Temporomandibular joint dysfunction and the brain stem reticular formation

C. J. Griffin

Introduction
Consideration of certain symptoms of temporomandibular joint (T.M.J.) dysfunction indicates that the basis of the symptomatology is concerned with a disturbance of proprioception at a mid-brain level. It is known that the linguo-mandibular reflex is mediated by the reticular formation of the brain stem and that proprioceptive impulses from the fifth nerve play an important role in maintaining the tonic activity of the brain stem reticular formation. In this respect Brodal states: "From an anatomical point of view it is reasonable to assume that in addition to exteroceptive proprioceptive impulses entering by direct spino-cerebellar reticular tracts, the trigeminal fibres of the same kind may be particularly important in maintaining the tonic activity of the reticular formation." The term tonic in this sense refers not only to normal muscle tonus but also to normal cortical activity.

It is for the above reasons that a brief review of the literature concerning the function of the reticular formation and a correlation of certain symptoms of temporomandibular joint dysfunction with this system seems warranted.

Reticular formation of the brain stem

There is some doubt whether the reticular formation of the diencephalon is analogous to the reticular formation of the brain stem and descriptions of the reticular formation are usually confined to the medulla oblongata, the pons, and mesencephalon. The reticular formation of the brain stem in this sense refers to a number of scattered nuclei separated widely by nerve fibres travelling in all directions. Olszewski and Unna. K. R.—The brain stem reticular formation. J. Comp. Neurol. 102: 3. 345-395 (June) 1955.


the red nucleus, cerebellar nuclei, secondary trigeminal fibres, projections from the mesencephalic nucleus of the fifth nerve and sensory fibres from the spinal cord as far down as the lumbosacral segments. It is also said to receive fibres from the hypothalamus, the preoptic area, the superior (mainly) and the inferior colliculi and other parts of the cerebral cortex (Fig. 2). As regards function one may speak of the caudally directed influences of the reticular formation and the ascending activating system.

Fig. 2.—Projections onto the reticular formation. (1) Projections from the sensori-motor area of the cerebral cortex. (2) Rubro-reticular fibres. (3) Projections from the superior colliculus. (4) Projections from the inferior colliculus. (5) Projections from the preoptic area. (6) Cerebello-reticular fibres. (7) Trigeminal projections onto the reticular formation. (8) Projections from the corpus striatum onto the reticular formation. (9) Spinal projections onto the reticular formation. RET. FORM.—reticular formation.

Caudally directed influences of the reticular formation

The caudally directed influences of the reticular formation are mediated by reticulo-spinal fibres which fibres terminate on motor neurones concerned with spinal reflexes. Apart from this there may be included the influence of the reticular formation on motor neurones concerned with brain stem reflexes. This influence may be summed up as facilitation or inhibition of cortical or subcortical induced movements, control of muscle tone, control of inspiratory and expiratory reflexes, and control of pressor and depressor reflexes. Its influence on muscle tone appears to be by way of fibres terminating on 

cerned with gamma efferent fibres to muscle spindles. Furthermore efferent discharges from the reticular formation have a depressant effect on second sensory neurones in the spinal cord and trigeminal system. Apart from this the reticular formation appears to have a reciprocal function as regards muscle tone and these reciprocal properties of the formation afford an important clue as regards a disturbance of its function. By reciprocity is meant that if a flexor reflex is inhibited an extensor reflex is facilitated or vice versa.

Ascending activating reticular system

Electrical stimulation of the reticular formation leads to a desynchronisation or activation of the electroencephalogram (E.E.G.). A background of maintained activity in the ascending activating system (impulses conducted by reticulothalamic fibres) appears to be essential for consciousness, wakefulness, and alertness (Fig. 1). Action potentials in the brain stem have been recorded after stimulation of almost any type of receptor.

