and standard deviation (SD) of frequencies and PTA obtained for normal, osteopenic and osteoporotic for right and left ear are shown in Table 1.

Table 1 shows that mean thresholds at all frequencies from 250 Hz to 8 kHz were better for normal women with a mean pure tone average threshold of 16 dBHL for right ear, 16 dBHL for left ear. Both osteopenic and osteoporotic group had poorer threshold compared to normal. Osteopenic group had poorer mean thresholds at all frequencies with a mean pure tone average threshold of 26 dBHL for right ear and 24 dBHL for left ear. The osteoporotic group also had poorer mean threshold at all frequencies with a mean pure tone average threshold of 22 dBHL for right ear and 20 dBHL for left ear. It is evident from Figure 1 that normal groups had a better threshold at all frequencies and PTA compared to osteopenic and osteoporotic group. To assess the difference in the thresholds of all the frequencies and PTA across three different groups and across two ears, two way ANOVA was done. At all frequencies the effect of reduced bone mineral density on hearing loss was significant with $p < 0.05$. Results of two way ANOVA are shown in Table 2. Results indicated that thresholds at all frequencies and pure tone average thresholds were significantly different between the three groups with $p < 0.05$. However, the effect of ear and the interaction effect of ear and groups were not significant at all the frequencies and PTA with $p > 0.05$. To evaluate significant differences in the three different groups, Scheffe's post hoc comparison was used. Results of Scheffe's post

Table 1. Mean and standard deviation of frequencies and pure tone average of normal, osteopenic and osteoporotic for right and left ear in dBHL

	Normal group				Osteopenic group				Osteoporotic group			
	Right ear		Left ear		Right ear		Left ear		Right ear		Left ear	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
250 Hz	16	7	15	6	27	9	24	12	16	7	15	6
500 Hz	17	8	19	7	27	9	26	9	23	8	24	15
1 kHz	15	5	15	5	25	9	24	7	23	8	21	8
2 kHz	14	3	15	5	27	14	21	9	24	9	21	11
4 kHz	15	5	15	9	34	14	27	12	28	12	28	11
8 kHz	19	13	17	8	39	21	40	24	36	13	28	13
PTA	16	4	16	5	26	9	24	8	22	8	20	8

PTA, pure tone average; SD, standard deviation.

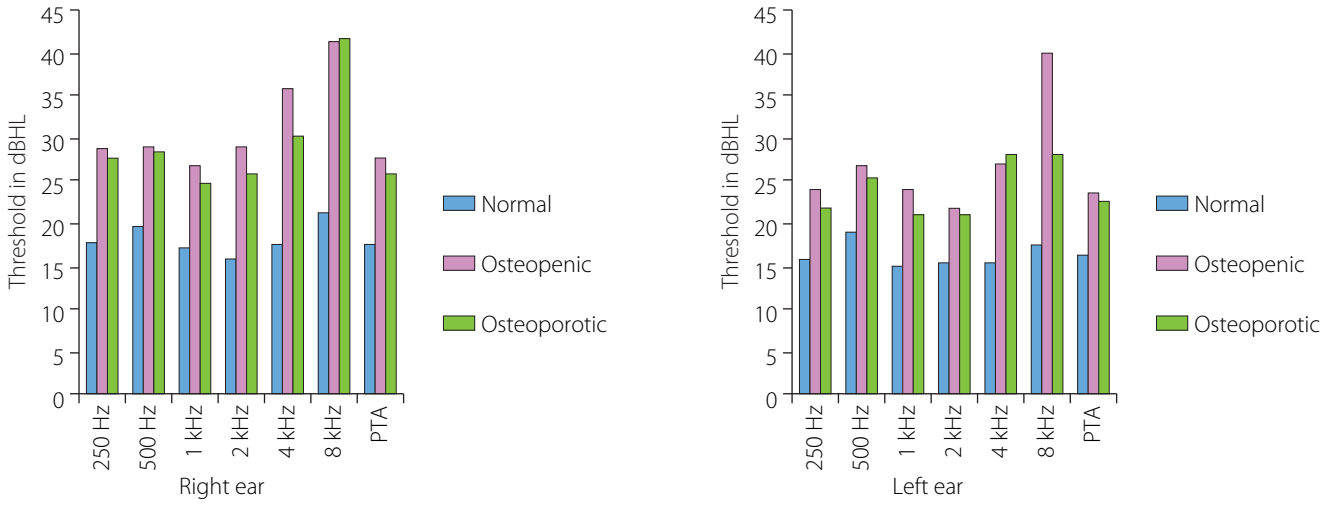

Figure 1. The mean threshold across all frequencies and pure tone average for right and left ear for normal, osteopenic and osteoporotic individuals.

