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Measurement of air-, bone- and teeth- conducted threshold levels by pure tone audiometry

Tomomi Yamada[1], Hazuki Maezono[2], Kazunori Nozaki[3],Mikako Hayashi[4] Takanori Matsui[5], Sonoko Kuwano[6]

Osaka University

1-8, Yamadaoka, Suita, Osaka 565-0871, Japan[1–4]

2-1, Yamadaoka, Suita, Osaka 565-0871, Japan[5]

1-1, Yamadaoka, Suita, Osaka 565-0871, Japan[6]

Masayuki Takada[7]

Kyushu University

4-9-1 Shiobaru, Minami-ku, Fukuoka 815-8540, Japan

Annemie Van Hirtum[8]

LEGI, UMR CNRS 5519, Grenoble Alpes University

1209-1211 rue de la piscine, 38000 Grenoble, France

ABSTRACT

We can hear the sounds transmitted differently. One is air-conducted sound through our ears. The other is bone-conducted sound transmitted through bones and soft tissues. When the bone-conducted hearing test is examined for the help of diagnoses, the vibrator for bone conduction is brought into contact with the mastoid behind the ear, and the threshold levels of bone-conduction are examined. In this study, we distinguished "teeth-conduction" from bone-conduction, and measured the pure tone threshold levels of air conduction, bone conduction via the mastoid and teeth conduction via anterior teeth on the upper and lower jaws using an audiometer. The results showed that all participants perceived teeth-conducted sounds. Characterizing the sound of the teeth conduction may help understand the tooth-drilling sound's discomfort and the satisfaction when eating food.

1. INTRODUCTION

[1] yamada@dent.osaka-u.ac.jp
[2] maezono@dent.osaka-u.ac.jp
[3] knozaki@dent.osaka-u.ac.jp
[4] mikarin@dent.osaka-u.ac.jp
[5] matsui@see.eng.osaka-u.ac.jp
[6] kuwano@see.eng.osaka-u.ac.jp
[7] takada@design.kyushu-u.ac.jp
[8] annemie.vanhirtum@univ-grenoble-alpes.fr

It is well known that we perceive both air- and bone-conducted sounds. "Air conduction" is defined as the sound which is transmitted to the inner ear through the outer and middle ears, and "bone conduction" is defined as the sound that it is transmitted to the inner ear by the mechanical vibrations of the skull bones and soft tissues (IEC 60050-801[1], JIS Z8109 [2]). Air- and bone-conducted audiometry tests are examined in order to identify the cause of the hearing loss and assist in diagnosis. The bone-conducted hearing level is usually measured at the mastoid behind the ear using a bone conduction vibrator. We have been conducting research focusing on the sound transmitted through not only our ears but and also through our teeth [3-5]. When we eat something food, tap teeth, have a dental treatment in daily life, we seem to be perceive the sounds through our teeth. We distinguished “the sound that is transmitted via teeth to the skull” from "bone-conducted sound" and defined it as "teeth-conducted sound" (teeth-conduction). How loud can we hear the teeth conducted sound? In this study, we measured air-, bone- and teeth-conducted threshold levels by pure tone audiometry.

2. METHOD

2.1. Apparatus

An audiometer (Acoustic analyzer AA30, Starkey, USA) was used. Air-conducted threshold levels were measured using a headset. Bone- and teeth-conducted threshold levels were measured using a bone-conduction vibrator by pure tone audiometry (Fig. 1). The minimum test level of each pure tone was minus 10 dB.

