学 位 研 究 紹 介

Muscle spindle discharge pattern from jaw-closing muscles during chewing different hardness of foods in awake rabbits.
異なる硬さの違いによる咀嚼時の閉口筋筋紡錘の活動様式

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1. Introduction

The information arising from the various orofacial sensory receptors including muscle spindles modify the fundamental pattern of chewing induced by the central pattern generator (CPG).

In most of the previous studies, muscle spindle discharges were analyzed when the animal was chewing one kind of food or lapping liquid. However, foods with different physical properties need to be processed during natural chewing. Therefore, our aim was to analyze the discharge pattern during chewing different hardness of foods to understand the relationship between the spindle discharge and the hardness of foods.

In addition, in previous studies only chewing sided spindle discharge was investigated. To understand the significance of non-chewing sided spindle information during natural chewing we analyzed discharges while the animal chewed foods ipsilateral and contralateral to recorded side of the neuron.

2. Experimental procedure

Eight male rabbits (Japanese white, 2-3 kg) were used. To record the EMG, teflon-coated stainless-steel wire electrodes were implanted bilaterally on masseter muscles. To record jaw movements, a small cylindrical magnet and a jaw-tracking system consists of two magnet sensors was fixed in the chin and head, respectively (Fig. 1). Glass coated elgiloy microelectrode (0.3-0.8 M Ω at 1 kHz) was used to record the single unit spindle discharge from left mesencephalic trigeminal nucleus. Rabbits were trained to accept test foods before recording. Two test foods with different hardness made of gelatin were used. A chewing cycle was divided into the fast-closing (FC), slow-closing (SC), and opening (OP) phases depending on the jaw movements. Ten consecutive chewing cycles from the early rhythmic chewing period were taken for analysis. The mean frequency of the discharge for each phase and the area of rectified EMG of ipsilateral masseter muscle were calculated for each food.

3. Results

Forty muscle spindle afferent units were successfully recorded during the chewing of soft and hard foods. The mean frequency of discharge was calculated for all the units (Fig. 2A). Spindle discharge was significantly higher for hard food than for soft food in the FC and SC phases of both ipsilateral and contralateral chewing. Masseter muscle activity was higher during the chewing of hard food than that of soft food and this was the case for both ipsilateral and contralateral chewing (Fig. 2B). We compared the mean spindle discharge between the sides of chewing for the 15 units for which we could obtain the data for both-sided chewing (Fig. 2C). In the SC phase of ipsilateral chewing, the discharge was significantly higher than that of contralateral chewing. Masseter muscle activity was higher in ipsilateral chewing than that of the contralateral chewing of hard food (Fig. 2D).

4. Discussion

The present study showed a clear relationship between the spindle discharge and hardness of foods during the natural chewing of food. This relationship was observed during both ipsi- and contralateral chewing. During ipsilateral chewing, the increase of spindle discharge during hard food chewing probably play a role for facilitating jaw-closing muscle activities and then increasing chewing force to compensate the hardness of food (so called load compensation), especially in the SC phase. Indeed, the area under the integrated EMG of the masseter muscle was significantly larger for hard food than for soft food. Inputs from the muscle spindles facilitate the motoneurons of jaw-closing muscles reflexively during chewing. The existence of hardness related increase of spindle discharge on the contralateral side to the chewing suggesting the significance of muscle afferent information to smooth chewing. The muscle spindle may play a role for stabilizing the jaw on the non-chewing side and assist in producing the appropriate force on the chewing side.

A phase dependent difference of spindle discharge between the chewing sides was also observed. This suggests the distinct roles of spindle information on the chewing and non-chewing sides. On the chewing side spindle information may be used for generating chewing force by reflexively increasing jaw-closing muscle activity. On the non-chewing side the spindle may give information about the state (i.e. amount, velocity and direction of shortening) of the muscle of that side.

Reference

Zakir HM, Kitagawa J, Yamada Y, Kurose M, Mostafeezur RM, Yamamura K.: Modulation of spindle discharge from jaw-closing muscles during chewing foods of different hardness in awake rabbits. Brain Res Bull., 83: 380-6, 2010.

Fig. 1

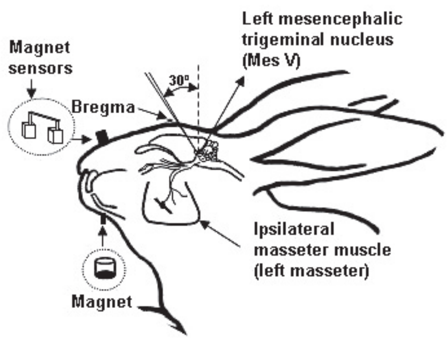

Fig. 1: Schematic diagram of experimental procedure.

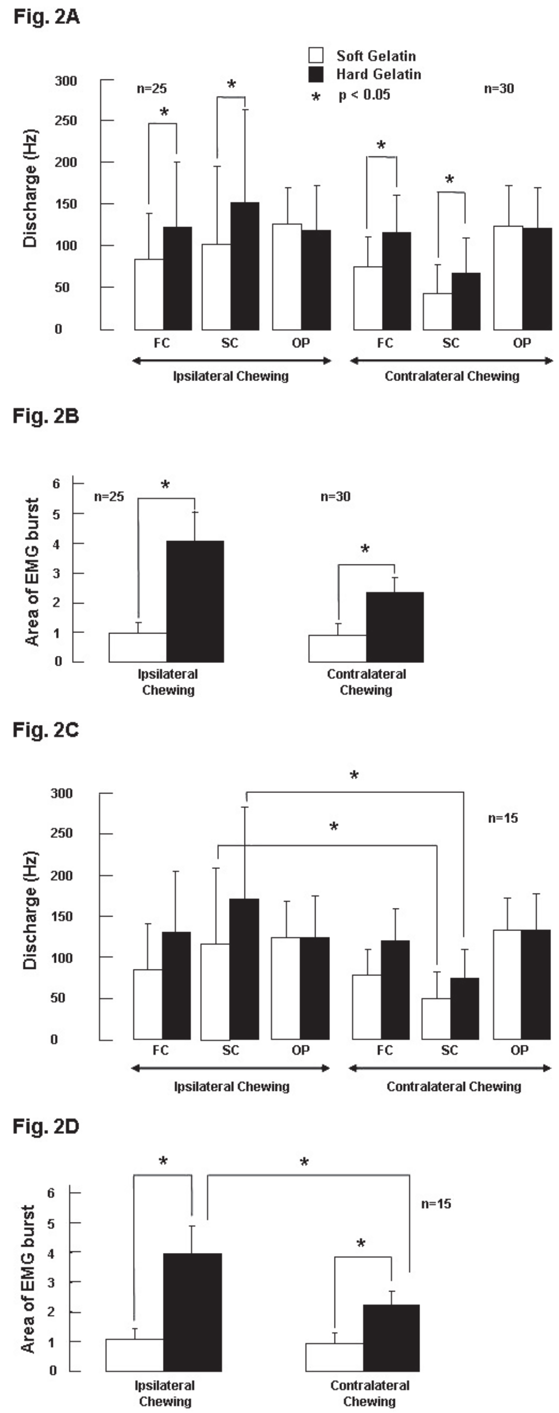

Fig. 2 A: Mean spindle discharge of all units. B: The area of the EMG of the ipsilateral masseter muscle. C: Comparison of the mean spindle discharge between the sides of chewing. D: Comparison of the area of EMG between the sides of chewing.