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Response characteristics of primary periodontal mechanoreceptive neurons simultaneously recorded in the trigeminal ganglion and mesencephalic trigeminal nucleus of the rat in response to trapezoidal and rectangular mechanical stimulation of a single tooth

Shigeru Miyata[1], Niichiro Amano[1], Takahiro Satoda[2],
Takatoshi Murata[3], Shigenori Kawagishi[4], Kenichi Yoshino[5],
Keiko Hayashi[1], and Yasuo Nishikawa[6]

[1](formerly) Division of Oral Neuroscience ; [4]Division of Multidisciplinary Studies ;
[5]Department of Oral Health Management ; Kyushu Dental University, Kitakyushu 803-8580, Japan
[2]Department of Oral Health Science, Faculty of Dentistry, Hiroshima University, Hiroshima 734-8553, Japan
[3]Department of Translational Research, Tsurumi University School of Dental Medicine, Yokohama 230-8501, Japan
[6]Department of Physiology, Osaka Dental University, Osaka 573-1121, Japan

E-mail: sxkk@nifty.com

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Abstract

Periodontal mechanoreceptors are dually innervated by primary neurons whose cell bodies exist in the trigeminal ganglion (TG) and the mesencephalic trigeminal nucleus (MTN). We obtained simultaneous recordings of single-unit responses of primary periodontal mechanoreceptive neurons located in the TG and MTN of the same animal to controlled experimental forces applied to a single tooth. Simultaneous single-unit recordings of electrophysiologically identified primary periodontal mechanoreceptive neurons in a rat's TG and MTN were performed while isosceles trapezoidal or rectangular mechanical stimuli were being applied in either the linguolabial or the labiolingual direction to the ipsilateral maxillary incisor. Fifty-four single units were recorded in 27 rats and classified as rapidly adapting (RA) or slowly adapting (SA) periodontal neurons on the basis of their responses to a decisive rectangular mechanical stimulus applied in the linguolabial direction. Significantly more RA neurons existed in the MTN than the TG (P < 0.05). The response characteristics of the SA and RA periodontal neurons were quite similar between the TG and MTN. The trapezoidal and rectangular stimuli applied in the linguolabial direction elicited a vigorous sustained spike discharge in SA periodontal neurons in both the TG and MTN, whereas both stimuli applied in the opposite (labiolingual) direction did not elicit any SA responses. Rectangular stimuli applied in both directions elicited high-threshold ON-OFF spike responses in the RA periodontal neurons in both the TG and MTN. We also found an unreported burst-type periodontal neuron; its responsiveness was characterized by a brief repetitive

責任者への連絡先：宮田　茂
〒239-0822　神奈川県横須賀市浦賀3-1-11
浦賀通りみやた歯科
E-mail：sxkk@nifty.com

spike discharge of high frequency in response to a slight tapping applied in both directions. Six of the 17 TG-RA neurons examined were this burst-type neuron. From the above results, it is presumed that during incisive process of rat chewing cycle, rapidly repeated chopping or chiselling movements bring about transient, forceful periodontal-masseteric reflex, which can be produced by abundant periodontal inputs from both the MTN and TG.

Key words : Primary periodontal neuron / Trigeminal ganglion / Mesencephalic trigeminal nucleus / Simultaneous recording / Rat

Introduction

Periodontal mechanoreceptors are dually innervated by primary neurons whose cell bodies exist in the trigeminal ganglion (TG) and the mesencephalic trigeminal nucleus (MTN). Well over 75% of the periodontal mechanoreceptors are supplied by the TG, with a lesser number by the MTN[1)]. MTN periodontal mechanoreceptors of a cat's canine tooth are known to be concentrated near the root apex, whereas TG periodontal mechanoreceptors are found around the middle of the root[2)]. We reported that MTN primary periodontal mechanoreceptive neurons innervating a rat maxillary incisor showed the highest frequency of one-to-one following in repetitive tapping at 100 Hz, and all tested neurons exhibited such very rapid adaptation as to show only ON-OFF responses to trapezoidal mechanical stimuli applied more rapidly than 0.6 Newton/sec (N/sec)[3)].

Tabata and Hayashi (1994)[4)] documented that about 90% of TG periodontal mechanoreceptive primary neurons innervating a rat incisor were directionally selective, and the ratio of the number of sustained- and transient-response neurons was about 10 to 1. To the best of our knowledge, there is no report on simultaneous recordings of single-unit responses of the primary periodontal mechanoreceptive neurons located in the TG and MTN of the same rat to controlled mechanical stimuli applied to a single tooth.

The purpose of the present study was to compare the response characteristics to trapezoidal or rectangular mechanical stimulation of the ipsilateral maxillary incisor between electrophysiologically identified primary periodontal mechanoreceptive neurons simultaneously recorded in a rat's TG and MTN. Preliminary reports of this research have been presented previously[5,6)].

Materials and Methods

A total of 27 male Wistar albino rats weighing 440 - 560 g were used in the present study. All procedures of the experiments were approved by the Animal Care and Use Committee at Kyushu Dental University, and were carried out in strict accordance with the National Institute of Health Guide for the Care and Use of Laboratory Animals. During experiments all efforts were made to minimize pain and the number of the rats used. Each rat was anesthetized with sodium pentobarbital (50 mg/kg, i.p.) and tracheotomized. During unit recording, the rat was paralyzed with pancuronium bromide (0.1 mg/kg, i.m., every hr) and artificially ventilated. The rat's rectal temperature was maintained at 37 - 38°C with a thermostatically controlled heating pad. The crowns of the left maxillary incisor and both mandibular incisors were cut off.