Table 2. F value and significance values: between groups, across ears and for interaction of group and ear

	Frequencies	F value	Significance (p)
Between groups (normal, osteopenic and osteoporotic)	250 Hz	5.88	.005
	500 Hz	5.19	.008
	1000 Hz	10.0	.000
	2000 Hz	6.4	.003
	4000 Hz	11.5	.000
	8000 Hz	9.8	.000
	PTA	8.176	.001
Across ear (right and left)	250 Hz	1.10	.297
	500 Hz	.001	0.97
	1000 Hz	0.37	0.54
	2000 Hz	1.000	0.32
	4000 Hz	.901	.346
	8000 Hz	.688	.410
	PTA	.859	.358
Interaction of group and ear	250 Hz	.145	.865
	500 Hz	0.081	0.9
	1000 Hz	0.06	0.93
	2000 Hz	0.702	0.50
	4000 Hz	.612	.545
	8000 Hz	.407	.667
	PTA	.429	.653

hoc comparison showed that the thresholds at all frequencies and PTA were significantly poorer in osteoporotic and osteopenic group compared to normal group. However, there was no significant difference between osteopenic and osteoporotic group. Table 3 shows the result of the Scheffe's test.

Immittance

Cross tabulation was done. Results can be summarized in terms of type of tympanogram obtained in normal, osteopenic and osteoporotic individuals as shown in Table 4. Table 4 shows that among the types of tympanogram obtained in the participants, A type was present in 23 ears

Table 3. Results of the Scheffe's test for thresholds at all frequencies and PTA across the three groups

Frequencies	Groups	Osteopenic	Osteoporotic
250 Hz	Normal Osteopenic	Significant*	Significant* Not significant
500 Hz	Normal Osteopenic	Significant*	Significant* Not significant
1000 Hz	Normal Osteopenic	Significant*	Significant* Not significant
2000 Hz	Normal Osteopenic	Significant*	Significant* Not significant
4000 Hz	Normal Osteopenic	Significant*	Significant* Not significant
8000 Hz	Normal Osteopenic	Significant*	Significant* Not significant
PTA	Normal Osteopenic	Significant*	Significant* Not significant

*$p < 0.05$.

Table 4. Type of tympanogram: count and percentage obtained in each group

Type	Value	Group			Total
		Normal	Osteopenic	Osteoporotic	
A	Count %	23 95.8	21 95.5	18 90.0	62 93.9
A_s	Count %	0 0	0 0	1 5	1 1.5
A_d	Count %	1 4.2	1 4.5	1 5	3 4.5
Total	Count %	24 100	22 100	20 100	66 100

Table 5. Mean and standard deviation of DPOAEs SNR in dB across the three groups and across right and left ear

	Normal group				Osteopenic group				Osteoporotic group			
	Right ear		Left ear		Right ear		Left ear		Right ear		Left ear	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1.5 kHz	11	7	15	6	10	6	12	8	12	6	14	6.9
2 kHz	17.6	6	18	6	11.8	9.5	13.6	9.7	15	7.8	15	7
3 kHz	18.3	5.5	18.2	5.0	13.0	8.2	13.2	7.6	13.6	7.9	14.1	7.7
4 kHz	12.6	5.3	15.6	4.9	6.9	6.2	11.4	8.0	10.1	4.7	9.7	7.6

SD, standard deviation.

in normal, 21 ears in osteopenic and 18 ears in osteoporotic group. A_d type was present in 1 ear in each of the groups. A_s was present in 1 ear in osteoporotic group.

Otoacoustic emission

DPOAEs SNR obtained in three different groups across two ears were compared. Table 5 shows mean and standard deviation. It is evident from Table 5 that mean DPOAEs SNR were similar across the three groups in both right and left ear for 1.5 kHz and 2 kHz, better in normal compared to osteopenic and osteoporotic group at 3 kHz and 4 kHz. Figure 2 shows that DPOAEs SNR are better in normal compared to osteopenic and osteoporotic group at high frequencies. To assess the difference

in DPOAEs SNR across the three different groups for two ears, two way ANOVA was done. Results of tests indicated that DPOAEs SNR were significantly different at 3 kHz and 4 kHz between normal, osteopenic and osteoporotic group with p <0.05. However, there was no significant difference between the groups at 1 kHz and 2 kHz with p >0.05. The effect of ear alone and the interaction effect of ear and group were not significant with p >0.05. Results of two way ANOVA are shown in Table 6.

To evaluate the significant difference between the three groups Duncan's post hoc comparison was administered. Results of Duncan's post hoc test showed that DPOAEs SNR for osteopenic and osteoporotic group were poorer compared to normal group. However, there was no significant difference between osteopenic and osteoporotic group. Results of post hoc test are shown in Table 7. Type of hearing loss is shown in Table 8 with cross tabulation. Table 8 shows that among the type of hearing loss which was obtained, 17 ears had normal hearing and 7 ears had minimal hearing loss in normal group, whereas 7 ears had minimal hearing loss, 14 ears had sensorineural hearing loss and 1 ear had normal hearing in osteopenic group. In the osteoporotic group, 5 ears had minimal hearing loss, 12 ears had sensorineural hearing loss and 3 had normal hearing.