Masticatory reflexes and the reticular formation

The slow component of the dental nociceptive reflex relays in the reticular formation. This slow component (the linguo-mandibular reflex) appears to have a well defined reciprocity with extensor reflexes and also respiratory reflexes. For example, if the linguo-mandibular reflex and the patellar reflex are elicited simultaneously and certain parts of the brain stem reticular formation <"granit, r., and kaada, b. r.—influence of stimulation of central nervous structures on muscle spindles in cat. acta physiol. scandinavica, 27: 130-160, 1952.> 
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<"french, j. d., von amerongen, f. k., and magoun, h. w.—an activating system in brain stem monkey. a.m.a. arch. neurul. & psychi., 68: 5, 577-585 (nov.) 1952.> 
<"french, j. d., yerasian, m., and magoun, h. w.—an extralemniscal sensory system in the brain. a.m.a. arch. neurul. & psychi., 69: 5, 595-618 (apr.) 1953.> 
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are stimulated, inhibition of the lingual
mandibular reflex can be noted and the
patellar reflex is facilitated. Conversely, if
other areas of the reticular formation are
stimulated, under the above conditions, the
lingual-mandibular reflex is facilitated and the
patellar reflex is inhibited. Possibly certain
of the reciprocal properties of the reticular
formation are due to cerebellar projections
to it. For example, stimulation of the
cerebellar vermis of the anterior lobe gives
rise to ipsilateral extensor facilitation and
flexor inhibition.[14] However, apart from
cerebellar projections, extensor and flexor
effects can be elicited from stimulation of
areas in the reticular formation alone.[15]

In temporomandibular joint dysfunction it is
often impossible to elicit the lingual-mandibular
reflex and certain cases exhibit intermittent trismus
reflecting bilateral inhibition of the lingual-
mandibular reflex and hypertonicity of the
mandibular elevators (extensors). The reason
for this appears to be activation of Group III
fibres associated with the musculo-tendinous
junction of the lateral pterygoid muscle. It
is known that this type of reflex activity is
mediated by polysynaptic reflex arcs and thus
one must envisage prolonged firing of inhibitory impulses to the mandibular depressors
and facilitatory impulses to the mandibular
elevators. In certain cases the tonic activity
of the reticular formation appears to be
stabilized and there is a general disturbance of
muscle tone. For example, subjects with
inhibition of the lingual-mandibular reflex may
have difficulty in flexing the trunk, or difficulty
in elevating the arm. Internal rotation of the
shoulder may be difficult and painful and
depression of the neck impaired.[16] A frequent

symptom occurring in temporomandibular
joint dysfunction is tinnitus. This may be
due to direct obstruction of blood supply to
the tympanic membrane or to reflex hypertonicity of the tensor tympani and levator
palati muscles. Photophobia is quite a com-
mon symptom and this may be related to
associated inhibition of the oculo-sensory
reflex.

The pathway for fibres affecting muscle
tonus is by way of reticular efferent fibres
to cranial and spinal motor nuclei. These
fibres appear to act on neurones mediating
gamma efferent impulses to muscle spindles
and these in turn are intimately associated
with alpha fibres to extrafusal muscle fibres.[17]

Vertigo and nausea are frequent symptoms of
temporomandibular joint dysfunction.[18] Vertigo
may arise from a disease of the
g a l b r y n h , the vestibular nerve, the vestibular
centres or other causes.[19] Now, just as rotatory
movement causes alteration in tone and move-
ments on both sides of the body which tend
to resist the rotatory movement and thus
maintain balance,[20] it follows that if the tonus
of head and neck musculature is disturbed
by temporomandibular joint dysfunction the
appropriate reflex adjustment of the muscula-
ture fails to occur and the subject loses
balance. The same reasoning may be applied
to the occurrence of nausea in the above condi-
tion. Nausea may be induced by increased
tension on the walls of the oesophagus,
stomach, or duodenum exciting the nerve
fibres located in these regions.[21] It has been
shown experimentally that when a subject is
exposed to odours that induce nausea the
abdominal muscles relax and the lower border
of the stomach descends an inch or two. The
descent of the stomach stretches the oesophageal
and gastric walls exerting tension on the
nerve endings. Thus the failure of adjustment
of the abdominal musculature to change in
posture may be implicated as the cause of
nausea in temporomandibular joint dysfunction.
Patients with the above symptomatology may
exhibit Rombergism indicating involvement of
cranial sensory nerve fibres. The overall
picture in an analysis of one hundred and
twenty-seven cases of temporomandibular joint