Figure 1 shows the schematic representation of stimulating and recording procedures used in this study. In the right maxillary incisor, a small notch was cut in its incisal edge, metal applicators' point was inserted into the notch, and the junction was covered with dental self-curing acrylic resin. Therefore, ramp-and-hold (i.e., isosceles trapezoidal) mechanical stimuli could be applied easily in either the linguolabial or the labiolingual direction through the applicator of an electromechanical force generator (DPS-250H, Dia Medical System, Tokyo, Japan) incorporating a vibrator (Model 101, Ling Dynamic Systems, CT, USA). Foil strain gauges bonded to the applicator arm provided a

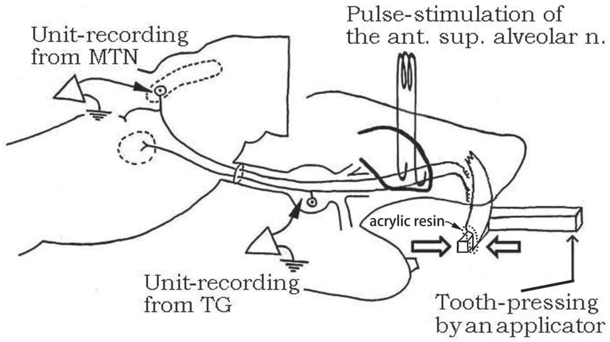

Fig. 1. Experimental arrangements for simultaneous single-unit recordings of electrophysiologically identified primary periodontal mechanoreceptive neurons in a rat's trigeminal ganglion (TG) and mesencephalic trigeminal nucleus (MTN) during controlled experimental forces applied in either the linguolabial or the labiolingual direction to the ipsilateral maxillary incisor.

continuous recording of the forces applied. The forces with the rates of application of 1, 3 and 5 N/sec will be referred to in this paper as trapezoidal mechanical stimuli, while those with the rates of application of 50, 75 and 83 N/sec will be referred to as rectangular mechanical stimuli.

After the rat's head was set in a Narishige stereotaxic instrument (Model SR-5R), the right anterior superior alveolar nerve was exposed by removing the eyeball. The exposed anterior superior alveolar nerve was not sectioned but was left intact for later electrophysiological testing for identifying a unit as the primary afferent. On the right side, a temporal craniotomy was performed, and restricted temporal lobe aspiration was performed to expose the floor of the middle cranial fossa. With gentle retraction of the base of the brain, the dorsal surface of the right TG was exposed, and its three peripheral divisions were confirmed with a surgical microscope. A 5-mm rostrocaudally elongated hole intersecting the right lambdoid suture was drilled, making it possible to insert a recording microelectrode vertically into all regions of the caudal MTN.

A varnish-coated Elgiloy microelectrode (15.3 - 17.8 MΩ at 5 Hz) was directed laterally at a 60-degree angle from the vertical plane in order to insert into the rostrocentral part of the TG by a stepping microdrive, in which maxillary incisor-sensitive units were distributed[4]. Another microelectrode was guided to the caudal part of the right MTN, in which spindle afferent potentials could be evoked by probing the jaw-closing muscles or by cyclic depressing of the mandible. Thereafter, the microelectrode was moved to a caudal side at intervals of 200 μm until periodontal afferent potentials could be elicited by manual pressure on the maxillary incisor. Single-unit activity was continuously monitored on a digital memory oscilloscope (VC-11, Nihon Kohden Corp., Tokyo, Japan) and stored on magnetic tape for off-line analysis. Iron was deposited from the microelectrode tip by passing anodal DC current (20 μA for 3 - 15 min), which was later converted to Prussian Blue spots for histological confirmation[7]. The chi-squared test was used to compare the incidence of unit types between the TG and MTN. The differences with $P < 0.05$ were considered as statistically significant.

Results

When unitary activity was detected in the right TG or MTN responding to manual pressure on the right maxillary incisor, the unit was electrophysiologically identified as a primary afferent by its ability to follow faithfully double pulse stimuli delivered at rates of 500 Hz[8] to the right anterior superior alveolar nerve. Figure 2 exemplifies the electrophysiological examination to identify a periodontal mechanoreceptive unit recorded in the MTN as the primary afferent. Successful simultaneous recordings of single units in both the TG and MTN of the same animal were attained in 19 rats. In the remaining eight rats, single units were recorded only in the TG or MTN of each animal. A total of 54 single units were recorded in the 27 rats.

On the basis of the response to a decisive rectangular mechanical stimulus (magnitude 0.3 N, velocity 75 N/sec, ramp time 4 msec, and plateau time 400 msec) applied in the linguolabial direction (see the middle of the bottom traces in Fig. 3B), all 54 single units could be broadly classified as either rapidly adapting (RA) or slowly adapting (SA) periodontal neurons. The RA periodontal neurons only generated action potentials during the dynamic phase of the rectangular mechanical stimulus, whereas the SA periodontal neurons fired action potentials in a repetitive fashion during the dynamic and static phases of the rectangular mechanical stimulus[9]. Table 1 shows the neuronal type (RA, SA) distribution of the 54 units in the two recording sites (TG, MTN). Looking at all 54 units, the proportion of the RA and SA periodontal neurons was significantly different between the TG and MTN (chi-squared test, $P < 0.05$).

