On the Afferent Ganglionated Nerve-fibres of the Muscles Innervated by the Fifth Cranial Nerve; and on the Innervation of the Tensor Veli Palatini and Tensor Tympani.

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With Plates 33 to 36.

It was shown by Sherrington that the skeletal muscles innervated by the spinal nerves receive afferent nerve-fibres from the posterior nerve-roots as well as efferent nerve-fibres from the anterior roots. These afferent nerve-fibres come from cells in the spinal root ganglia, and constitute from one third to one half of the myelinate fibres in any muscular nerve-trunk. On the other hand, the external ocular muscles do not receive any ganglionated nerve-fibres, and the direct fibres which pass to them are efferent-afferent (Sherrington, Sherrington and Tozer, Dogiel).

It is of interest to inquire whether the muscles innervated by the fifth cranial nerve resemble the skeletal muscles innervated by the spinal nerves in receiving ganglionated afferent nerve-fibres, or whether they resemble the external ocular muscles in not receiving such nerve-fibres.

The subject has already been investigated, with very diverse conclusions.

Sappey ('72) stated that Palleta, Louth and Longet, "ne voient dans cette union"—of the motor and sensory parts of the mandibular division of the fifth cranial nerve—"qu'un
simple accolement et admettent en conséquence que le nerf maxillaire inférieur se compose de deux branches parfaitement distinctes dans toute l’étendue de leur distribution, une branche inférieure et interne ou sensitive, et une branche supérieure et externe ou motrice, qui a reçu tour à tour les noms de nerf buccinato-buccal, de nerf masticateur, de nerf maxillaire inférieur moteur.”

Sappey himself was of a different opinion. He held that “les deux branches du nerf maxillaire inférieur s’envoient reciproquement un grand nombre de filets”; that “parmi les divisions de ce tronc nerveux s’il en est qui se détachent plus particulièrement de la racine motrice, et d’autres de la racine sensible, les premières renferment aussi quelques fibres destinées à des organes sensibles, et les secondes quelques fibres destinées à des muscles.”


The foregoing investigations were undertaken in the case of man. Willems (‘11) has stated that in the rabbit “rien n’est plus facile que d’enlever le ganglion et les branches qui en dérivent, en respectant la racine motrice avec toutes les branches motrices, à l’exception du mylohyoïden qui se mêle intimement avec les fibres du nerf dentaire inférieure à la sortie du crâne.”

The inferior maxillary division of the fifth cranial nerve innervates the masseter, temporal, external pterygoid, internal
pterygoid, tensor veli palatini, tensor tympani, mylohyoid, and anterior belly of digastric.

Though the innervation of the tensor veli palatini—both in man and in other mammals—by the fifth nerve has been described by anatomists, the evidence afforded by cases of disease and by division of the roots of the nerve in man is equivocal. Krause found no anomalies in the position of the palate after extirpation of the Gasserian ganglion and division of the motor root. Cushing found a marked asymmetry of the palate in four cases, and elicited movements of the palate by electrical stimulation of the peripheral stump of the fifth nerve in one case. Davies found asymmetry of the palate in five, and no asymmetry in twenty-one, of twenty-six cases operated on by Horsley; and he records that in three cases Horsley stimulated the peripheral end of the divided fifth nerve without any movement of the palate resulting. Davies concluded that “the balance of evidence seems to show that the fifth nerve has nothing to do with the innervation of the palatal muscles.”

Beevor and Horsley ('88) stated that in Macacus sinicus movements of the palate occurred on intra-cranial stimulation of the vago-accessorius, but did not occur on intra-cranial stimulation of the seventh nerve. They did not state whether movements of the palate did or did not occur on intra-cranial stimulation of the fifth nerve.

Davies further states that “no change has been observed to follow excision of the Gasserian ganglion, either in the tenseness of the drum or the increased power of the individual, when tested with a Galton whistle, to appreciate high-pitched sound,” and consequently discards the innervation of the tensor tympani by the fifth nerve.

To obtain additional information on these matters Sir Victor Horsley was good enough, at my request, to divide the roots of the fifth cranial nerve proximal to the Gasserian ganglion in two monkeys (Macacus cynomolgus). The wounds healed by first intention. The animals were allowed to live for thirty days, and then killed by an overdose of
chloroform. The muscles and nerves, both on the cut and uncut (normal) side, were then dissected out. Sections of the muscles were stained by van Giesen's method. The nerves were stained by osmic acid and examined in transverse section.

