Systemic effects of the peripheral disturbance of the trigeminal system: Influences of the occlusal destruction in dogs

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Abstract: Although there is an increasing amount of information pertaining to intracranial pathways of the trigeminal nerve, its clinical significance still remains unclear in many ways. I assumed that dental disorders including malocclusion would lead to the disturbance of the central nervous system via the trigeminal nerve. Based on this belief, this study was conducted to find out systemic effects of the occlusal destruction by grinding teeth unilaterally in dogs. As the result, abnormal involuntary movement and symptoms of autonomic failure were observed.

These experimental results indicate that the trigeminal nuclear complex contains not only the functions of the sensory relay in the face and the control of chewing movement, but it is likely that it modulates motor, especially postural control and autonomic system. It is believed that the dental aspects, especially occlusion, play an important role for the proper functioning of the trigeminal system.

Key words: Trigeminal system, Occlusal destruction, Postural control, Involuntary movement, Autonomic failure.

Introduction

Trigeminal pathways to the basal ganglia, the parabrachial nucleus, the cerebellum, the vestibular nuclei, the brain stem reticular formation and superior colliculus have been reported in recent years. Their function and clinical significance, however, have not been clarified in many respects.

Mandibular dysfunction leads to an increased incidence of those diseases that are thought to be attributed to improper posture and autonomic failure. It has been pointed out that orofacial dyskinesia is improved dramatically by the adjustment of the denture occlusion. These findings suggest that various disorders may result from the disturbance of the peripheral trigeminal inputs, which may be caused by malocclusion.

Few experiments have been made so far to study chronic systemic effects of malocclusion. In this study, I examined experimentally long-term systemic effects of dental disorders involving malocclusion in beagle dogs. Specifically, dogs' teeth were

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Materials and Methods

Three female beagle dogs born in June, 1986 were used in this experiment. These dogs had been specially raised for safety tests by Fujisawa Pharmaceutical Co. Ltd. with known genetic predispositions and characteristics. For this reason, no control was set up. The experiment was initiated, when the terminal molars erupted at the age of eight months. The dogs were raised in cages where temperature and humidity were kept constant at Fujisawa experimental center.

The dogs' teeth were destroyed unilaterally on the first day of experiment. This was accomplished by grinding both upper and lower teeth on the right side with a diamond bur (made by Shofu, No. 3) under anesthesia with 30 mg/kg of pentobarbital to reduce the dental dimension by about 3 mm in the terminal molar region (Fig. 1). These pulps were exposed in some areas.

These dogs were fed soft diet (Dogmeal with milk) for a week after the treatment. Ordinary meal consisted of a daily amount of 300 g of solid food (Labodiet) during an experimental period of one year.

Observations were made of not only food intake, body weight and stool, but also external appearance including movement and posture. General hematological examination were made on a monthly basis.

Experimental Results

1. Changes in intraoral and occlusal condition

The mandibular midline always shifted to the right about a half a lower tooth one week after the occlusal destruction (Fig. 2). An extraoral fistula was formed in the right maxillary area five months after the treatment in Case No. 1 (Fig. 3).

2. Symptoms of autonomic failure

There were no changes in general hematological finding before and one year after the occlusal destruction in all cases. Fig. 4 shows changes in body weight of each dog. All the dogs lost weight for up to two weeks after the occlusal destruction. However, they gained their weights to about 7-8 kg in ten to twenty weeks and maintained the level thereafter.

The observation of stool samples during the experimental period revealed no particular abnormalities.

Loss of the hair luster was observed in all cases a few months after the occlusal destruction, which remained unchanged with no improvement throughout the experimental period. Severe hair loss was observed in Case No. 1 ten months after the occlusal destruction (Fig. 5).

Salivation was observed in all cases for about two weeks after the occlusal destruction. Lacrimation began to appear three months after the occlusal destruction and remained throughout the experimental period in all cases. This lacrimation was observed on both side at first, which remained on the right side in Case No. 1 and Case No. 2 (Fig. 6) but in Case No. 3 on the left side.

