# Effect of vitiligo on the cochlea

Mohamed Abd Elatif ElGohary, Reda Mohamed Abd Alwahab Behairy, Amal Mahmoud Awida

Audiovestibular Unit, ENT Department, Faculty of Medicine for Girls, Al Azhar University, Cairo, Egypt

Correspondence to Reda Behairy, MD in Audiovestibular Medicine, Lecturer of Audiovestibular Unit, ENT Department, Faculty of Medicine for Girls, Al Azhar University,Cairo, Egypt. Tel: 01013235487; e-mail: drredabehairy@yahoo.com

**Received** 24 June 2018
**Accepted** 8 October 2018

**The Egyptian Journal of Otolaryngology**
2019, 35:6–11

**Background**
Vitiligo is the disappearance of functional melanocytes (MCs) from the involved skin by a mechanism(s) that has not yet been identified.
**Objective**
The aim was to study the effects of different types of vitiligo on cochlear function.
**Patients and methods**
This study involved 30 vitiligo patients who constituted the study group and 30 matched healthy individuals who served as the control group. Cochlear function was studied using pure-tone audiometry and transient-evoked otoacoustic emission.
**Results**
Normal pure-tone thresholds were found in vitiligo patients with no statistically significant difference between the control and vitiligo groups on both ears. There was a statistically significant difference between control and vitiligo groups as regards the signal-to-noise ratio at a frequency band of 4 kHz on both ears. Cochlear function is affected equally in both generalized and localized vitiligo subgroups. The duration of vitiligo does not have an effect on cochlear function.

**Keywords:**
otoacoustic emission, pure-tone audiometry, signal-to-noise ratio, vitiligo

Egypt J Otolaryngol 35:6–11

1012-5574

## Introduction

Vitiligo is an idiopathic, acquired, circumscribed hypomelanotic skin disorder resulting from loss of pigment-forming melanocytes (MCs). Many possible causes of vitiligo have been proposed, including stress, infections, mutations, neural factors, melatonin receptor dysfunction, and impaired MC migration and/or proliferation by Kemp *et al.* [1].

MCs are found not only in the skin but also in the leptomeninges, retinal pigment epithelium, uveal tract, and in the inner ear. The role of MCs in the inner ear is not completely understood. It is known that they are necessary for the normal development and function of the stria vascularis Steel and Barkway [2], Cable *et al.* [3], Tachibana [4], and Araki *et al.* [5].

Franz *et al.* [6] and Ardic *et al.* [7] have suggested a direct relation between cochlear dysfunction and decreased amounts of melanin. It is thus thought that melanin has a protective role against harmful agents in the inner ear. Loss of MCs, resulting in decreased melanin production as occurs in vitiligo, could decrease cochlear health.

Evaluation of auditory functions in patients with vitiligo has been the subject of only a few studies and a variety of abnormalities have been reported. In this regard, the present study was designed to detect the effect of vitligo on the cochlea.

## Patients and methods

### Patients

The study group included 30 vitiligo patients (eight men and 22 women). The duration of the disease ranged from 6 months to 30 years. They were divided as follows: (a) according to the type of vitiligo into generalized (15 patients) and localized (15 patients) and (b) according to the duration of vitiligo into: less than 10 years and greater than or equal to 10 years. They were selected from the Dermatology Clinic at Al Zhraa University Hospital. Thirty healthy participants served as a control group (six men and 24 women). The age of the control and study groups ranged from 6 to 40 years with a mean of 20.4±8.1 and 21.2±10.2, respectively.

Exclusion criteria for the control and study groups included any middle ear disease, previous ear surgery, familial hearing loss, ototoxic drug intake,

chronic noise exposure, head trauma, and presence of any systemic disease such as diabetes or hypertension. Patients with other autoimmune disorders and skin manifestations were also excluded.