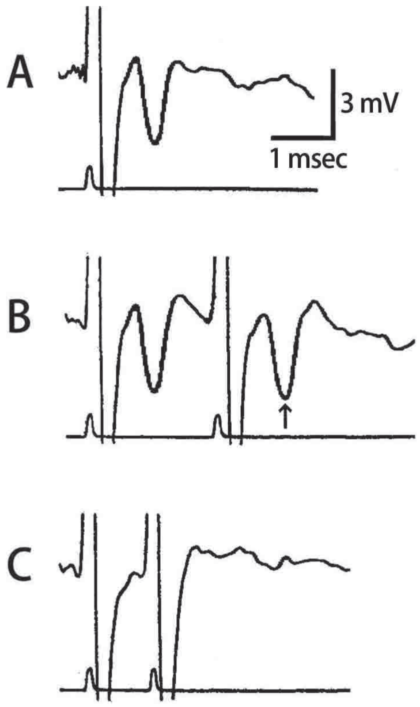

Figure 2. An example of the electrophysiological identification of a primary periodontal mechanoreceptiv unit in the MTN by means of double pulse stimulation of the anterior superior alveolar nerve. In each record, upper and lower traces show unitary responses and stimulus signals, respectively. A, this single unit responding to manual pressure on the maxillary incisor exhibited a single spike potential with a consistent latency of 0.6 msec in response to a single suprathreshold stimulus (3.8 mA, 0.2 msec duration). B, the unit followed faithfully double pulse stimuli separated by 2 msec (i.e., 500 Hz). The upgoing arrow indicates unit response to the second stimulus. C, the unit was not able to follow double pulse stimuli separated by 1 msec (i.e., 1 kHz), which was shorter than the refractory period. The time and voltage calibrations are the same for all records.

Figure 3 shows typical discharge patterns of a TG-SA and an MTN-RA periodontal neuron that were encountered in three of the 19 rats. Under the same magnitude of loading applied in the linguolabial direction, the SA responses of the TG periodontal neuron showed greater spike numbers and spike frequencies to the trapezoidal stimuli compared to the rectangular stimuli (Fig. 3A, B). The maximum frequency of the SA spike responses amounted to 107 Hz during the trapezoidal stimulation at 5 N/sec velocity and 0.5 N magnitude. This TG-SA periodontal neuron exhibited directional preference properties just like an SA periodontal mechanosensitive unit in the dog, as illustrated in Figure 2 in a 1970 study by Hannam[10]. When the incisor was stimulated 180 degrees from its sensitive linguolabial direction, the vigorous sustained spike responses of the TG-SA neuron were abolished and OFF spikes occurred. Such OFF responses to the trapezoidal and rectangular mechanical stimuli were an OFF spike and double OFF spikes, respectively (Fig. 3C, D). The stretch receptor, a Ruffini-like corpuscle, located in the lingual periodontal ligament of rats[1,11] appears to be a preeminent

Table 1. Distribution of the neuronal types (RA, SA) of 54 periodontal neurons in two recording sites (TG, MTN) in the rat

Neuronal type	RA	SA	Total
TG	17 (57)	13 (43)	30 (100)
MTN	21 (88)	3 (12)	24 (100)
Total	38	16	54

RA, rapidly adapting; SA, slowly adapting; TG, trigeminal ganglion; MTN, mesencephalic trigeminal nucleus. The data are the number of neurons (percentage).