Table 6. F value and significance values of DPOAEs between groups, across ears and for interaction of group and ear

	Frequencies	F value	Significance
Between groups (normal, osteopenic and osteoporotic)	1500 Hz	0.565	0.572
	2000 Hz	2.841	0.067
	3000 Hz	3.57	0.03
	4000 Hz	4.26	0.01
Across ear (right and left)	1500 Hz	2.201	0.143
	2000 Hz	0.005	0.944
	3000 Hz	0.013	0.90
	4000 Hz	2.37	0.12
Interaction of group and ear	1500 Hz	0.052	0.949
	2000 Hz	0.516	0.599
	3000 Hz	0.009	0.991
	4000 Hz	0.848	0.434

Discussion

The results demonstrate an inverse relation between BMD and hearing loss. Both osteopenic and osteoporotic women had poorer thresholds than normal women. Findings from the present study show the presence of sensorineural hearing loss in patients with osteopenia and osteoporosis. The mechanisms showing the relationship between sensorineural hearing loss and osteoporosis is quite complex. Studies theorized that inflammation and bone demineralization may contribute to the association between weakening bones and sudden sensorineural hearing loss [9]. On the other hand, according to some researches, it has been shown that there is a correlation between BMD loss in osteoporotic patients and conductive hearing loss; in those patients over a specific age, changing the structure of the ossicles or hormonal mechanism in hearing may correlate BMD loss with hearing loss [5,10]. Demineralization of cochlear capsule was found to be correlated with hearing loss in patients with metabolic bone disorders such as Paget's disease and osteogenesis imperfecta [14]. Similar mechanisms might underlie the relationship between sensorineural hearing loss and

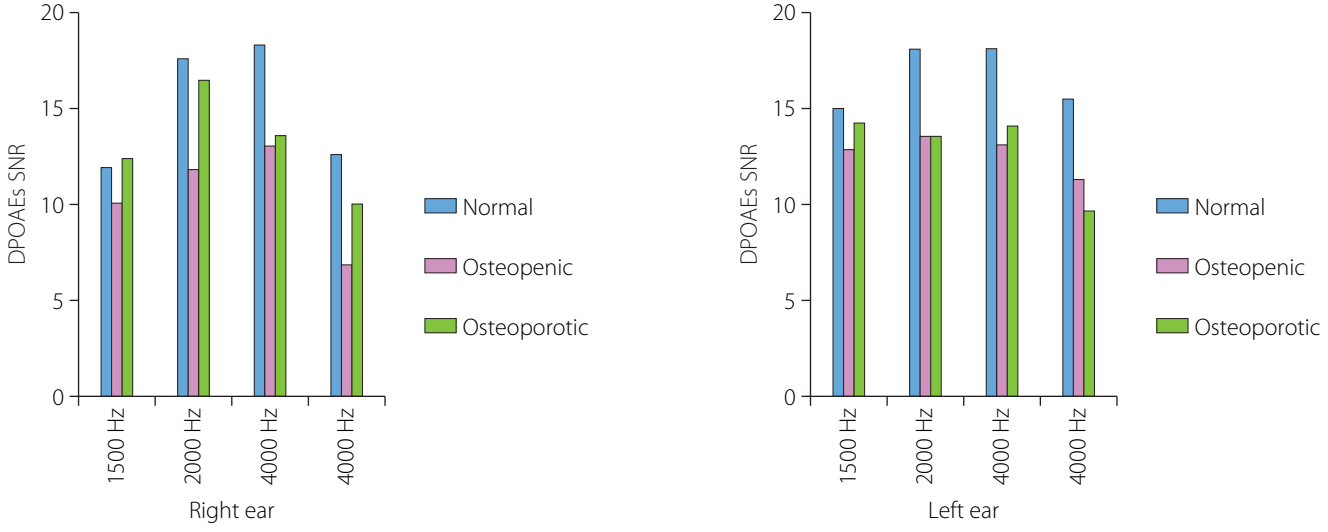

Figure 2. Mean DPOAEs SNR across frequencies between normal, osteopenic and osteoporotic groups in right and left ear.

Table 7. Results of the Scheffe's test for DPOAEs SNR at different frequencies across the three groups

Frequencies	Groups	Osteopenic	Osteoporotic
1500 Hz	Normal	Significant*	Significant*
	Osteopenic		Not significant
2000 Hz	Normal	Significant*	Significant*
	Osteopenic		Not significant
3000 Hz	Normal	Significant*	Significant*
	Osteopenic		Not significant
4000 Hz	Normal	Significant*	Significant*
	Osteopenic		Not significant

*p <0.05.