### Methods

All participants included were subjected to the following: otological examination, audiometric testing using Interacoustics AC40 (Interacoustics, Danish) pure-tone audiometry (PTA) was done (air conduction and bone conduction threshold). Immittancemetry were performed using Miaco 44 (MI44) (Miaco, German) to insure normal middle ear function. Transient-evoked otoacoustic emissions (TEOAEs) using Madsen Capella (Otometrics, Danish) (cochlear emission analyzer) were elicited by nonlinear click stimuli at stimulus intensity ranges from 80 dB peak equivalent sound pressure level, 80 μs duration, at a rate of 50 clicks per second, within a time window of 20 ms. TEOAEs were analyzed by recording 260 sweeps in one session and averaged within five frequency bands centered at (1, 1.5, 2, 3, and 4 kHz). According to Kemp [8], those who showed an overall reproducibility of 70% were described to have a pass result and those with less than 70% but still had greater than 50% were considered to have a present TEOAE and were described to have a partial pass result.

### Statistical analysis

Data were analyzed with SPSS version 21 (SPSS Inc., Chicago, Illinois, USA). The normality of data was first tested with one-sample Kolmogorov–Smirnov test. Qualitative data were described using number and percent. The association between categorical variables was tested using $\chi^2$-test. Continuous variables were presented as mean±SD. The two groups were compared with Student's *t*- test. Analysis of variance test was used for comparison of means of more than two groups.

## Results

No statistically significant difference was found between control and study groups as regard age and gender. No statistically significant difference between control and study groups in PTA threshold at all frequencies. TEOAE (SNR) shows highly statistically significant difference between control and study groups at high frequency. All of the control show pass response. In the study group, most of the ears show pass response (39/60) 65%, about one third of the ears(21/60) 35% show patial pass response. Neither the control nor the study group showed failed response. No statistically significant difference was found in the pure tone threshold between control group and type of vitiligo subgroups at any frequency in right and left ears ($P>0.05$). TEOAE (SNR) shows highly statistically significant difference between control group and different type of vitiligo subgroups at frequency band 4 kHz in right and left ears. No statistically significant difference was found in the pure tone threshold of the control group and vitiligo subgroups according to vitiligo duration. TEOAE (SNR) showed highly statistically significant difference between control group and different duration of vitiligo subgroups at frequency band 4 kHz in the right and left ears. But no statistically significant difference was found between the two vitiligo subgroups with different vitiligo duration.

## Discussion

The present study was designed to examine cochlear function in generalized and localized vitiligo patients and to detect the effect of duration of vitiligo on cochlear function. There is no statistically significant difference in results between control and study groups as regards age and gender (Tables 1 and 2).

In the current study, audiological assessment using PTA shows that there is no hearing loss in the control and study groups and no statistically

**Table 1 Age distribution of the control group and the study group**

| Control (*n*=30) | | Study group (*n*=30) | | Test of significance | *P* |
|---|---|---|---|---|---|
| Mean±SD | Minimum–maximum | Mean±SD | Minimum–maximum | | |
| 20.4±8.1 | 6–40 | 21.2±10.2 | 6–40 | 1.184 | 0.236 |

No statistically significant difference was found between control and study groups as regards age.

**Table 2 Gender distribution of the control group and the study group**

| Gender | Control (*n*=30) [*n* (%)] | Study (*n*=30) [*n* (%)] | Test of significance | *P* |
|---|---|---|---|---|
| Male | 6 (20.0) | 8 (26.7) | $\chi^2$=0.373 | 0.542 |
| Female | 24 (80.0) | 22 (73.3) | | |

No statistically significant difference between control and study groups as regards gender.

**Table 3 Comparison of pure-tone thresholds (mean±SD) in control and study groups**

| Frequency in Hz | Side | Control (*n*=30) | Study (*n*=30) | *t*-test | *P* |
|---|---|---|---|---|---|
| 250 | Right | 10.00±5.25 | 11.00±4.24 | 0.812 | 0.420 |
| | Left | 10.00±4.55 | 10.17±4.45 | 0.143 | 0.886 |
| 500 | Right | 10.33±4.72 | 11.33±4.90 | 0.805 | 0.424 |
| | Left | 10.00±4.15 | 12.17±4.09 | 2.037 | 0.062 |
| 1000 | Right | 10.67±4.50 | 10.50±4.80 | 0.139 | 0.890 |
| | Left | 10.67±4.10 | 10.83±3.73 | 0.165 | 0.870 |
| 2000 | Right | 9.00±4.62 | 9.83±4.25 | 0.727 | 0.470 |
| | Left | 12.00±3.62 | 11.33±4.72 | 0.614 | 0.542 |
| 4000 | Right | 11.33±4.72 | 11.17±4.68 | 0.137 | 0.891 |
| | Left | 11.67±4.80 | 11.83±5.94 | 0.120 | 0.905 |
| 8000 | Right | 11.67±4.01 | 13.17±6.36 | 1.092 | 0.279 |
| | Left | 11.00±3.81 | 13.17±6.76 | 1.530 | 0.131 |