All the masticatory muscles, including the tensor veli palatini and tensor tympani, together with the mylohyoid and anterior belly of the digastric, showed evidence of degeneration—loss of transverse striation, increase in the number of nuclei, and proliferation of the interstitial tissue.

The tensor veli palatini and tensor tympani are, consequently, innervated by the fifth cranial nerve, and belong to the group of masticatory muscles. This conclusion agrees with that obtained by investigation of their development. The Anlage of the masticatory muscles divides into an internal lamina, giving rise to the internal pterygoid, pterygo-tympanicus or tensor veli palatini, and tensor tympani; and an external lamina, giving rise to the external pterygoid, temporal and masseter.

It may be added that no degenerative changes were found in the levator veli palatini—a muscle which is developed from the pharyngeal musculature, and is innervated by a branch of the pharyngeal plexus (Cords) from the vaso-accessorius (Beevor and Horsley).

In the muscle-nerves on the uncut (normal) side medullated fibres of all sizes were present from a diameter of under 4 μ up to a certain maximum. This maximum was 12.8 μ in the nerves passing to the tensor veli palatini, internal pterygoid, external pterygoid, temporal, masseter, and anterior belly of digastric; 11.4 μ in the nerve to the mylohyoid, and 5.6 μ in the nerve to the tensor tympani.

Medullated nerve-fibres were also present in the muscle nerves on the cut side, of all diameters from one under 4 μ up to the same maxima as in the corresponding nerves on the uncut side, e.g. it was 12.8 μ in the branch of the mylohyoid nerve to the anterior belly of the digastric and 11.4 μ in the branch to the mylohyoid muscle. The number of medullated nerve-fibres in the branches on the cut side formed from 35 to
39 per cent. of the number found in the corresponding nerves on the uncut side. This percentage held though the absolute numbers were different in the two animals. Thus in animal "A" the number of medullated nerve-fibres in the trunk of the mylohyoid nerve on the uncut side was 906; on the cut side it was 335, = 36 per cent. In animal "B" the number of medullated nerve-fibres in the trunk of the mylohyoid nerve on the uncut side was 736, on the cut side it was 280, = 37 per cent.

The persisting medullated nerve-fibres in the muscle branches on the cut side were distributed fairly evenly among the degenerated ones until near the muscles (fig. 2); in the nerve-filaments just outside the muscles the persisting and degenerated nerve-fibres were largely, though not wholly, segregated from one another (fig. 3), and the former tended to lie on one side of the filament.

To ascertain the source of these non-degenerating nerve-fibres serial sections were made through the mandibular division of the fifth nerve, from the site of operation to the point where the various branches had begun to diverge from one another. In neither animal are any medullated fibres visible in the motor root above the level of the Gasserian ganglion—all had undergone degeneration. At the level of the Gasserian ganglion, and for a little distance below, medullated fibres can be seen passing from the sensory into the motor root. They lie, for the most part, in the lateral part of the motor root, and are more sparsely scattered in its median part (fig. 4).

The ramus lateralis—which innervates the external pterygoid, temporal and masseter muscles—is formed from the lateral part of the motor root (figs. 5, 6, 7, 8); it also receives, from the ramus posterior, those fibres which form its (sensory) buccal nerve constituent (fig. 6). The ganglionated afferent fibres for the muscle branches of the ramus lateralis thus have a simple direct path.

The paths of the (degenerated) motor and ganglionated afferent fibres of the ramus medialis—which innervates the
internal pterygoid, tensor palati and tensor tympani—and of the mylohyoid nerve are more complicated. In each case the persisting afferent nerve-fibres in the motor root, accompanied by (degenerated) motor fibres, pass into those branches by two routes. The ramus medialis (figs. 5, 6, 7) is formed partly by fibres which pass downwards and inwards, from the motor root, into the ramus, partly by fibres which leave the lateral part of the motor root (fig. 6) and sweep round the back of the ramus posterior from without inwards and so enter the ramus. The relative numbers of the (degenerated) motor fibres following these two paths—internal and external—could not be determined, but it was possible to do so in the case of the persisting afferent fibres. In animal “A” the internal path contains 50 medullated fibres, whilst the ramus medialis, when fully formed, contains 219, i.e. about one quarter followed the internal path and three quarters the external one, round the ramus posterior. The ramus medialis passes through the otic ganglion, giving off, just as it enters, the branch for the tensor tympani (fig. 7), and subsequently dividing into branches for the internal pterygoid and tensor palati. The branch to the tensor tympani receives a fine filament from the otic ganglion containing (in animal “A”) eight medullated fibres; above that point it contains twenty-eight medullated fibres. The branch to the internal pterygoid and tensor palati receives three fine filaments from the otic ganglion containing twenty-nine medullated fibres. The medullated fibres entering these branches from the otic ganglion are all small—under 4 μ in diameter.