Table 8. Type of hearing loss: count and percentage in the three different groups

Type	Value	Group			Total
		Normal	Osteopenic	Osteoporotic	
Normal hearing	Count	17	1	3	21
	%	70.8	4.5	15.0	31.8
Minimal HL	Count	7	7	5	19
	%	29.1	31.8	25.0	28.7
Sensorineural HL	Count	0	14	12	26
	%	0	63.6	60.0	39.3
Conductive HL	Count	0	0	0	0
	%	0	0	0	0
Total	Count	100	100	100	100
	%	24	22	20	66

HL, hearing loss.

osteoporosis. There are some possible explanations for our findings. Postmenopausal women with reduced bone mineral density are likely to have systemic evidence of illness affecting many bones including those of inner ear. The bone of the cochlear capsule is lamellar bone with few haversian canals and vascular elements, and thus consists of maximally compact bone tissue. Earlier radiological studies done by Henkin et al (1972) showed increased sclerosis of otic capsule in few patients with osteoporosis [7]. Our study hypothesizes that involvement of the otic bone which supports and protects the delicate cochlear and vestibular neuroepithelial structures, could lead to secondary degenerative changes in spiral ligament, stria vascularis [3] and cochlear hair cells either by local ischemia or by toxic effect caused by the release of enzymes which could lead to sensorineural hearing loss.

The results of the present study are in accordance with the study done by Henkin et al (1972), who diagnosed bilateral sensorineural deafness, significantly greater than their age related mean level, in five or seven patients with confirmed osteoporosis who presented with severe bone pain [7]. Osteoporosis may be caused by multiple mechanisms such as cardiovascular risk factors, bone demineralization, inflammation and endothelial dysfunction [9]. Although the exact cause is not known we hypothesize that hearing loss could be due to deficiency in calcium. It could be postulated that reduction in the ionized calcium may affect the cellular function in the inner ear which includes the active mechanism and also the transmission of nerve action potentials generated in cochlea by inhibiting the release of transmitter at the synapses. This gives a possible explanation for the presence of sensorineural hearing loss in osteoporosis. Further experimental researches and clinical trials are needed to validate our hypothesis.

The results of the present study showed normal middle ear status with A type tympanogram in almost all of the ears in both osteoporotic group and osteopenic group. Similar results were mentioned in the study done by Ozkiris et al (2013), who reported that there is no significant difference between normal, osteopenic and osteoporotic group in tympanometric values [15]. We speculate that this could be due to difference in the mineral content of the bone in the ossicles compared to the general skeleton. Calcium and phosphorous content of the woven bone of the ossicles are significantly greater than that of the ordinary haversian bone of the mastoid cortex and other regions, indicating that there are fundamental metabolic differences in the bone of ossicles compared to general skeleton bones [16]. This metabolic difference between bone of the ossicles and general skeleton could have con-

ferred some degree of protection to the middle ear ossicles. Hence the middle ear ossicles could be relatively infrequently involved in the osteoporosis.

In our study reduced DPOAE SNR was seen predominantly at high frequencies. In support of the results of the present study, a recent study done by Kahveci et al (2014) reported that DPOAE results of patients with osteoporosis at 6 kHz were significantly lower than those of normal and osteopenic patients [17]. Although the exact mechanism is not known, we theorize that this could be due to susceptibility of basal region of cochlea for more and early damage in general, so the same trend that is damage to the basal region in the early stages of osteoporosis could be followed. However additional studies have to be done to further explore other possibilities.

Conclusion

The present study indicates a stronger relation between osteoporosis and hearing loss. The effect of osteoporosis on auditory system using test battery indicates bilateral sensorineural hearing loss. The results in this research, through evidence of association between osteoporosis and hearing loss, can allow for integrated work of an orthopeadician, audiologist, otorhinolaryngologist who are concerned with the alterations caused by osteoporosis. Cochleo-vestibular symptoms are probably often overshadowed by other more generalized features of osteoporosis. Hence, it is important to disclose the need for preventive processes to minimize the demineralization mechanism of the auditory system caused by osteoporosis, as well as prioritize the early diagnosis of hearing loss in people with osteoporosis. A further study with a large group of population is suggested. Future studies could be done to find the effect of reduced bone mineral density on cochlear potentials.

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Case Report

Effects of intratympanic gentamicin treatment on hearing and vestibular functions in a case with symptoms of Meniere's disease

Vipin GPG, Thanuja S, Dhyana J
JSS Institute of Speech and Hearing, Mysore, India

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Correspondence to
Vipin GPG
Lecturer
JSS Institute of Speech and Hearing
Mysore 570004 - India
Phone +91 9844489366
Email vipinghosh78@gmail.com

Authors' contribution
Vipin GPG: formulation of research idea, research writing
Thanuja S: correspondence with various departments, preparation of the manuscript
Dhyana J: data collection, analysis