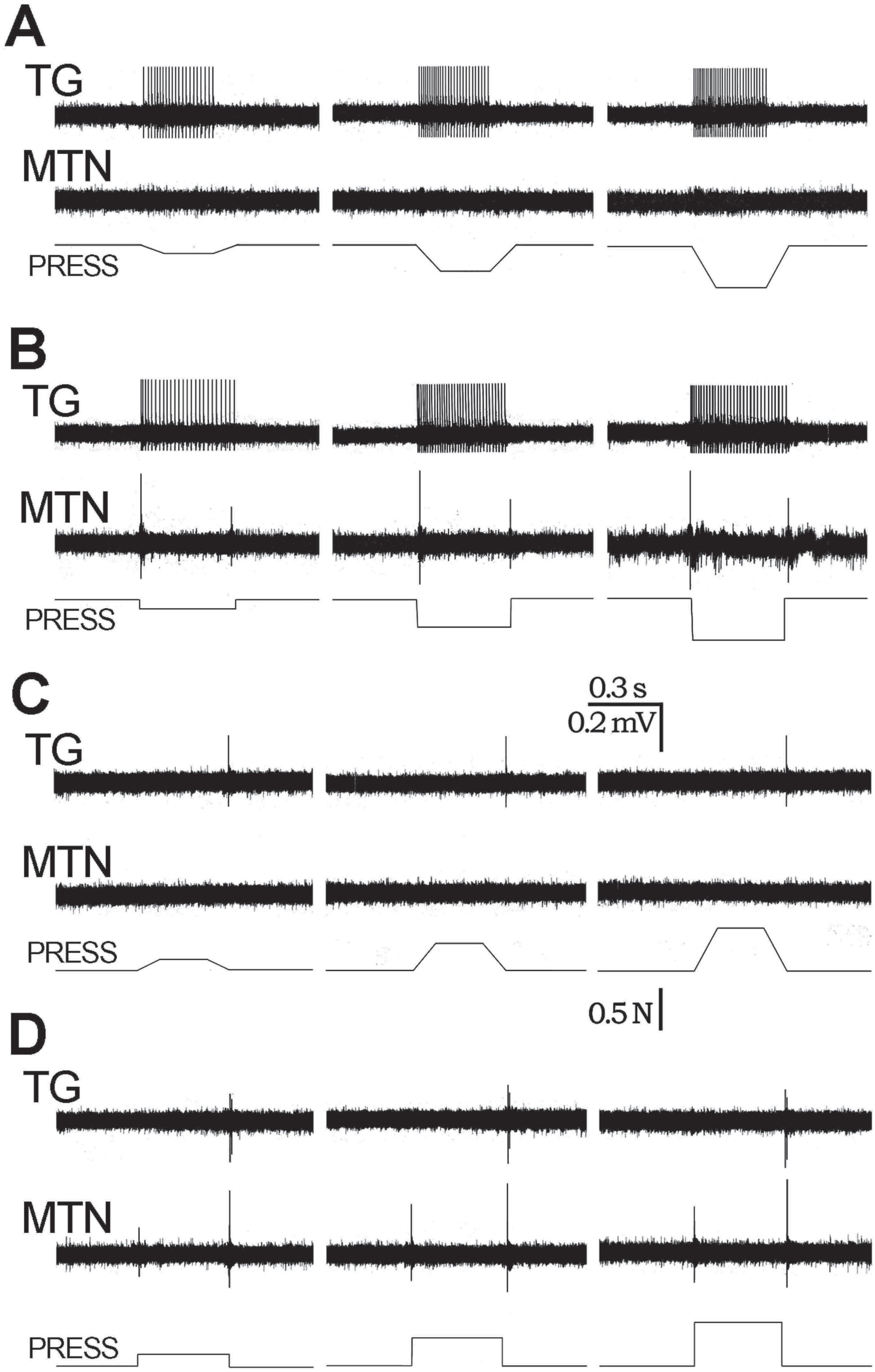

Fig. 3. Simultaneous recordings of a slowly adapting (SA) and a rapidly adapting (RA) periodontal mechanoreceptive primary neuron located in the TG and MTN of the same rat, respectively, to isosceles trapezoidal (bottom traces in A and C) and rectangular (bottom traces in B and D) tooth-pressing stimuli applied in the linguolabial (downward stimuli in A and B) or labiolingual (upward stimuli in C and D) direction. Trapezoidal stimuli were stepwisely increased in velocity and magnitude as follows: 1 Newton/sec (N/sec) and 0.1 N; 3 N/sec and 0.3 N; 5 N/sec and 0.5 N (from the left to the right in the bottom traces in A and C). In the rectangular stimuli, graded velocities and magnitudes were as follows: 50 N/sec and 0.1 N; 75 N/sec and 0.3 N; 83 N/sec and 0.5 N (from the left to the right in the bottom traces in B and D). Sustained spike responses were elicited in this TG-SA neuron, while ON-OFF spike responses were elicited in the MTN-RA neuron. The voltage, time, and force calibrations in C were also applied in A, B and D.

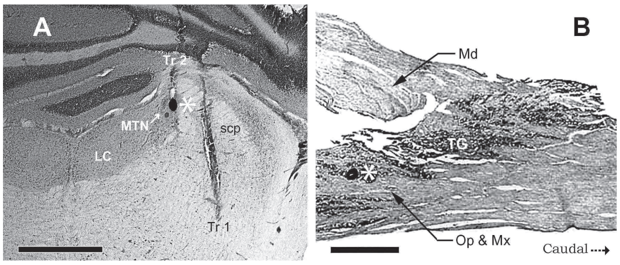

Fig. 4. Photomicrographs showing the recording sites (Prussian Blue spots) of the MTN-RA (A) and the TG-SA (B) periodontal neuron illustrated in Figure 3. A, Prussian Blue spot (asterisk) was located at the termination of the electrode track 2 (Tr 2) within the MTN. A large oval cell body of another primary afferent MTN neuron was seen just at the lower left of the spot. B, Prussian Blue spot (asterisk) was found in the rostrocentral part of the TG. LC, locus coeruleus; scp, superior cerebellar peduncle; Op, ophthalmic nerve; Mx, maxillary nerve; Md, mandibular nerve. Scale bar, 1 mm for A and B.

candidate for this TG-SA periodontal neuron.

As shown in Figure 3A - D, the MTN-RA periodontal neuron did not respond at all unless the incisor was stimulated by the rectangular mechanical stimuli applied more rapidly than 50 N/sec. The response of the MTN-RA neuron to linguolabially applied stimuli was only one ON-OFF spike. It was noted that the rectangular mechanical stimuli in the reverse (labiolingual) direction produced a very similar ON-OFF spike whose appearance was a mirror image of the ON-OFF spike evoked by the linguolabially applied stimuli. Figure 4 shows the histological verification of recording sites of the TG-SA and the MTN-RA periodontal neuron illustrated in Figure 3.