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Masticatory and respiratory reflexes

It would appear that the influence of the reticular formation on respiratory reflexes is mediated by reticulo-spinal fibres and the areas from which these fibres arise influence respiratory activity differently. There is an area mainly concerned with inspiratory reflexes and another mainly concerned with expiratory reflexes. Stimulation of the central stump of the vagus inhibits the lingual-mandibular reflex. Conversely if the stump of the vagus inhibits, the lingual-mandibular reflex is depressed. It is therefore conceivable that an increase in respiratory activity by reticulo-spinal fibres (Figure 3).

The trigeminal system and the ascending activating system

The trigeminal system is intimately associated with ascending activating reticular system. Rossi and Zirondoli have shown that section of the brain stem rostral to the principal trigeminal nucleus induces a sleep pattern in the E.E.G. A transsection caudal to this nucleus had no effect. Similarly bilateral sections of other cranial nerves did not effect the occlusion has recently given excellent results. The evidence suggests that respiratory reflexes may be affected in two ways by unwarranted trigeminal inputs. These pathways are: (1) excitation of the vagus via the reticular formation, and (2) excitation of respiratory neurones by reticulo-spinal fibres (Figure 3).
was the fact that bilateral distraction of the semilunar ganglions induced a sleep pattern in the E.E.G. It is apparent that the trigeminal system projects freely to the reticular formation and in fact has an ascending activating system of its own (Figure 3).

Apart from this, and this seems of great clinical importance, efferents from the reticular formation presumably have a depressant effect on trigeminal second order sensory neurones. The suppression of the second order sensory neurones appears to be in the nature of an inhibition and Hagbarth and Kerr state "... there seem to be no major objection to the assumption that sensory interneurones can be inhibited by mechanisms similar to those underlying inhibitory processes in the motor system".

This concept may be visualized (Fig. 4) as follows. Primary afferent sensory fibres, (1) and (2), conduct impulses from the skin overlying the mandibular depressors and elevators. In this description only the connections of fibre (1) will be described but fibre (2) has similar connections. Upon entering the pons fibre (1) bifurcates, a branch (a) proceeds to the sensory nucleus of the fifth nerve (S.V.), and a branch (b) proceeds to the spinal nucleus of the fifth nerve (SP.V). The two branches synapse with second order sensory neurones in these nuclei. The axon of the second order sensory neurone (c) from the sensory nucleus conducts the impulse to higher centres via the trigeminal lemniscus (T.L.) at the same time sending an impulse to the reticular formation (RF.) via the collateral (e). Similarly the axon of the second order sensory neurone (d) from the spinal nucleus conducts the impulse to higher centres via the spinal trigeminal tract (S.T.) and also to the reticular formation (RF.) via the collateral (e).
centres and also sends an impulse to the reticular formation via the collateral (f). The branch (e) from the sensory nucleus synapses with three neurones, two inhibitory and one excitatory (the open circles represent inhibitory neurones and the filled in circles represent excitatory neurones). An axon (g) from one of the inhibitory neurones feeds back on the second order sensory neurone hyperpolarising its cell membrane so that for a time no further impulses can be transmitted by this neurone. An axon (N) also from an inhibitory neurone conducts an impulse to a motor neurone in the motor nucleus (M.V) hyperpolarising the cell membrane of that neurone so that the gamma efferent fibres to intrafusal muscle fibres concerned with this neurone are inhibited (4). At the same time an excitatory impulse is conducted by the axon (M) to the motor nucleus exciting a motor neurone whose gamma efferent fibres (5) transmit the impulse to the muscle spindle. Only one connection (f) is shown from the axon (d) from the second order sensory neurone in the spinal nucleus although it has similar connections as the axon (c). The connection illustrated is with an inhibitory neurone whose axon (h) feeds back on the second order sensory neurone in the spinal nucleus also hyperpolarising its cell membrane. The experimental evidence for the above connections is that if the skin overlying an extensor muscle is pinched gamma efferents in the extensor muscle are excited and gamma efferents in the flexor muscles antagonistic to the extensor are inhibited. For the sake of simplicity the connections of only one collateral to the motor nucleus of the fifth via the reticular formation is illustrated. It is generally conceded that tactile sensibility for the fifth nerve is mediated by the sensory nucleus and pain and thermal sensibility by the spinal nucleus of the fifth. Thus under normal circumstances the reticular formation exerts a restraining influence on impulses conducted by the trigeminal as well as by spinal nerves. It follows that if the tonic activity of the reticular formation is disturbed, and this appears to be the case in temporomandibular joint dysfunction, the restraining influence of this system on sensory modalities conducted by the fifth is affected.