No statistically significant difference between control and study groups in pure-tone audiometry threshold at all frequencies.

**Table 4 Comparison of TEOAE SNR (mean±SD) in control and study groups**

| Frequency band | Side | Control (*n*=30) | Study (*n*=30) | *t*-test | *P* |
|---|---|---|---|---|---|
| 1000 | Right | 8.33±5.25 | 8.33±5.30 | 0.097 | 0.923 |
| | Left | 9.73±7.67 | 8.00±5.36 | 1.015 | 0.314 |
| 1500 | Right | 12.07±6.22 | 12.77 ±5.31 | 0.469 | 0.641 |
| | Left | 11.13±4.44 | 12.03 ±4.32 | 0.796 | 0.429 |
| 2000 | Right | 13.13±7.72 | 14.10 ±5.80 | 0.549 | 0.585 |
| | Left | 13.13±5.26 | 14.03 ±6.60 | 0.584 | 0.561 |
| 3000 | Right | 12.13±8.17 | 12.63 ±6.38 | 0.264 | 0.793 |
| | Left | 11.27±4.48 | 12.57 ±6.15 | 0.936 | 0.353 |
| 4000 | Right | 16.87±4.67 | 10.33 ±6.57 | 4.442 | ≤0.001** |
| | Left | 15.73±5.76 | 9.53±5.60 | 4.230 | ≤0.001** |

TEOAE (SNR) shows highly statistically significant difference between control and study groups at high frequencies. **Means highly statistically significant difference.

significant difference of PTA threshold between control and vitiligo groups at any frequency from 250 to 8000 Hz (Table 3).

These results are in agreement with Anbar *et al.* [9], Shalaby *et al.* [10], Ozuer *et al.* [11], Escalante-Ugalde *et al.* [12], and Orecchia *et al.* [13], who found that vitiligo patients had near-normal pure-tone thresholds and no statistically significant difference between the control and vitiligo groups in PTA on both ears.

The current study disagrees with the results of Mohamed *et al.* [14], Fleissig *et al.* [15], Mahdi *et al.* [16], Akay *et al.* [17], Hong *et al.* [18], who found different degrees of SNHL in vitiligo patients as

**Table 5 Number and percent of pass, partial pass, and failed responses of TEOAE in control and study groups**

| TEOAE | Side | Control [*n* (%)] | Study [*n* (%)] |
|---|---|---|---|
| Pass | Right | 30 (100) | 20 (66.6) |
| | Left | 30 (100) | 19 (63.3) |
| Partial pass | Right | 0 (0) | 10 (33.4) |
| | Left | 0 (0) | 11 (36.7) |
| Failed | Right | 0 (0) | 0 (0) |
| | Left | 0 (0) | 0 (0) |

All of the control show pass response. In the study group, most of the ears show pass response [(39/60) 65%], about one-third of the ears [(21/60) 35%] show patial pass response. Neither the control nor the study group showed a failed response.

compared with controls. This difference was statistically significant ($P<0.001$). This disagreement may be due to different sample sizes and different ages of the study group.

Comparing the cochlear function of both ears in patients with vitiligo with the cochlear function of the control group using TEOAEs was done. Cochlear dysfunction was evident in patients with vitiligo in the form of smaller S/N ratio at 4000 Hz band (Table 4) and higher percentage of abnormal TEOAE findings in the form of partial pass response (35%) (Table 5). This supports previous studies that demonstrated subclinical abnormalities of melanin-containing cellular elements of the auditory system in patients with vitiligo Tosti *et al.* [19] and Aydogan *et al.* [20]. Also Mohamed *et al.* [14] reported that TEOAEs had the advantages of detecting minimal cochlear dysfunction in vitiligo patients.