In this study, a small number of spontaneously active SA units (three) were obtained in the TG of three rats. In common with these units, a spontaneous spike discharge at about 60 Hz increased to about 130 Hz while the trapezoidal mechanical stimuli were being applied in the linguolabial direction, whereas the spontaneous spike discharge completely disappeared while the trapezoidal stimuli were being applied in the labiolingual direction (not illustrated).

Figure 5 is a typical record of the combination of a TG-RA and an MTN-RA periodontal neuron, which was the most frequently encountered combination in this study (9/19 rats). Both the TG-RA and MTN-RA periodontal neurons were unexcitable even at high intensities of the trapezoidal mechanical stimuli (data not shown). As shown in Figure 5A, when the graded rectangular mechanical stimuli were applied in the linguolabial direction, the TG-RA and MTN-RA periodontal neurons responded with a pattern of ON-OFF spikes, similar to the response of the MTN-RA periodontal neuron illustrated in Figure 3. As seen in Figure 5A, the ON spike responses of the TG-RA periodontal neuron were characterized by a burst consisting of about 15 spikes within 50-msec duration, which presented an appearance of a tapered delta shape because the spike size decreased exponentially with time. The number of spikes increased with the increase in stimulus intensity.

When an extremely shortened and weakened (8-msec duration and 0.03 N magnitude) rectangular mechanical stimulus (tapping) was applied in the linguolabial direction, this TG-RA periodontal neuron produced a brief ON spike response alone consisting of a burst of five spikes with 20-msec duration (Fig. 5B). We therefore suspected that the waning event of the amplitude of the spike burst was not due to transmission of the mechanical vibration to the recording microelectrode after the tooth-tapping, but rather it was a characteristic of the generation mechanism of the action potentials from this burst-type TG-RA neuron. Furthermore, the possibility of a multiunit recording was eliminated following the waveform analysis of a high-speed trace. Six of the 17 TG-RA neurons examined displayed such burst-type spike responses.

The rectangular mechanical stimuli applied in the reverse (labiolingual) direction produced ON-OFF spike responses in both the TG-RA and MTN-RA periodontal neurons (Fig. 5C). Waveforms of these ON-OFF spike responses corresponded to those in which the ON-OFF spike responses to the linguolabially applied stimuli interchanged their positions (Fig. 5A, C).

