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Functional reversibility of temporomandibular joint mechanoreceptors

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ABSTRACT

Objective: Previous studies have reported that the maturation of temporomandibular joint (TMJ) mechanoreceptors occurs during the early stages of mastication, and indicated that TMJ mechanoreceptors lose their function when masticatory loading is decreased. The purpose of the present study was to investigate whether the resumption of proper TMJ loading during the early growth period could restore TMJ mechanoreceptor function.

Designs: Ninety-nine 2-week-old male Wistar rats were divided into two groups and fed either pellets [control group ($n = 33$)] or a liquid diet [experimental group ($n = 66$)]. At 5 weeks of age, the experimental group was split into changing-diet ($n = 33$) and liquid-diet ($n = 33$) groups; the former was fed pellets instead of a liquid diet. TMJ mechanoreceptor activities were recorded from the trigeminal ganglion at 5, 7 and 9 weeks. The firing threshold and maximum instantaneous firing frequency of single TMJ units were measured in each group.

Results: In the changing-diet group, the firing properties of TMJ units were recovered at 7 weeks.

Conclusions: Proper TMJ loading during the early growth period can lead to the restoration of TMJ mechanoreceptor function.

1. Introduction

Joints play important roles in smooth movement and often endure loading during dynamic movement. The temporomandibular joint (TMJ) afferents are involved in the proprioceptive control of mastication, and allows the effector organ, the mandible, to move efficiently. Sensory receptors in the TMJ, as well as the muscle spindles and cutaneous and periodontal mechanoreceptors, transmit information regarding the position of the mandible and the degree of occlusal contact to the brain to achieve rhythmic masticatory movements[1–5].

The TMJ is a diarthrodial joint both morphologically and functionally. Like many other joints, the TMJ is load-bearing[6]. A previous study reported that TMJ loading is an important factor in the normal structure and function of the joint components[7], as well as those of other related components in the stomatognathic system. Moreover, ithas been reported that TMJ mechanoreceptors, important afferents in regulating mastication, lose their functionfollowing a decrease inmasticatory loading[8,9]. However, it is unknown whether TMJ mechanoreceptors show functional recovery if a proper mechanical load is re-applied. This is an important issue in the field of dentistry, since many patients have orofacial dysfunction caused by temporomandibular disorders and/or abnormal occlusal conditions. However, there are no studies investigating the early correction of the masticatory environment during growth with respect to the functional recovery of

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TMJ mechanoreceptors. Studies have shown that mechanical stimulation might accelerate peripheral nerve regeneration[10]and that periodontal Ruffini endings (oral mechanoreceptors) have high potential for neuroplasticity[11]. Thus, the present study aimed to investigate whether appropriate TMJ re-loading during the early growth period could restore TMJ mechanoreceptor function. We tested the hypothesis that the resumption of proper TMJ loading during the early growth period can restore TMJ mechanoreceptor function.

2. Materials and methods

The present experimental procedures were approved by the Animal Welfare Committee and performed in accordance with the Animal Care Standards of Tokyo Medical and Dental University.

2.1. *Animal preparation*

Ninety-nine 2-week-old male Wistar albino rats were used in this experiment (Fig. 1A). To prevent the experimental group from having any experience of chewing solid food, all rat pups were fed by their mothers and examined every 12 h to observe weaning. Soon after weaning, the rats were randomly divided into control (*n* = 33) and experimental groups (*n* = 66). The control group was fed chow pellets (CE-2, CLEA Inc, Tokyo, Japan) while the experimental group was fed a liquid diet consisting of CE-2 powder mixed with water in a blender at a ratio of 1:4 (w/v) in a graduated feeding tube (Dyets® Inc., Bethlehem, PA, USA). At the age of 5 weeks, the experimental group was then further divided into liquid-diet group and changing-diet groups, where rats in the changing-diet group were fed pellets instead of the liquid diet until the end of the experiment (at 9 weeks of age). Food and water were freely accessible throughout the experiment. The body weight of the rats was measured once per week throughout the experimental period (Fig. 2).