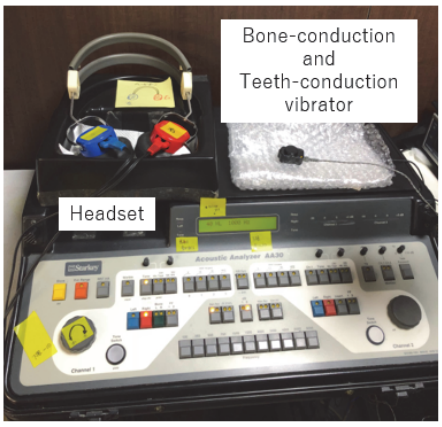

Figure 1: Audiometer

2.2. Procedure

This study is being conducted with the approval of the Ethics Committee of the Osaka University Graduate School of Dentistry and Osaka University Dental Hospital. The measurement was conducted in a soundproof room of the Graduate School of Dentistry, Osaka University. The minimum audible threshold was measured by the 5 dB step ascending method using pure-tone test sounds of 250, 500, 750, 1000, 1500, 2000, 3000, 4000 and 6000 Hz. First, the air-conducted hearing thresholds of both ears were measured. Next, the bone-conduction vibrator was pressed against the mastoid process behind the right ear was examined. Next, the threshold level of the teeth-conducted sound perceived by the subject was measured by pressing the bone-conduction vibrator on the surfaces of the upper and lower anterior teeth (Fig. 2). In consideration of hygiene, the bone-conduction vibrator was covered with a thin film of 11 micro millimeters in thickness and replaced for each subject. In standard bone conduction measurement, perception in the inner ear of the opposite ear is blocked by air conduction masking noise, but in this report, bone conduction and teeth conduction hearing levels are measured with both ears open.

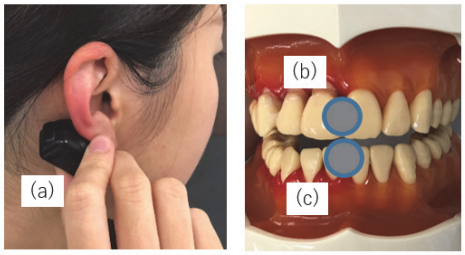

Figure 2: Positions. (a) Mastoid, (b)Upper anterior teeth, (c)Lower anterior teeth

2.3. Participants

Twenty-three participants (12 men and 11 women) aged 20 to 33 years old (average age 26.4 yrs) participated.

3. RESULTS

One participant had a clinical history of sudden deafness in one ear. Therefore, his data were excluded from statistical analysis. All participants were able to perceive the pure tone test sound transmitted from the teeth as a sound.

The audiogram of a 22-year-old male participant is shown in Fig. 3 as an example. It showed that he had good hearing levels at all frequencies.

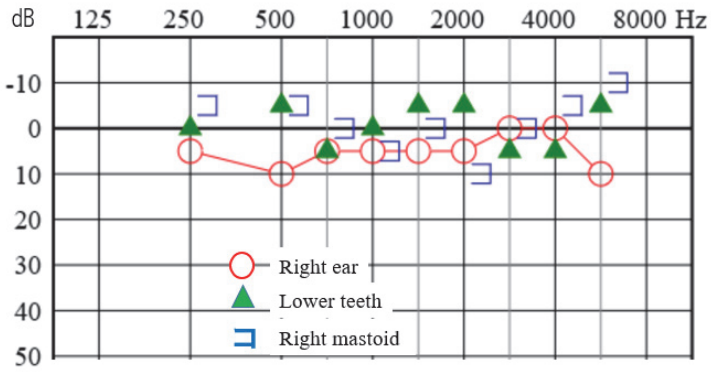

Figure 3: An example of audiogram

Table 1 shows the minimum audible thresholds (median values) of left and right ears (air-conduction), upper and lower anterior teeth (teeth-conduction), and mastoid (bone-conduction). The threshold differences between left and right ears, upper and lower anterior teeth by 0-5 dB were observed.

Table 1: Median hearing threshold levels (dB HL)

	Frequency (Hz)								
	250	**500**	**750**	**1000**	**1500**	**2000**	**3000**	**4000**	**6000**
Left ear	10	10	7.5	10	10	10	5	5	7.5
Right ear	10	5	5	5	5	5	5	5	5
Upper teeth	0	0	0	5	5	10	5	10	5
Lower teeth	5	5	5	5	7.5	7.5	7.5	10	0
Mastoid	0	5	0	2.5	5	10	2.5	2.5	-5

We calculated the average difference of hearing levels based on the values of upper and lower teeth and a mastoid from the hearing level of the both ears obtained for each participant. The results are shown in Fig. 4. A difference in reversal between air conduction and bone conduction hearing levels was observed in several participants at 2000 Hz. Teeth conduction levels were almost the same within ±5 dB on average as bone conduction except at 6000 Hz.