Both the TG and the MTN are collections of

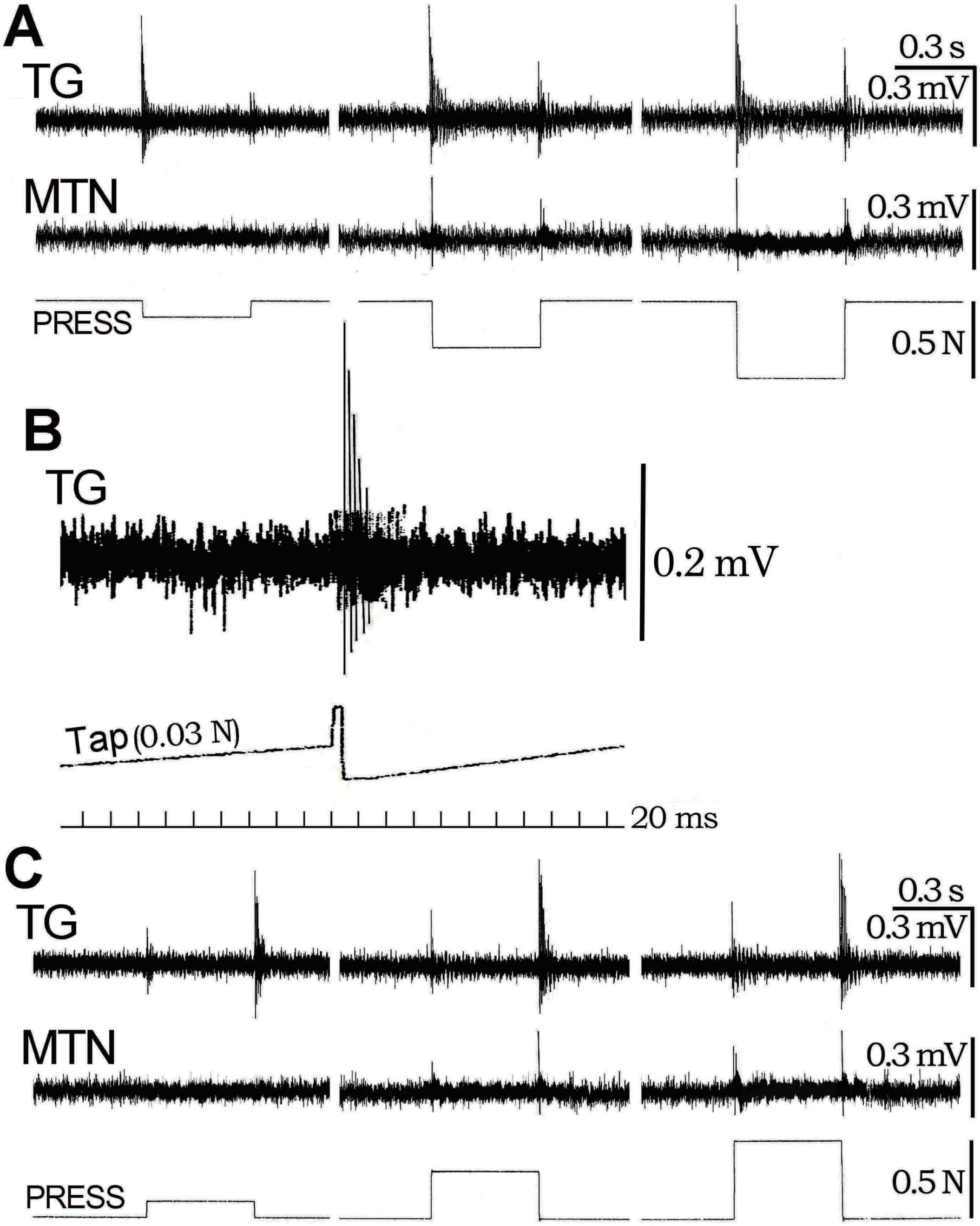

Fig. 5. Responses of a TG-RA and an MTN-RA periodontal neuron in the same rat. Both RA neurons were unexcitable even at high intensities of trapezoidal tooth-pressing stimuli, but showed ON-OFF spike responses to rectangular stimuli (A-C). B, when an extremely shortened and weakened (8 msec duration and 0.03 N magnitude) rectangular tapping was applied linguolabially, a brief ON spike response alone was elicited in the TG-RA neuron. This ON spike response was characterized by a high-frequency burst of five spikes within 20-msec duration. The waveform of ON and OFF spike responses were interchanged mutually according to the change of the direction of tooth-pressing. Note that the direction of rectangular tapping signal (second trace from bottom) is reversed in B.

cell bodies of primary trigeminal afferent neurons. In the rat MTN, there are numerous cells ranging in size from 200 to 300 μm in diameter, clustering with soma-soma contacts[12,13]. In the rat TG, intraganglionic synapses have become a focus of attention[14,15]. In the present study, there were seven rats in which the activity of two periodontal single units was recorded simultaneously by one microelectrode inserted into the TG (6 rats) or MTN (2 rats). When two periodontal single