The dog of Case No. 2 showed the symptom of lacrimation on the right side, which was accompanied by persisted reddish nodule in the left eye throughout the experimental period (Fig. 7).

3. Effects on the motor system

Resting tremor was observed in Case No. 1 severely, a slight one in Case No. 3 for a few months, starting in Case No. 1 three months after and in Case No. 3 six months after the occlusal destruction. Up and down movement twice per second was observed mainly in the left hind leg. These movement was no longer observed clearly after four months.

All the dogs showed the muscle weakness in the left hind leg. Case No. 1 and No. 3 began to show adduction of the left hind leg with pelvic distortion a few months after the occlusal destruction (Fig. 8, 9). Case No. 1 and No. 3 walk lame like scoliosis. These states did not improve after half a year. The adduction of the left hind leg caused the pelvis to rotate, resulting in unnatural horizontal sitting position (Fig. 10). In contrast, increased tendon reflex was observed in the right hind leg in Case No. 1 and No. 3, persisting throughout the experimental period after lameness. With adduction of the left hind leg, the dogs moved in such a manner to protect the left leg. When forces were applied to the left hind leg, Case No. 1 show little resistance against the forces. Consequently, the dog was unable to walk straight and walked slanting the body (Fig. 9).

Discussion

Few reports suggest that toothache and other forms of dental disorders may cause
specific clinical symptoms, except temporomandibular joint arthrosis, which seems to be closely related with malocclusion. I conducted experimental occlusal destructions in dogs to study the influence exerted by such malocclusions that cause chronic changes in length of the masticatory muscles. As the result of this experiment, the mandible was displaced to occlude. Weight loss, lacrimation, salivation, hair loss, etc. were observed as autonomic symptoms, while tremor, lameness and improper posture were observed as motor dysfunctions. There were mandibular displacement and two possible systemic influences in this experiment.

1. Oral condition of the occlusal destruction

The grinding of tooth structure for the occlusal destruction stimulated the pulpal tissues directly, causing severe pain during meals. The act of eating seemed to be restricted until pulpal protection was completed with the formation of secondary dentin. It is believed that pain disappears after the destruction of pulpal tissues, but that prior to the pulpal destruction, excessive nociceptive stimuli from trigeminal exteroceptors are inputted mainly into the trigeminal spinal nucleus via the semilunar ganglion. In this experiment, this process seemed to have continued for approximately one month after the start of the experiment.

The mandible was displaced to the ipsilateral side one week after the unilateral occlusal destruction, which resulted in the difference in length of the masticatory muscles, especially jaw-closing muscles. Consequently, occlusion is defined as appropriate contact between upper and lower teeth on both side. That is to say, dental conditions involving occlusion made an influence on the trigeminal proprioceptive informations such as the muscle spindle afferents, jaw-closing muscles and the mechanoreceptors afferents of periodontal ligaments.

The muscle contraction for mastication is activated by a centrally-formed reflex mechanism having a rhythmical pattern. In spite of the unilateral occlusal destruction, occlusion is completed with the mandible shifting, Therefore, γ-based outputs of the masticatory system and the whole motor system should also modified. It seems that the experimental unilateral occlusal destruction did produce the chronic latery in the trigeminal proprioception, resulting in abnormal movement and posture.

2. Systemic influences of the occlusal destruction

No noteworthy changes were observed in general hematological examinations seen in a state of autonomic failure.

Body weight decreased for about two weeks following the occlusal destruction, as shown by the body weight curve (Fig. 4). This was followed by an increasing tendency for four months, but the experimental dogs weighted about 2 kg less than usual in this condition. The observed weight loss seemed to be a direct result of abnormal inputs other than pain sensation. Inputs from the temporomandibular joint are conveyed to the trigeminal spinal nucleus. It is connected with the parabrachial nucleus and the amygdala. In this experiment, subsequent temporomandibular joint dysfunction may have caused the dysfunction of the amygdala which is closely associated with the autonomic function including ingestion, resulting in weight loss, lacrimation, salivation and hair loss.