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Abstract

Meniere's disease is an inner ear disorder characterized by vertigo, tinnitus, aural fullness and fluctuating hearing loss. Intra tympanic gentamicin administration is a form of treatment procedure used to alleviate the symptoms of Meniere's disease. It is an aminoglycoside antibiotic which damages the ill functioning labyrinth. Some of the earlier studies have reported that this procedure keeps hearing at risk though it improves vestibular symptoms. However, few studies have reported an improvement in hearing sensitivity as well as symptoms of Meniere's disease in persons administered with intratympanic gentamicin. Present study highlights the detailed audiological evaluations before and after gentamicin therapy and its interpretations in a 50-year old female with symptoms of Meniere's disease in the right ear. Pure tone audiometry, speech audiometry, immitance audiometry and oto-acoustic emissions evaluation were carried out. Pre-treatment evaluations suggested severe sensorineural hearing loss in right ear and mild mixed hearing loss in left ear. Post-treatment re-evaluations were done after three and seven days of treatment. Improvement in vestibular symptoms and bilateral hearing sensitivity were noted in the first re-evaluation and the same effects persisted along the second evaluation. The possible explanations for these findings are discussed in the present paper. The outcome of the study suggests detailed pre and post-treatment audiological evaluations to monitor the benefits and side effects of such treatment procedures.

Key words

Meniere's disease, gentamicin, hearing sensitivity.

Meniere's disease is an inner ear disorder characterized by vertigo, tinnitus, aural fullness and fluctuating hearing loss [1]. Different conservative treatment procedures like administration of diuretics, steroids, calcium channel blockers, vasodilators, low-salt diet etc are applied to alleviate the symptoms of Meniere's disease. Various surgical procedures are also developed for easing the symptoms of Meniere's disease. However, surgical treatment measures are not often used because of the risks involved. In order to minimize the complications and risks involved in the surgical procedures, intratympanic delivery of aminoglycosides or corticosteroids has been introduced recently [2]. Gentamicin is such an aminoglycoside antibiotic administered to alleviate the vestibular tribulations especially related to Meniere's disease. Gentamicin is injected into the intratympanic middle ear space and further absorbed into the inner ear through the semi permeable round window membrane. This method aims to chemically damage the ill functioning labyrinth, thus alleviating the vestibular problems associated. Intratympanic gentamicin injection is a minor surgical procedure performed under local anesthesia consequently reducing the risks of major surgical procedures as in labyrinthectomy, cochleovestibular nerve section etc. This makes it a handy solution for severe vertigo problems even though it keeps hearing sensitivity of the person at risk as it can be toxic to the cochlear structures as well [3]. There have been few studies in the literature on the effect of such treatment procedures on vestibular and hearing systems.

Wu and Minor (2009) [4] studied the effect of intra tympanic gentamicin on vestibular symptoms and hearing in 34 individuals with unilateral Meniere's disease. They reported that the vestibular symptoms were under control in 90% of the subjects after gentamicin therapy. Hearing sensitivity was improved in 5 subjects after the treat-

ment while it remained unchanged in 23 subjects and was worse in 6. El Betalgy et al (2012) [2] compared the effect of intratympanic gentamicin with intratympanic dexamethasone on vertigo, tinnitus, aural fullness and hearing sensitivity. The results suggested that both the treatment procedures helped in controlling all the symptoms of Meniere's disease. However, the gentamicin injection resulted in more deterioration of hearing sensitivity in comparison to intratympanic dexamethasone treatment. Zhai et al (2010) [5] reported that the hearing deterioration was observed in 16% of subjects with Meniere's disease while it improved vertigo symptoms in 89% of the subjects after intratympanic gentamicin administration. Such heterogeneity of results warrants more research on the effect of gentamicin on hearing and vestibular systems.

Case presentation

A 50-year old female was referred to the Department of Audiology, JSS hospital, Mysore for detailed audiological evaluation. Otoscopic evaluation at the Department of ENT revealed that the tympanic membrane in the left ear was dull. No other significant findings were reported. Detailed case history was carried out at the Department of Audiology. The case complained of blocking sensation, fluctuant tinnitus and reduced hearing sensitivity in the right ear along with vertigo since one week. Left ear was reported to be normal. No other significant otological complaints were reported.

Pre-treatment audiological evaluation

On the first visit a detailed pre-treatment audiological evaluation including pure tone audiometry, speech audiometry, immittance evaluation and oto-acoustic emission (OAE) evaluation were carried out.

Table 1. Findings of pre-treatment pure tone audiometry and speech audiometry

Procedure	Right ear	Left ear
PTA (dB)	80	40
SRT (dB)	90	50
SIS (%)	80	80
UCL (dB)	100	100

Pure tone audiometry and speech audiometry was carried out using a calibrated Maico MA53 audiometer. The pure tone average (PTA) was calculated in both the ears as the average of pure tone thresholds at 250 Hz, 500 Hz and 1000 Hz in each ear. Speech audiometry comprised of Speech Recognition Threshold (SRT), Speech Identification Scores (SIS) and Uncomfortable Level (UCL) testing. Interacoustics AT 625 immittance meter was used to perform immittance evaluation and acoustic reflex threshold measurements. Immittance evaluation encompassed static compliance (SC), peak pressure (PP) and ear canal volume (ECV) measurements. Based on these measurements, type of tympanogram was also identified. Ipsilateral and contra lateral acoustic reflex thresholds measurements were carried out as well in both the ears. The audiogram obtained for the subject is given in Figure 1. The results of pure tone audiometry and speech audiometry are given in Table 1 and immittance evaluation findings in Table 2. Distortion product (DP) and transient evoked (TE) OAEs were carried out using interacoustics oto read instrument.

