Investigation of Tactual Sensation of Periodontal Ligament by using Electrical Stimulation*

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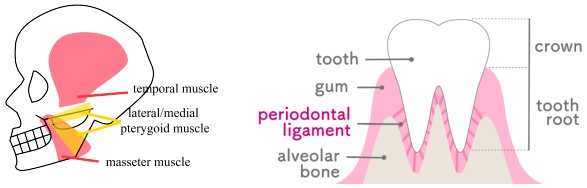
I. Introduction

Food texture, the repulsive force from the food when chewing, is perceived mainly by two oral tissues: The masticatory muscles and the periodontal ligament. The masticatory muscle is an aggregation of muscles to move the jaw bone for chewing food(Fig.1(a)). The periodontal ligament is fiber tissue connecting the tooth and alveolar bone(Fig.1(b)) that has mechanoreceptors to perceive force applied to the tooth. Previously, information from masticatory muscle has been mainly focused on in this research field [1], but the periodontal ligament received less attention, and the organ's function remains unclear.



(a) Masticatory muscle. (b) Inside the gum.

Fig. 1: Oral tissue perceiving food texture.

Then, we aim to develop a system enabling stimulating tactile receptors in the periodontal ligament independently to elucidate the function of the periodontal ligament. In the periodontal ligament, four sensory receptors have been reported to exist: Free nerve ending, Ruffini ending, coiled nerve ending, and spindle-shaped nerve endings [2]. This research activity aims to establish a technology that separately stimulates these receptors. In this study, we conducted a trial of electric stimulation of the periodontal ligament surface and confirmed the generation of toothache-like and tactile sensations.

II. Periodontal ligament electrical stimulation system

Fig.2(a) shows an electrical stimulation device. The device consists of a main circuit board developed by Kajimoto et.al. [3], a converter, and a flexible circuit board for stimulation. On the flexible circuit board, 45 electrodes are mounted in a 1.5 mm pitch(Fig.2(b)). This board with the electrode is fixed on the specific part of the gum using a custom-made mouthpiece for a person.

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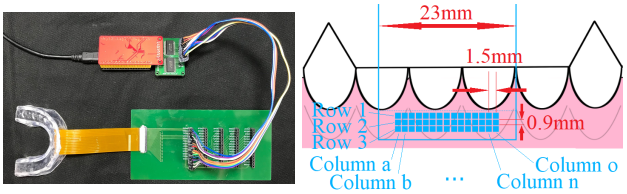

(a) Stimulation device (b) 45 stimulation points on the gum

Fig. 2: Stimulation system

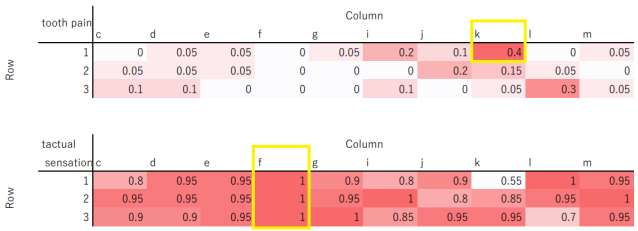

Fig. 3: Occurrence probability of each sensation(Above: Pain, Below: Tactile). Tactual sensation is likely to arise at column f, while pain at row 1, column k.

Experiments were conducted for three days. On the first day, participants were asked to make mouthpieces. On the second and third day, electrical stimulation was conducted to the gum using the mouthpiece. The voltage was between 174 to 262 V, the pulse width was 49.98 us and the amplitude was between 7 to 11 mA. Cathodic stimulation was applied. 30 electrodes out of 45 were stimulated 20 times each in total. Participants were instructed to answer sensation by choosing "tooth pain", "tactual sensation", and "no sensation"(UEC Ethical Review Committee:22084). Fig.3 shows the typical result of the occurrence probability (0-100%) of each stimulation point of a participant, on the first day. From this result, we could succeed in generating tactual sensations and find a place of dependency on the generated feelings.

III. Conclusion

In this study, we discuss the importance of the periodontal ligament for feeling food texture and developed a system to electrically stimulate it. Results show the potential of the system to display tactual sensation.

References

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