The largest changes produced by the unilateral occlusal destruction in dogs were tremor, lameness and improper posture. The fact that the tremor was transient may have been an influence of the other nociceptive sensation such as the temporomandibular joint pain. Abnormal motor dysfunctions such as resting tremor, lameness with pelvic distortion were observed. The lateralities of muscle tone and tendon reflex were also observed. The information from mechanoreceptors and muscle spindles in the areas innervated by the trigeminal nerve is inputted into the striatum and substantia nigra. These trigeminal proprioceptions are well known to reach the trigeminal mesencephalic nucleus. A possibility of autonomic and somatic effectors in the spinal cord being modified by the spinal trigeminal nucleus has also been raised from anatomical viewpoint. Therefore, the occlusal destruction would induced systemic motor dysfunctions. The trigeminal nuclear complex have a close relation to motor function including postural control, so that these trigeminal nuclei have connections with the basal ganglia, the cerebellum, the vestibular nucleus, the brain stem reticular formation and superior colliculus.

These symptoms and abnormal phenomena seen in this experiment may have resulted from the disturbance of the peripheral trigeminal inputs caused by the occlusal destruction. A close connection has been proven to exist between the trigeminal spinal nucleus and the amygdala via the parabrachial nucleus. The trigeminal mesencephalic nucleus is also connected with the striatum. The amygdala is considered to be closely associated with autonomic function, while the striatum is thought to have an influence on involuntary movement. For these reasons, I believe that the occlusal destruction in this study have resulted in autonomic symptoms as well as motor and postural abnormalities. The observed individual differences in symptoms and phenomena may be a result of varying conditions of the occlusal destruction including the situations of the temporomandibular joint.

These experimental results suggest that the systemic effects of the trigeminal input disturbance are too important to be neglected. Especially, the systemic influences of dental disorders involving malocclusion must be reexamined.

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和文抄録

三叉神経系の歯列における障害が全身に及ぼす効果について

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三叉神経の歯列障害は解剖学的に明確な定義が存在している。その機能及び臨床的意義については不明な点が多い。歯列異常を含む歯科的な障害が、三叉神経を介して中枢神経系に波及を及ぼしていると考えられる。異常歯列や咬合の不正は、中枢神経に影響を及ぼし、疼痛、運動障害、咀嚼障害などのを伴う。本研究は、三叉神経系の歯列障害における効果について検討した。結果、歯列の異常が、異常な神経反応を引き起こす。三叉神経系の機能は、唾液の分泌や歯列の安定性を維持するために必要であり、異常な神経反応を伴う異常な機能を示した。本研究は、三叉神経系の歯列異常の影響を評価することに有用である。

Fig. 1. The occlusal destruction by grinding teeth unilaterally.

Fig. 2. The mandibular midline shift to the right about a half a lower tooth observed in all cases after the occlusal destruction. Case of No. 1 dog is shown.

Fig. 3. An external fistula in the maxillary area in Case No. 1.

Fig. 4. Loss of hair faster and hair loss observed in all cases. An example of Case No. 1 is shown.

Fig. 5. Abnormal lacrimation on the right eye observed in Case No. 1 and No. 2. Case No. 1 is shown.

Fig. 6. Abnormal lacrimation on the right eye and reddish nodule in the left eye in Case No. 2.

Fig. 7. The adduction of the left hind leg with pelvic distortion observed in Case No. 1 and Case No. 3. The case of No. 1 dog is shown.

Fig. 8. Walking lameness with pelvic distortion in Case No. 1 and No. 3. The case of No. 1 dog is shown.

Fig. 9. Unnatural horizontal sitting in Case No. 1 and No. 3. The case of No. 1 dog is shown.