2.2. *Stimulation and recording*

For electrophysiological recordings, rats were lightly anaesthetized with 60 mg/kg thiamylal sodium (Isozol®, Yoshitomi Pharmaceutical, Osaka, Japan) administered intraperitoneally (i.p.). The depth of anaesthesia was monitored by checking pupil size, flexor and corneal reflexes, and heart rate. A

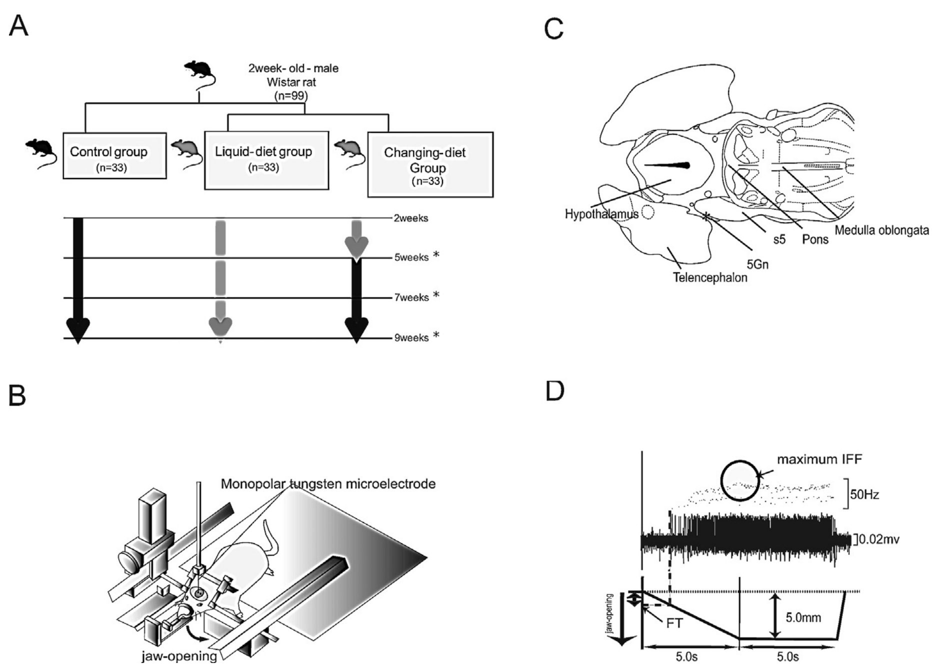

Fig. 1 – Experimental design. (A) Summary of experimental protocol and time schedule. Soon after weaning, rats were divided into control (solid-diet) and experimental (liquid-diet) groups. At 5 weeks of age, the experimental group was further divided into liquid-diet and changing-diet subgroups. Electrophysiological recordings of TMJ mechanoreceptors were obtained in anesthetized rats in all groups at 5, 7 and 9 weeks. An asterisk indicates the recording time. Dark and light arrows indicate feeding periods with pellets and liquid diets, respectively. (B) Schematic drawing of the experimental setting. The rat's head was fixed to a stereotaxic apparatus. A 3.0 mm wide aperture was prepared in the skull, and a monopolar tungsten microelectrode was inserted into the trigeminal ganglion. A string was attached to the mandible, and the ramp-and-hold jaw opening was achieved using an automatic pulling machine. (C) Schematic representation of the trigeminal ganglion drawn from a horizontal section of the brain (9.2 mm below the bregma (reproduced with permission from Paxinos and Watson, 1998). An asterisk indicates the recording site. (D) The firing threshold (FT) was defined as the magnitude (mm) of jaw opening when the first potential was recorded. The vertical dashed line indicates the timing of the first spike potential. The maximum IFF was calculated as the minimum firing interval (Hz) between two consecutive spikes. Abbreviations: s5, the sensory root of the trigeminal nerve; 5Gn, the trigeminal ganglion; FT, the firing threshold; IFF, the instantaneous firing frequency.