In temporomandibular joint dysfunction areas of hyperalgesia and paraesthesia can usually be located on the skin overlying the masticatory and accessory masticatory muscles. The hyperalgesia may be explicable on the basis of hyperexcitability of second order sensory neurones whereas the paraesthesia may be explicable on the basis of depression of second order sensory neurones. The assumed effects are illustrated schematically (Fig. 5). The connections of primary afferent sensory fibres (1) and (2) are as in Figure 4. Aberrant proprioceptive inputs are conducted centrally by a fibre (3) whose neurone of the first order is located in the mesencephalic nucleus of the fifth nerve (M.S.V.). The centrapetal process (A) of this neurone bifurcates, the branch (c) synapses with an excitatory neurone (filled in circle) in the reticular formation (RF), and the branch (b) synapses with an inhibitory neurone (open circle) in the reticular formation. The inhibitory neurone has three processes, (d) (e), and (f). The process (d) synapses with a motor neurone in the motor nucleus (M.V) of the fifth nerve which is already under inhibition by a process from a neurone associated with a second order sensory neurone. The inhibition of gamma efferent fibres (4) by the second order sensory neurone is reinforced by the proprioceptive input and the mandibular flexors (depressors) are inhibited. The branches (e) and (f) synapse with inhibitory neurones in the reticular formation whose processes synapse with second order sensory neurones in the sensory nucleus (S.V) and the spinal nucleus (S.P.V) of the
fifth nerve. The process to the spinal nucleus is represented by (k). The effect is inhibition of inhibitory neurones whose processes synapse with second order sensory neurones in the sensory and spinal nuclei of the fifth nerve. The second order sensory neurones are thus released from central inhibition and are thus excitable. This may explain the hyperalgesia of the skin overlying the mandibular extensors.

As mentioned above, the branch (c) of the centrapetal process of the first order proprioceptive neurone synapses with an excitatory neurone in the reticular formation. This neurone has three processes, (g), (h), and (l). The branch (g) excites the motor neurone in the motor nucleus of the fifth nerve which is already excited by an excitatory neurone in the reticular formation associated with a second order sensory neurone. The result is that gamma efferent fibres (5) conduct impulses to the intrafusal muscle fibres of the muscle spindle of the mandibular extensors. There is thus hypertonicity of the mandibular extensors. The branches (h) and (l) excite inhibitory neurones in the reticular formation which are already under excitation by collaterals from second order sensory neurones. The processes of these inhibitory neurones synapse with second order sensory neurones and thus central inhibition of second order sensory neurones is reinforced. This may explain the phenomenon of parasthesia in temporomandibular joint dysfunction which usually occurs in the skin overlying the mandibular flexors.

Apart from the above symptomatology associated with temporomandibular joint dysfunction patients often express their symptoms in a bizarre fashion, for example they may state that “they have trains shunting in the head”. Or they may say that “there is a lump of lead in the jaws”. Some state that they have a feeling of imminent dissolution whilst others complain of insomnia and still others of lassitude. In short not only does the depressant influence of the reticular formation on second order sensory neurones appear to be disturbed but also the ascending activating system.

Department of Histology and Embryology, University of Sydney.


Ne plus ultra • Wine lives its life in the same sort of way as a man. One brings it up carefully during its infancy, when it is “undrinkable, green, bitter”, then it attains maturity and finally goes into decline. “One should drink it while it is good, and not keep it forever just because it is good.”—Alain Hervé, Réalités, March, 1964.