Interpretation of test findings

PTA suggested a hearing loss of severe degree in the right ear and mild degree in the left ear. The SRT scores

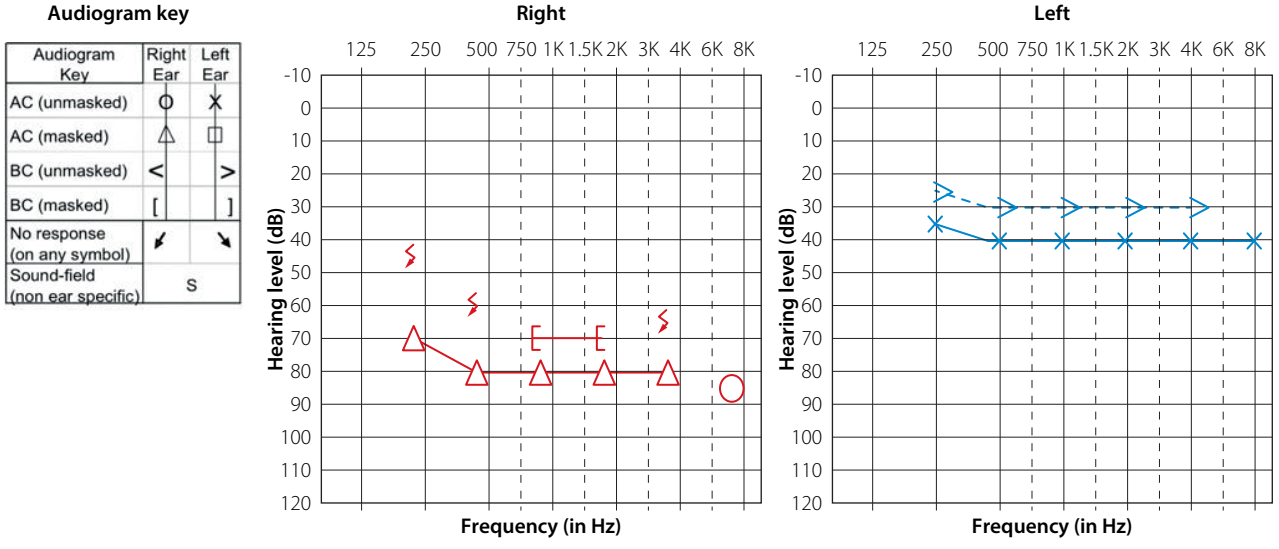

Figure 1. Pre-treatment audiogram showing pure tone thresholds of right and left ears across 250 Hz to 8 kHz.

Table 2. Findings of pre-treatment immittance evaluation

Procedure	Right ear	Left ear
Type	A	B
SC	-65	NP
PP	0.6	NP
ECV	1.5	1.9

NP, no peak found.

were in good correlation with PTA and the SIS scores were fair in both the ears. High UCL suggested a probable absence of recruitment in both the ears. Immittance evaluation results indicated middle ear pathology in the left ear and normal middle ear functioning in the right ear. Ipsilateral and contra lateral acoustic reflexes were found to be absent in both the ears. Absence of acoustic reflex can be attributed to the severe hearing loss in the right ear and middle ear pathology in the left ear. DP and TEOAEs were also found to be absent in both the ears. Absence of oto acoustic emissions in the right ear indicates an outer hair cell (OHC) dysfunction, while similar finding in the left ear cannot be directly attributed to the OHC dysfunction as OAEs are susceptible to middle ear pathologies. The final diagnosis made after the detailed audiological evaluation was severe sensorineural hearing loss in the right ear and mild mixed hearing loss in the left ear.

