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Psychoacoustic effect of air-conducted sound on bone-conducted sound in dental drilling noise

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ABSTRACT

When the teeth are drilled for the dental treatment in dental clinics, patients perceive the bone-conducted sound via their teeth in addition to the air-conducted sound from the ear. It is important to identify the characteristics of both the air-conducted and the bone-conducted dental drilling sounds in order to reduce the unpleasant feeling during treatment. We have reported that high-frequency components in the air-conducted dental drilling sound have a great effect on the unpleasant impression in our former studies. In this study, the psychological evaluation of the bone-conducted dental drilling sounds via teeth with and without air-conducted sound from the ear was examined in order to find psychoacoustics effect of masker. As the results, some difference was found in the psychological evaluation between bone-conducted sounds alone, and air-conducted plus bone-conducted sounds.

Keywords: Dental drill, Psychoacoustics, Bone-conducted sound
I-INCE Classification of Subject Number: 79

1. INTRODUCTION

The sound produced by a dental drill can markedly influence the sound environment in a dental clinic. Indeed, approximately half of the respondents of a questionnaire survey regarding their impression of dental situations experienced an unpleasant feeling when they heard drilling sounds related to dental treatment [1].The comfortable sound environment at a dental clinic should be given to patients. In order to

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find clues to improve the sound quality of dental drills for patients, we investigated the impression of the sound quality of dental drills. In our former studies [2, 3], it was suggested that the air-conducted sound emitted by a dental drill have rich high frequency components up to 20 kHz and it is found that *Comfort Index* (*CI*) named by Kuwano *at.el* [4], which is composed of L_{Aeq} and sharpness, had a significant effect on the subjective unpleasant impression based on the psychological experiment. These reports are limited to air-conducted dental sounds. Therefore, it is important to identify the characteristics of bone-conducted sounds.

The bone-conducted sound is perceived via teeth when drilling their teeth for the treatment or eating something food, in addition to the air-conducted sound through the ears. We have proposed countermeasures for bone-conducted sound besides those for air-conducted sound in order to reduce the discomfort of the patient during treatment. In this study, the air-conducted and the bone-conducted sounds were simultaneously recording while eating rice crackers and conducted psychological experiment in order to find loudness level of perceived sound with bone-conducted sound while eating crackers. Further, in the clinical dental caries treatment situations, psychological evaluation was conducted for bone-conducted drilling sound during dental treatment with and without air-conducted sounds including air-conducted drilling sound emitted by a dental drill and other noise.

2. METHOD

This study was approved by the Ethics Committee of Osaka University Graduate School of Dentistry.

2.1 Psychological experiment during eating rice clackers

2.1.1 Recording air- and bone-conducted sound during eating rice crackers

The measurement was conducted while participants were repeatedly eating rice crackers. The condenser microphone was placed at a position of side the ears. The electret condenser microphone was modified for recording the bone-conducted sound and placed on the bone behind the subjects' ears. Its sound inlet was covered in order to block air-conducted sound. Both the air-conducted sound and the bone-conducted sound were recorded simultaneously using a multi-channel data station (DS2000, Ono Sokki).

2.1.2 Sound stimuli

We mix-pasted both the air-conducted sound and the bone-conducted sound and edited the duration of edited sounds first 8 s after starting to eat using sound software (Audition, Adobe).

2.1.3 Procedure

We conducted psychological measurements using the the method of adjustment [5]. Participants were seated alone in a room. We asked participants to eat rice crackers and instructed participants how to adjust the volume of the sound stimuli from the loudspeaker so that the sound from the loudspeaker and the sound they heard when eating rice crackers were perceived as being the same loudness. They could adjust while they were eating rice crackers. We measured the sound level from the loudspeaker simultaneously.

2.1.4 Participants

Six females and eight males aged between 25 and 33 years participated in this experiment. The hearing of all participants was examined using an audiometer and all had normal hearing ability.

2.2 Psychological experiment in clinical situation

We conducted psychological measurements during dental treatment using the semantic differential scale with 15 adjective pairs selected on the basis of the pre-experimental results [2]. Participants were laid on a dental chair for dental treatment in Osaka University Dental Hospital. We asked participants to cover their ears with earplugs and headphones to block air-conducted sound during treatment. We instructed to judge the impression of the perceived sound during drilling their tooth for treatment with and without air-conducted sound. The air-conducted sounds included dental drilling sound, dental vacuum sound and environment noise. The location of the teeth for treatment, the duration and the depth of drilling were different among participants.

3. RESULTS and DISCUSSION

3.1 Loudness of perceived sound during eating rice clackers

The measurement air-conducted sound level of eating rice crackers were 31-33 dB and the background noise in the room was 29 dB. The participants judged the loudness of their perceived sound from 36 to 51 dB when they were eating rice crackers. They perceived sound with bone-conducted sounds as louder than the air-conducted sound by 5-17 dB (average 10.5 dB). This suggested that bone-conducted sound affected the loudness of perceived sound.

3.2 Psychological evaluation in clinical setting

The example results for the drilling sounds in the case of dental caries treatment of upper tooth and lower tooth are shown in Fig. 1.

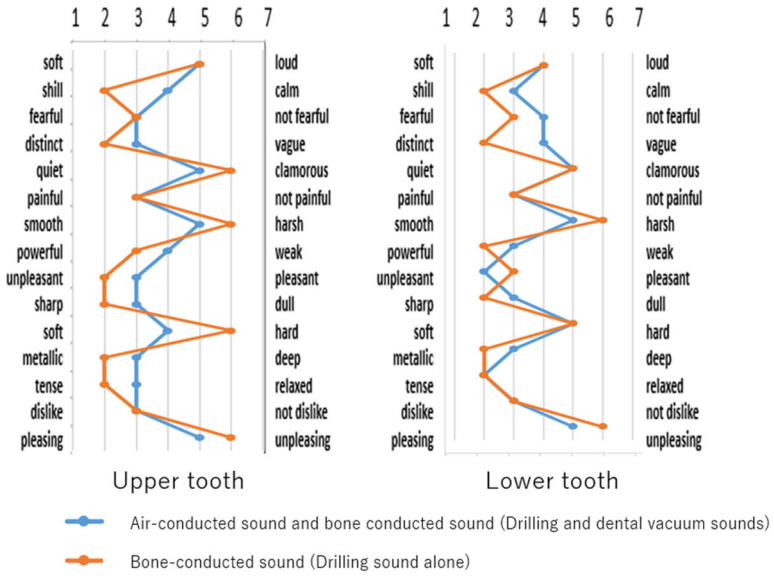

Fig.1 Profiles of subjective impressions of the mixed air-and bone-conducted sounds and bone conducted sound alone during clinical dental treatment.

The clinical situations were various. So it is difficult to assess these results from small samples. However, the results may suggest a tendency that the perceived sound of bone-conducted sound alone were shriller, more distinct, harsh, sharp, metallic and unpleasing than the mixed with air- and bone-conducted sounds. There were several kinds of sounds in clinical room. Especially, a dental vacuum device for absorption of cooling water created loud noise. So the evaluation of the adjective "soft-loud" was close between the mixed sound and bone-conducted drilling sound alone. The results also suggested that the tendency showed clear in upper tooth treatment.

4. CONCLUSIONS

The air- and bone-conducted perceived sound via teeth of eating rice crackers were evaluated louder than the sound through ears by 10 dB. Some difference was found in the psychological evaluation between bone-conducted sounds and air-conducted plus bone-conducted sounds. Bone-conducted sound via teeth affects sound quality. Further investigation is being conducted to examine the effect of bone-conducted sounds.

5. ACKNOWLEDGEMENTS

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