This result agrees with Aslan *et al.* [21], who found a significant reduction in the amplitude of TEOAEs only at 4 kHz in the vitiligo group. The current study agrees also with Anbar *et al.* [9], who found that 64 ears (60%) of patients with vitiligo had cochlear dysfunction while the control group exhibited no abnormalities using DPOAEs.

The lost cochlear emission in the vitiligo group was previously explained by Schrott *et al.* [22]. They stated that hypopigmentation disorders may lead to degeneration of the outer hair cells beginning from the basal turn of the cochlea. The MCs in the inner ear have multiple roles critical for hair cell survival, including maintenance of the normal function of the stria vascularis Tachibana [4]. Inner ear melanin functions as an intracellular calcium buffer and as a depot of essential metal ions that control the activity of various enzymes and metabolic processes Barrenas and Lindgren [23], and Barrenas and Axelsson [24]. MCs in the inner

**Table 6 Comparison of pure-tone thresholds (mean±SD) in the control group and study subgroups according to the vitiligo type**

| Frequency in Hz | Side | Control (*n*=30) | Types of vitiligo | | *F* | *P* |
|---|---|---|---|---|---|---|
| | | | Generalized (*n*=15) | Localized (*n*=15) | | |
| 250 | Right | 10.00±5.25 | 10.40±4.31 | 14.00±2.24 | 1.553 | 0.220 |
| | Left | 10.00±4.55 | 10.20±4.20 | 10.00±6.12 | 0.014 | 0.986 |
| 500 | Right | 10.33±4.72 | 10.80±5.14 | 14.00±2.24 | 1.264 | 0.290 |
| | Left | 10.00±4.15 | 12.40±4.11 | 11.00±4.18 | 2.045 | 0.139 |
| 1000 | Right | 10.67±4.50 | 10.40±4.55 | 11.00±6.52 | 0.044 | 0.957 |
| | Left | 10.67±4.10 | 10.80±4.00 | 11.00±2.24 | 0.019 | 0.982 |
| 2000 | Right | 9.00±4.62 | 10.00±4.33 | 9.00±4.18 | 0.365 | 0.696 |
| | Left | 12.00±3.62 | 11.80±4.76 | 9.00±4.18 | 1.128 | 0.331 |
| 4000 | Right | 11.33±4.72 | 10.80±4.93 | 13.00±2.74 | 0.465 | 0.630 |
| | Left | 11.67±4.80 | 11.20±6.00 | 15.00±5.00 | 1.059 | 0.354 |
| 8000 | Right | 11.67±4.01 | 12.80±6.31 | 15.00±7.07 | 0.948 | 0.393 |
| | Left | 11.00±3.81 | 12.40±6.63 | 17.00±6.71 | 2.729 | 0.074 |

No statistically significant difference was found in the pure-tone threshold between the control group and type of vitiligo subgroups at any frequency in right and left ears ($P>0.05$).

**Table 7 Comparison between mean and SD of TEOAE (SNR) of the control group and study subgroups according to the vitiligo type**

| Frequency band | Side | Control (*n*=30) | Types of vitiligo | | *F* | *P* | Post-hoc test |
|---|---|---|---|---|---|---|---|
| | | | Generalized (*n*=15) | Localized (*n*=15) | | | |
| 1000 | Right | 8.33±5.25 | 7.80±5.28 | 11.80±4.82 | 1.222 | 0.302 | – |
| | Left | 9.73±7.67 | 7.44±5.01 | 10.80±6.76 | 1.054 | 0.355 | |
| 1500 | Right | 12.07±6.22 | 13.52±5.17 | 9.00±4.74 | 1.421 | 0.250 | – |
| | Left | 11.13±4.44 | 11.52±4.22 | 14.60±4.28 | 1.373 | 0.262 | |
| 2000 | Right | 13.13±7.72 | 14.64±5.54 | 11.40±6.95 | 0.619 | 0.542 | – |
| | Left | 13.13±5.26 | 13.88±6.57 | 14.80±7.46 | 0.457 | 0.636 | |
| 3000 | Right | 12.13±8.17 | 13±6.081 | 10.80±8.29 | 0.220 | 0.803 | – |
| | Left | 11.27±4.48 | 12.96±6.25 | 10.60±5.77 | 1.862 | 0.165 | |
| 4000 | Right | 16.87 ±4.67[a,b] | 11.08±6.23[a] | 6.60±7.67[b] | 11.471 | ≤0.001** | Control vs. generalized vitiligo, control vs. localized vitiligo |
| | Left | 15.73 ±5.76[a,b] | 9.68± 5.46[a] | 8.80±6.87[b] | 8.855 | ≤0.001** | Control vs. generalized vitiligo, Control vs. localized |