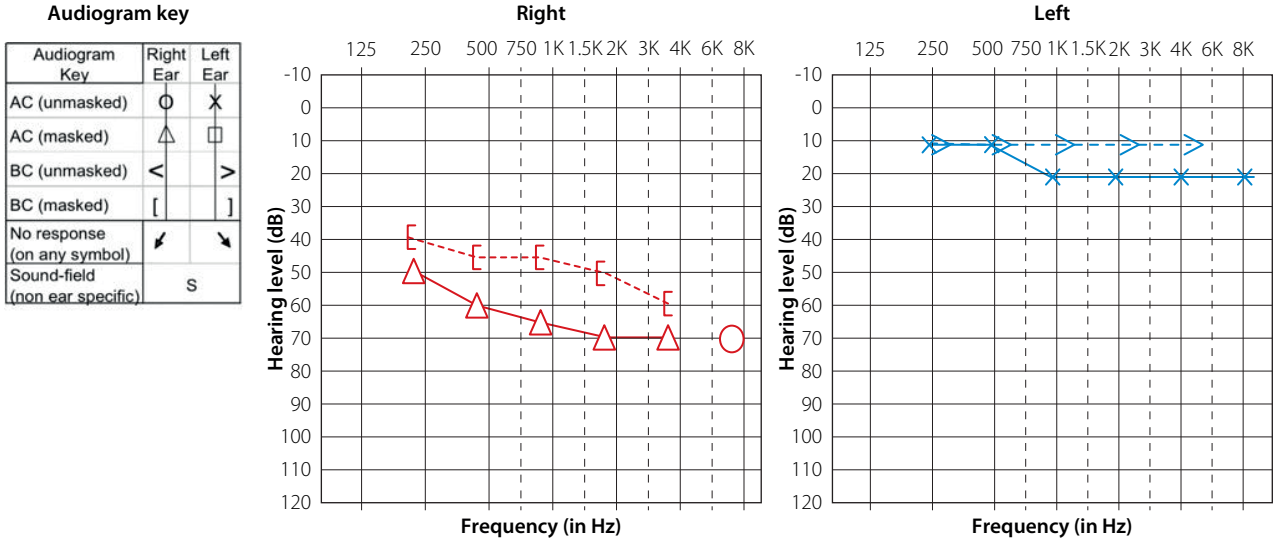

Figure 2. Audiogram obtained after three days of treatment showing pure tone thresholds of right and left ears across 250 Hz to 8 kHz.

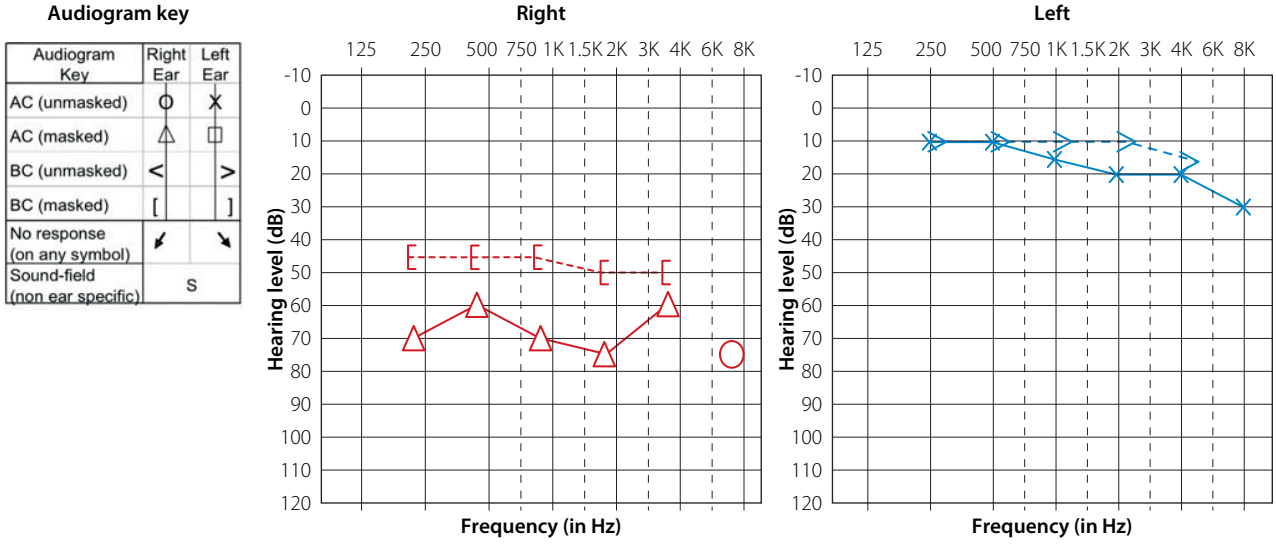

Figure 3. Audiogram obtained after seven days of treatment showing pure tone thresholds of right and left ears across 250 Hz to 8 kHz.

After the pre-treatment audiological evaluation the patient had undergone intra tympanic gentamicin injection (0.5 ml) in the right ear at the Department of ENT, JSS Hospital, Mysore. Gentamicin buffered with sodium bicarbonate was used. Topical anesthesia was applied. The patient was also prescribed antibiotics as the patient was found to have otitis media in the left ear.

Audiolgical re-evaluations

Two audiological re-evaluations were done on the subject after three days and seven days of gentamicin treatment. Re-evaluation consisted of pure tone audiometry, speech audiometry, immittance evaluation and OAEs. Audiograms obtained after three and seven days of treatment are shown in Figure 2 and 3 respectively (see page 35). The results of audiological evaluations are given in Table 3 and 4.