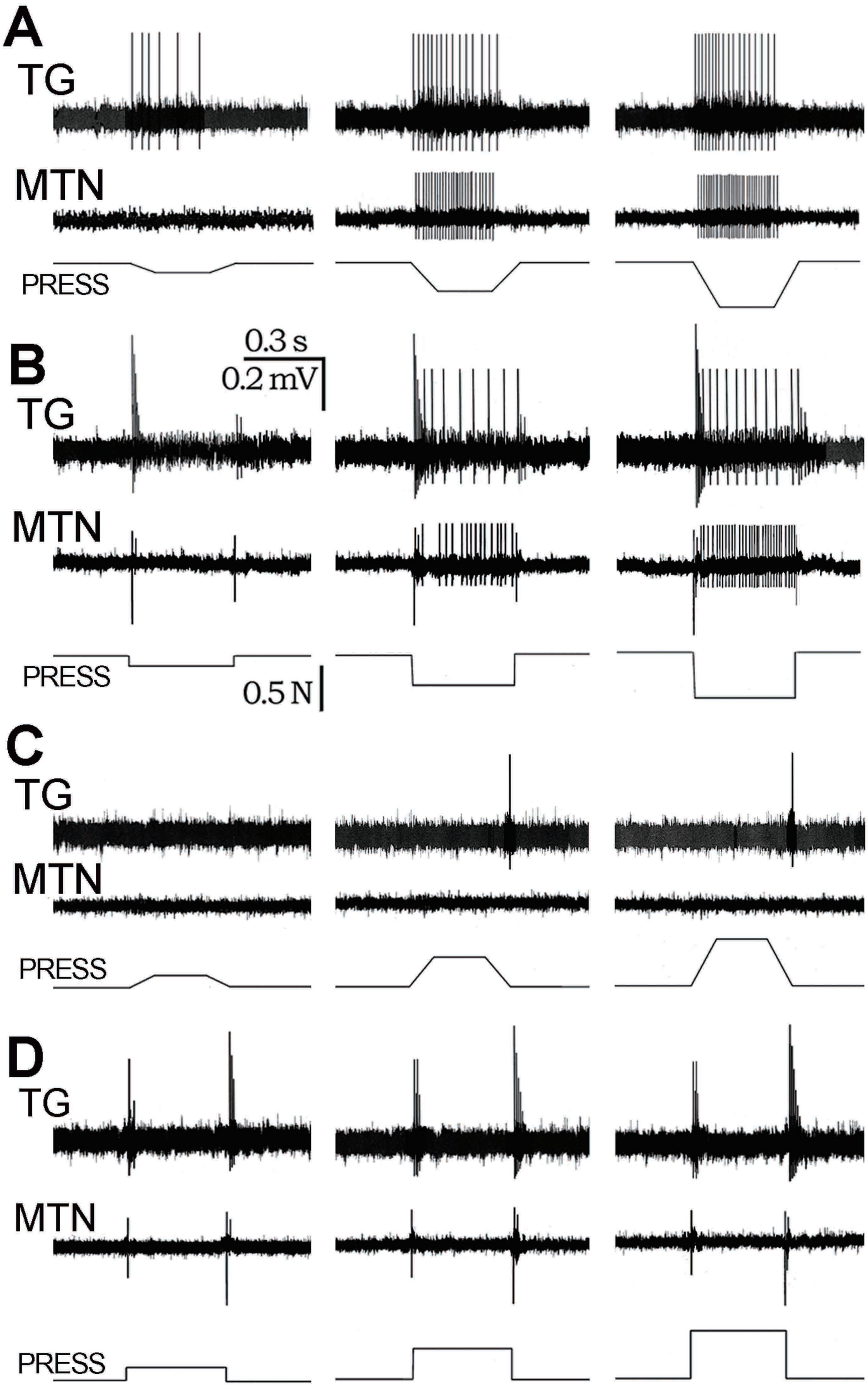

Fig. 6. Simultaneous recordings of an SA and an RA periodontal neuron through respective microelectrodes placed in a rat's TG and MTN. (A, B) Both TG-SA and MTN-SA neurons exhibited a clear directional sensitivity and responded with vigorous sustained spike discharges exclusively to linguolabially applied tooth-pressing, whereas vigorous continuous spike responses were abolished by labiolingually applied tooth-pressing (C, D). In contrast, large-amplitude TG- and MTN-RA neurons responded with ON-OFF spikes to both linguolabially and labiolingually applied rectangular tooth-pressings. Voltage, time, and force calibrations in B apply to A, C and D.

units were caught in the same microelectrode, the activity of each unit was identified from its waveform in a stationary state of a high-speed trace on the memory oscilloscope.

Figure 6 shows the simultaneous recordings of an SA and an RA periodontal neuron through respective microelectrodes placed in the TG and MTN of the same rat. The MTN-SA periodontal neuron is one of the three which were obtained from the MTN of all animals (see Table 1). There was a strong resemblance in the response characteristics of the SA and RA periodontal neurons between the TG and MTN. Both the TG-SA and MTN-SA periodontal neurons exhibited prominent directional preference, and responded with a continuous spike activity exclusively to the linguolabially applied mechanical stimuli (Fig. 6A, B), whereas the labiolingually applied stimuli abolished the sustained spike activity in both neurons, and evoked an OFF spike in the TG-SA periodontal neuron (Fig. 6C, D).

The continuous spike responses of the TG-SA and MTN-SA periodontal neurons were more remarkable as to the total number of evoked spikes and the discharge frequency to the trapezoidal than to the rectangular mechanical stimuli with the same magnitude (Fig. 6A, B). The maximum frequency of the SA spike activity amounted to 120 Hz and 70 Hz in the MTN and TG periodontal neurons, respectively, during the trapezoidal mechanical stimulation at 5 N/sec velocity and 0.5 N magnitude; it decreased to 83 Hz and 40 Hz, respectively, during the rectangular stimulation at 83 N/sec velocity and 0.5 N magnitude (Fig. 6A, B). This MTN-SA periodontal neuron showed greater maximum discharge frequency compared to the TG-SA periodontal neurons illustrated in Figures 3 and 6. In addition, the MTN-SA periodontal neuron was slightly high-threshold, and thus it could not respond to the trapezoidal as well as the rectangular mechanical stimuli with the smallest magnitude.

As seen in Figure 6B and D, both the TG-RA and MTN-RA periodontal neurons responded with ON-OFF spikes exclusively to the rectangular mechanical stimuli in both directions. Although this was the same event as that illustrated in Figure 5A and C, a substitution of the waveforms of the ON-OFF spike responses arose between the linguolabial and labiolingual stimulations (Fig. 6B, D). Such an exchange of ON and OFF spike responses would be effective to provide sensory information about changing the direction of forces delivered to the maxillary incisor. The TG-RA periodontal neuron in Figure 6B was the same as the TG-RA periodontal neuron in Figure 5 regarding its ON discharge of a brief burst of high-frequency spikes in response to the linguolabially applied stimuli.

Discussion

We observed an absolute majority of the RA-type periodontal neurons in the MTN compared to the TG ($P < 0.05$, see Table 1). Taking into consideration that an excessive dynamic loading as steep as 75 N/sec was used as the criterion for classifying the neurons as the RA versus SA type, the above result provides further evidence that the rat MTN periodontal neurons may be involved in information transmission of the displacement velocity and the vibration delivered to the incisor[3)].

We found six TG-RA periodontal neurons which exhibited a brief repetitive spike discharge of high frequency in response to a slight tapping applied linguolabially. Unlike the TG-SA periodontal neurons probably supplying the Ruffini-like corpuscles in the lingual periodontal ligament[1,11)], these burst-type TG-RA neurons were devoid of directional sensitivity, and they responded to both the linguolabially and labiolingually applied stimuli. In addition, the burst-type TG-RA periodontal neurons were so sensitive to mechanical transients that they could not respond at all unless the incisor was stimulated more rapidly than 50 N/sec.