Groups with similar superscript letters are statistically significantly different according to post-hoc tests. TEOAE (SNR) shows highly statistically significant difference between control group and different types of vitiligo subgroups at a frequency band of 4 kHz in right and left ears. **Means highly statistically significant difference.

**Table 8 Comparison of pure-tone thresholds (mean±SD) in the control group and study subgroups according to vitiligo duration**

| Frequency in Hz | Side | Control (*n*=30) | Duration of vitiligo | | *F* | *P* |
|---|---|---|---|---|---|---|
| | | | <10 years (*n*=19) | ≥10 years (*n*=11) | | |
| 250 | Right | 10.00±5.25 | 10.79±4.49 | 11.36±3.93 | 0.374 | 0.690 |
| | Left | 10.00±4.55 | 9.74±4.24 | 10.91±4.91 | 0.244 | 0.784 |
| 500 | Right | 10.33±4.72 | 10.80 ±5.07 | 12.27±4.67 | 0.651 | 0.525 |
| | Left | 10.00±4.15 | 11.84±4.15 | 12.73±4.10 | 1.958 | 0.151 |
| 1000 | Right | 10.67±4.50 | 10.26±4.24 | 10.91±5.84 | 0.076 | 0.927 |
| | Left | 10.67±4.10 | 10.53±4.05 | 11.36±3.23 | 0.171 | 0.844 |
| 2000 | Right | 9.00±4.62 | 10.26±3. 90 | 9.09±4.91 | 0.502 | 0.608 |
| | Left | 12.00±3.62 | 11.84±5.58 | 10.45±2.70 | 0.565 | 0.572 |
| 4000 | Right | 11.33±4.72 | 12.11±4.81 | 9.55±4.16 | 1.063 | 0.352 |
| | Left | 11.67±4.80 | 12.11±6.08 | 11.36±5.95 | 0.072 | 0.931 |
| 8000 | Right | 11.67±4.01 | 13.16±5.82 | 13.18±7.51 | 0.586 | 0.560 |
| | Left | 11.00±3.81 | 12.63±6.32 | 14.09±7.69 | 1.405 | 0.254 |

No statistically significant difference was found in the pure-tone threshold of the control group and vitiligo subgroups at any frequency.

**Table 9 Comparison of TEOAE (SNR) mean±SD in the control group and study subgroups according to vitiligo duration**

| Frequency band | Side | Control (*n*=30) | Duration of vitiligo | | *F* | *P* | Post-hoc test |
|---|---|---|---|---|---|---|---|
| | | | <10 years (*n*=19) | ≥10 years (*n*=11) | | | |
| 1000 | Right | 8.33±5.25 | 8.53±5.36 | 8.36±5.60 | 0.008 | 0.992 | – |
| | Left | 9.73±7.67 | 8.26±5.10 | 7.55±6.01 | 0.547 | 0.582 | |
| 1500 | Right | 12.07±6.22 | 13.68±5.31 | 11.18±5.15 | 0.766 | 0.469 | – |
| | Left | 11.13±4.44 | 12.58±4.05 | 11.09±4.80 | 0.716 | 0.493 | |
| 2000 | Right | 13.13±7.72 | 14.89±5.57 | 12.73±6.20 | 0.499 | 0.610 | – |
| | Left | 13.13±5.26 | 15.37±6.066 | 11.73±7.12 | 1.070 | 0.350 | |
| 3000 | Right | 12.13±8.17 | 13.11±6.84 | 11.82±5.72 | 0.140 | 0.869 | – |
| | Left | 11.27±4.48 | 13.53±6.30 | 10.91±5.77 | 1.887 | 0.161 | |
| 4000 | Right | 16.87±4.67[a, b] | 11±6.77[a] | 9.18±6.35[b] | 10.168 | ≤0.001** | Control vs. <10 years, control vs. ≥10 years |
| | Left | 15.73±5.76[a, b] | 9.47±5.87[a] | 9.64±5.35[b] | 8.795 | ≤0.001** | Control vs. <10 years, control vs. ≥10 years |