The subject reported reduction in aural fullness, tinnitus and vertigo symptoms on the first re-evaluation which was carried out three days after the treatment. The frequency of tinnitus and vertigo spells was reported to be reduced. Thresholds at all the frequencies were observed to be improved. The same improvement was hence reflected in the PTA. Improvement was observed in the SRT and SIS scores also. Immittance evaluation revealed a development of middle ear infection in the right ear and persistence of middle ear infection in the left ear. OAEs were found to be absent in both the ears. However, there was no further significant change in the symptoms and pure tone thresholds in the second re-evaluation from the first re-evaluation. Provisional diagnosis made after both the evaluations were moderately severe mixed hearing loss in the right ear and minimal hearing loss in the left ear.

Table 3. Results of pure tone audiometry and speech audiometry in the first and second re-evaluation

Procedure	1st re-evaluation		2nd re-evaluation	
	Right ear	Left ear	Right ear	Left ear
PTA (dB)	65	16.6	68.3	15
SRT (dB)	70	20	75	25
SIS (%)	100	100	100	100
UCL (dB)	>100	>100	>100	>100

Table 4. Results of immittance evaluation in the first and second re-evaluation

Procedure	1st re-evaluation		2nd re-evaluation	
	Right ear	Left ear	Right ear	Left ear
Type	As	B	B	B
SC	0.2	NP	NP	NP
PP	-21	NP	NP	NP
ECV	1.5	1.7	1.4	1.7

NP, no peak found.

Discussion

It is clear from the audiograms that there was significant improvement in pure tone thresholds in both the ears after treatment. Similar findings though infrequent have been reported in earlier studies. Wu and Minor (2009) [4] reported an improvement of hearing thresholds in 5 out of the 34 subjects with unilateral Meniere's disease who had undergone intra tympanic gentamicin treatment. Kerem et al (2004) [6] reviewed studies carried out in the treatment of Meniere's disease with gentamicin and reported that the procedure is more vestibulotoxic than cochleotoxic. Vanucchi and Pecci (2009) [7] also have reported similar findings in individuals with Meniere's disease. They studied the effect of intratympanic gentamicin on 30 individuals with Meniere's disease and reported control of vertigo in all the subjects and improvement in the hearing thresholds in few. Speech discrimination scores were also reported to be improved in 10 subjects after the treatment. This improvement in hearing thresholds and speech discrimination scores were attributed to the decompression effect of gentamicin on the prolonged contraction of hair cells induced by Meniere's disease. In addition, they also suggested that the partially damaged hair cells can recover the function due to the control of hydrops episodes, thus could improve the hearing thresholds and speech discrimination scores.

Improvement in pure tone thresholds and speech discrimination scores in the present case may also be ascribed to the decompression effect of gentamicin and recovery of hair cell functioning as reported in the earlier studies. It was also observed that there was no significant change in the hearing thresholds and speech discrimination scores in the second re-evaluation from the first re-evaluation. This suggests that in the present case, maximum effect of gentamicin occurred initially and remained stable thereafter. Further, the improvement in hearing thresholds in the left ear may be attributed to the improvement of the middle ear functioning in response to the antibiotic medication prescribed for otitis media in the left ear. However, it was observed that the right ear also developed middle ear dysfunction after the treatment which may be a consequence of the intratympanic procedure adopted to deliver gentamicin to the middle ear.

Improvement in vertigo, tinnitus and aural fullness was also reported by the subject. This is in accordance with various earlier studies [2, 4, 8]. ElBeltagy et al (2012) [2] suggested the vestibulotoxic nature of gentamicin along with the damage to cells responsible for endolymph production as the possible reasons for release from the symptoms of Meniere's disease. In the present case too, a similar effect of gentamicin within the cochlea may have resulted in the reduction of vertigo, aural fullness and tinnitus.

Conclusion

Gentamicin is an aminoglycoside antibiotic administered to alleviate the vestibular problems especially related to Meniere's disease. This method damages the ill functioning labyrinth, thus alleviating the vestibular problems associated. The present case report illustrates the audiological findings before and after the gentamicin therapy in an individual with symptoms of Meniere's disease in the right ear. Detailed audiological evaluations revealed an improvement in hearing threshold and speech discrimination scores in the right ear along with control of symptoms like vertigo, tinnitus and blocking sensation after gentamicin treatment. This improvement may be attributed to the decompression effect of gentamicin and functional recovery of outer hair cells after the treatment. However, the subject developed middle ear dysfunction in the right ear which may be a consequence of the intratympanic procedure followed to deliver gentamicin. The absence of continued improvement in the second re-evaluation from the first suggested a maximum effect of treatment in the initial stages which gets stabilized thereafter. Detailed pre- post-treatment audiological evaluations are hence warranted in such treatment procedures to monitor the benefits and side effects of the procedure. This will help the professional to select the appropriate subsequent rehabilitation options, if required. Studying the effect of gentamicin on the vestibular and hearing functions in more number of subjects and quantifying the amount of improvement using vestibular and tinnitus inventories is required for generalizing the findings.

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