Any discussion concerning the nature of the periodontal receptors innervated by the burst-type TG-RA periodontal neurons must of course be speculative. However, there are two candidates for this periodontal receptor. Although the existence of Pacinian corpuscles in the periodontal ligament has been denied[16], an unknown burst-type mechanoreceptor resembling Pacinian corpuscles (which are activated best by 60 - 300-Hz vibration[17]) might exist in the rat periodontal ligament. Berkovitz and Shore's (1978)[18] ultrastructural observation in the periodontal ligament of the rat incisor has referred to the presence of lamellar, knob-like, neural terminations where single myelinated nerve fibers are surrounded by bundles of small myelinated fibers in close apposition. Such structures are generally similar to those reported by Bonnaud et al. (1978)[19] in the cat and by Harris and Griffin (1974)[20] in humans, which were described by Bonnaud et al.[19] as resembling the structure of Pacinian corpuscles.

Another candidate for the burst-type periodontal receptor might be included in the nociceptive category with the greatest response to damaging stimuli. Unfortunately, there is little published information regarding nociceptive afferents in the rat periodontal ligament, although a study of the feline periodontal ligament is available[21]. We are planning further experiments to clarify the structural and functional properties of the periodontal receptors innervated by the newly identified burst-type TG neurons.

The direction in which a rat maxillary incisor is pressed has been reported to determine the production of the excitatory or inhibitory periodontal-masseteric reflex (PMR)[22,23]. In the excitatory PMR, a linguolabial tapping on the maxillary incisor induced a fast transient electromyographic (EMG) activity and a subsequent tonic EMG activity in the ipsilateral masseter muscle[22]. As seen in Figure 6B, the early transient RA and the following tonic SA spike discharges in the TG-RA and TG-SA periodontal neurons bear a close resemblance to the EMG pattern of the excitatory PMR. In particular, repetitive excitatory inputs of the large-amplitude ON spikes from the burst-type TG-RA neuron would be the most advantageous to evoke the early transient excitation in the masseteric motoneurons. On the other hand, the existence of the inhibitory PMR was disclosed from the finding that labiolingual pressing on the rat maxillary incisor induced an inhibition of ongoing spontaneous EMG activity in the ipsilateral masseter muscle[23]. This phenomenon could be explained from our finding that the labiolingually applied tooth-pressing completely depressed the spontaneous spike discharge in the three spontaneously active TG-SA neurons, in contrast to the linguolabially applied tooth-pressing, which resulted in a facilitation of the spontaneous spike activity. These properties may be a reflection of the direction of occlusal forces during masticatory movements.

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ラット三叉神経節および三叉神経中脳路核において同時記録された一次歯根膜機械受容ニューロンの単一歯台形状および矩形状機械刺激に対する応答特性

宮田 茂[1]・天野 仁一朗[1]・里田 隆博[2]・村田 貴俊[3]
河岸 重則[4]・吉野 賢一[5]・林 恵子[1]・西川 泰央[6]
九州歯科大学 [1](旧)摂食神経科学分野；[4]総合科学分野；[5]口腔保健管理学講座
[2]広島大学大学院口腔健康科学講座
[3]鶴見大学歯学部探索歯学講座
[6]大阪歯科大学生理学講座

抄　録

歯根膜機械受容器は三叉神経節および三叉神経中脳路核の一次求心性ニューロンによって二重支配されている。単一歯に加えた実験的制御力に対する同一動物の三叉神経節および中脳路核の一次歯根膜機械受容ニューロンの単一ユニット応答を同時記録した。具体的には、人工呼吸を施したネンブタール麻酔・パンクロニゥム非動化ラットの右側上顎切歯に二等辺台形状または矩形状機械刺激を舌唇または唇舌方向に加えている間に、同側三叉神経節および中脳路核において電気生理学的に同定した一次歯根膜機械受容ニューロンから同時に単一ユニット記録を行った。27匹のラットから54個の単一ユニットが記録された。それらのユニットは舌唇方向に加えた基準の矩形状機械刺激(刺激の大きさ＝0.3 Newton、刺激速度＝75 N/sec、ランプタイム＝4 msec、プラートタイム＝400 msec)に対する応答に基づいて速順応性あるいは遅順応性歯根膜ニューロンに分類された。中脳路核には三叉神経節に比べて統計学的に有意に多数の速順応性歯根膜ニューロンが存在した($P < 0.05$)。遅順応性および速順応性歯根膜ニューロンの応答特性は三叉神経節と中脳路核間で非常に類似していた。舌唇方向に加えた台形状および矩形状刺激は三叉神経節、中脳路核両方の遅順応性歯根膜ニューロンに活発な持続するスパイク発射を誘発するのに反して、反対方向(唇舌方向)に加えた台形状および矩形状刺激はいかなる遅順応性応答も誘発しなかった。両方向に加えた矩形状刺激は三叉神経節と中脳路核両方の速順応性歯根膜ニューロンに高閾値のオン-オフ・スパイク応答を誘発した。著者らはまた、未だ報告のないバースト型歯根膜ニューロンを発見した。その応答性は、両方向に加えた軽いタッピングに応答して短い反復性の高頻度スパイク発射を示すという特徴を持っていた。記録した17個の三叉神経節の速順応性ニューロンのうち、６個がこのバースト型ニューロンであった。以上の結果から、ラットの咀嚼サイクルの咬断期に急速に繰り返されるchoppingあるいは chiselling動作は、中脳路核と三叉神経節の両方からの豊富な歯根膜入力に起因する一過性で強力な歯根膜・咬筋反射をもたらすと考えられる。

キーワード：一次歯根膜ニューロン／三叉神経節／三叉神経中脳路核／同時記録/ ラット