Groups with similar superscript letters are statistically significantly different according to post-hoc tests. TEOAE (SNR) showed a highly statistically significant difference between the control group and different duration of vitiligo subgroups at a frequency band of 4 kHz in the right and left ears. But no statistically significant difference was found between the two vitiligo subgroups with different vitiligo duration.

ear are required for the development of endocochlear potentials, control of ions and fluid gradient between the endolymph and the perilymph Halaban *et al.* [25].

In the current study, the cochlear function of the ears of patients with generalized vitiligo and the cochlear function of the ears of patients with localized vitiligo were compared. No statistically significant difference in the PTA threshold and the TEOAE S/N ratio were found (Tables 6 and 7). This suggests that there is no significant effect of vitiligo subtype on cochlear function.

These results are in agreement with Fleissig *et al.* [15] and Anbar *et al.* [9], who found that hearing losses in the groups with different types of vitiligo were not significantly different from each other. On the other hand, Sharma *et al.* [26] and Hong *et al.* [18] found generalized vitiligo and nonsegmental vitiligo to be a risk factor for SNHL.

PTA and TEOAE results showed no statistically significant difference between patients with a duration of less than and more than 10 years (Tables 8 and 9). It is concluded that the duration of vitiligo does not have an effect on cochlear function. This could be explained by the possibility that otic MCs are affected at the start of the vitiligo and then stabilized afterwards Mahdi *et al.* [16].

Fleissig *et al.* [15], Shalaby *et al.* [10], and Sharma *et al.* [26] found that the duration of vitiligo does not affect hearing. They postulated that there is no correlation between the duration of vitiligo and hearing loss.

The current study contradicts Aslan *et al.* [21], who concluded that the duration of vitiligo affects hearing. They found a statistically significant positive correlation between the duration of vitiligo and hearing loss.

## Conclusion

Vitiligo has an effect on cochlear function and the affection is usually asymptomatic for a long time. Cochlear function is affected equally in both generalized and localized vitiligo subgroups. There is no correlation between the duration of vitiligo and hearing loss. TEOAE is a sensitive test for detecting cochlear dysfunction before symptoms become manifested as the TEOAE was impaired in 35% of the ears with normal hearing.

### Recommendation

Vitiligo patients required routine monitoring by specialists for early identification of auditory changes. Further study should be done to assess the effect of vitiligo on the central auditory nervous system.

### Financial support and sponsorship

Nil.

### Conflicts of interest

There are no conflicts of interest.

## References

1 Kemp EH, Waterman EA, Weetman AP. Immunological pathomechanisms in vitiligo. Expert Revi Mol Med 2001; 3:1462–3994.

2 Steel KP, Barkway C. Another role for melanocytes. Their importance for normal stria vascular is development in the mammalian inner ear. Development1989 2015; 107:453–463.

**3** Cable J, Jackson IJ, Steel KP. Light (Blt), a mutation that causes melanocyte death, affects stria vascularis function in the mouse inner ear. Pigm Cell Res 1993; 6:215–225.

**4** Tachibana M. Sound needs melanocytes to be heard. Pigm Cell Res 1999; 12:344–354.

**5** Araki S, Mizuta K, Takeshita T, Morita H, Mineta H, Hoshino T. Degeneration of the stria vascularis during development in melanocyte deficient mutant rats (Ws/Ws rats). Eur Arch Otorhinolaryngol 2002; 259:309–315.