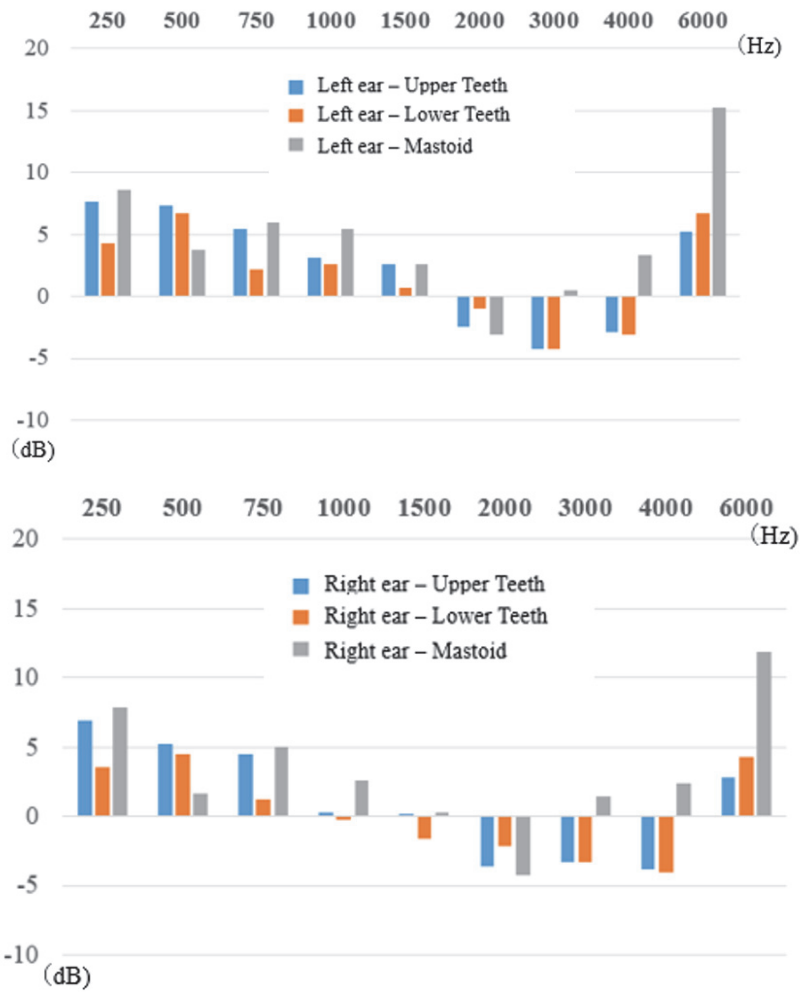

Figure 4:Average hearing level differences between air-conduction and, teeth- and bone-conduction.

4. DISCUSSION & CONCLUSION

According to clinical reports, 80% of the air- and bone-conduction differences are statistically within ±10 dB on average, and a air-bone-bone conduction difference of 10 dB or less is not an error. The skin over the mastoid of the temporal bone (behind ears) is usually thin, and a bone conduction vibrator can transmit the vibration to the temporal bone with hearing organs directly. Teeth and jaws (alveolar bones) do not adhere, and there is periodontal tissue in the gap between teeth and the upper and lower jaws. While the maxilla bone is sutured to the temporal bone, there is a temporomandibular joint space between the mandible bone and the temporal bone. So, we predicted that it was difficult to perceive the sound through lower teeth. However, in the results, the vibrations from the teeth on both of upper and lower jaws were perceived as sound at a low threshold. These results suggest that

teeth transmitted vibration as the sound, and the periodontal tissue and temporomandibular joint may play a role in transmitting the sound without attenuating it. We have reported the measurement of teeth-conducted vibration from the anterior teeth of the upper jaw to the frontal or mastoid regions during dental drilling treatment [5]. The results in this study suggest that this vibration may be perceived as a teeth-conducted sound for dental patients. In further research, we will conduct the measurement of the high frequency for more participants and examined the relations between vibration intensity and perception. Characterizing the sound of the teeth-conduction may help understand the tooth-drilling sound's discomfort and the satisfaction when eating food.

5. ACKNOWLEDGEMENTS

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