**6** Franz P, Aharinejad S, Firbas W. Melanocytes in the Modiolus of Guinea Pig Coclea. Acta Otolaryngol (Stockh) 1990; 109:221–227.

**7** Ardic FN, Aktan S, Kara CO, Sanli B. High-frequency hearing and reflex latency in patients with pigment disorder. Am J Otol 1998; 19:365–369.

**8** Kemp DT. Otoacoustic emissions, their origin in cochlear function and use. Br Med Bull 2002; 63:223–224.

**9** Anbar TS, El-Badry MM, McGrath JA, Abdel-Azim ES. Mostindividuals with either segmental or non-segmental vitiligo display evidence of bilateral cochlear dysfunction. Br J Dermatol 2015; 172:406–411.

**10** Shalaby M, El-Zarea G, Nasar A. Auditory function in vitiligo patients. Egypt Dermatol Online J 2006; 2:7.

**11** Ozuer MZ, Sahiner T, Aktan S, Sanli B, Bayramoğlu I. Auditory evoked potentials in vitiligo patients. Audiol 1998; 27:255–258.

**12** Escalante-Ugalde C, Poblano A, Montes de Oca E, Lagunes R, Saul A. No evidence of hearing loss in patients with vitiligo. Arch Dermatol 1991; 127:1240.

**13** Orecchia G, Marelli MA, Fresa D, Robiolio L. Audiological disturbances in vitiligo. J AM Acad Dermatol 1989; 21:1317–1318.

**14** Mohamed E, Said E, Sayed D, Awad S, Ahmed M. Auditory system dysfunction in patients with vitiligo: is it a part of a systemic autoimmune process? Egypt J Otolaryngol 2017; 33:594–602.

**15** Fleissig E, Gross M, Ophir I, Elidan J, Bdolah-Abram T, Ingber A. Risk of sensorineural hearing loss in patients with vitiligo. Audiol Neurotol 2013; 18:240–246.

**16** Mahdi P, Rouzbahani M, Amali A, Khiabanlu SR, Kamali M. Audiological manifestations in vitiligo patients. Iranian J Otorhinolaryngol 2012; 1:66.

**17** Akay BN, Bozkir M, Anadolu Y, Gullu S. Epidemiology of vitiligo associated autoimmune diseases and audiological abnormalities. Ankara study of 80 patients in Turkey. Eur J Acad Dermatol Venereol 2010; 24:1144–1150.

**18** Hong CK, Lee MH, Jeong KH, Cha CI, Yeo SG. Clinicalanalysisof hearing levels in vitiligo patients. Eur J Dermatol 2009; 19:50–56.

**19** Tosti A, Bardazzi F, Tosti G, Monti L. Audiologic abnormalities in cases of vitiligo. J Am Acad Dermatol 1987; 17:230–233.

**20** Aydogan K, Turan OF, Onart S, Karadogan SK, Tunali S. Audiological abnormalities in patients with vitiligo. Clin Exp Dermatol 2006; 31:110–113.

**21** Aslan S, Serarslan G, Teksoz E, Dagli S. Audiological and transient evoked otoacoustic emission findings in patients with vitiligo. Otolaryngol Head Neck Surg 2010; 142:409–414.

**22** Schrott A, Spoendlin H, *et al.* Pigment anomaly associated inner ear deafness. Acta Otolaryngol (Stockh) 1987; 103:451–457.

**23** Barrenas ML, Lindgren F. The influence of inner ear melanin on susceptibility to YYS in human. Scand Audiol 1990; 19:97–102.

**24** Barrenas ML, Axelsson A. The development of melanin in the striavascularis of the gerbil. Acta Otolaryngol 1992; 112:50–58.

**25** Halaban R, Heberi DN, *et al.* Biology of melanin. In: Freed berg IM, Eisen AZ, Wolff K, Austen KF, Goldsmith LA, Katz SI, *et al.* editors. Fitzpatrick's dermatology in general medicine. 6th ed. New York: Mc Grow Hill International Book Co; 2003. 127–148.

**26** Sharma L, Bhawan R, Jain RK. Hypoacusis in vitiligo. Indian J Dermatol Venereol Leprol 2004; 70:162–164.