The mylohyoid nerve is formed partly from internal fibres (degenerated and intact) which pass from the inner part of the motor root (fig. 5), a little higher up than the direct fibres of the ramus medialis, round the back of the ramus posterior from within outwards, and thus come to lie between the ramus lateralis and the ramus posterior (figs. 6 and 7); they are joined by external fibres (degenerated and intact) from the deeper, more posterior part of the ramus lateralis, and pass inwards on the anterior aspect of the ramus posterior.
(fig. 8) to take up a position on its antero-median side. Here they are joined by a filament from the otic ganglion, containing a few small medullated fibres. It was not found possible to estimate the relative numbers of intact fibres following the two paths.

It follows, from these observations, that in Macacus cynomolgus all the muscles which are innervated by the fifth cranial nerve receive not only direct medullated nerve-fibres from the motor root, but also afferent nerve-fibres which originate in the Gasserian ganglion. These ganglionated afferent nerve-fibres form about one third of the total number of the medullated nerve-fibres passing to each muscle. They are of all sizes up to the same maximum diameters as are found in the corresponding intact branches of the opposite side. The ramus medialis and mylohyoid branches also receive a few fine medullated fibres from the otic ganglion.

The proportion of ganglionated afferent nerve-fibres found in the muscle-branches of the trigeminus is thus closely similar to that shown by Sherrington to exist in the branches of spinal nerves passing to skeletal muscles.

Examination, by serial sections, of the mandibular division of the fifth nerve in man (figs. 9–20) showed similar results. The motor root receives fibres, just below the Gasserian ganglion, from the ramus posterior. The fibres of the ramus lateralis pass directly from the motor root into the ramus. The ramus medialis and the mylohyoid nerve are formed from fibres which leave the motor root and pass, some inside, some outside the ramus posterior, and then join to form these two branches. In some respects the constitution of the ramus medialis and of the mylohyoid nerve is even clearer than is the case in Macacus, owing to the inner and outer fibres of the mylohyoid nerve being situated distinctly more proximal—nearer the Gasserian ganglion—than are the inner and outer fibres of the ramus medialis, and also owing to the separation of the fibres of the ramus posterior into groups.

Examination by serial sections of the mandibular division
of the fifth nerve in the rabbit and dog gave the same results in regard to the entry of sensory fibres into the motor root, and the constitution of the ramus lateralis, ramus medialis, and mylohyoid nerve.

These observations show that in Macacus, man, rabbit and dog, the muscles innervated by the fifth cranial nerve receive afferent fibres, which originate in the Gasserian ganglion, and pass into the motor root. The motor and ganglionated afferent nerve-fibres of the ramus lateralis have a simple direct path; those of the ramus medialis and of the mylohyoid nerve have, for a space, a double course, being divided by the ramus posterior into two groups which again unite to form those nerves (fig. 21). The reasons for this curious path are doubtful—the phenomena suggest a downward growth of the ramus posterior occurring later than that of the muscular branches, and splitting up those destined for the ramus medialis and mylohyoid nerve. This actually occurs in rabbit embryos—the mylohyoid nerve is present in the 5½ mm. stage, the rami medialis and lateralis are developed in the 8 mm. stage, the ramus posterior not until the 9 mm. stage. I could not obtain embryos of Macacus, man or dog.

Information as to the end-organs of the afferent nerve-fibres of the masticatory muscles is as yet scanty and incomplete. Cipollone has stated that muscle-spindles are present in the masseter and pterygoid muscles.

Mesencephalic Root of the Fifth Nerve.—May and Horsley ('10) showed that practically all the axons of the globular cells of the mesencephalic root of the fifth nerve leave the pons by the motor root of that nerve, that destruction of it does not cause either motor or sensory loss, that stimulation of the root on the cut surface of the mesencephalon produces no effect on the muscles of mastication unless the excitation spreads to the pontine masticatory nucleus, and “that avulsion of the peripheral branches of the inferior division causes chromatolysis in the mesencephalic root cells, a result suggesting that these axons run in the peripheral
branches, though examination by the Marchi method has failed to reveal them."

Willems ('11) also found chromolytic changes in the mesencephalic nucleus after avulsion of the individual motor branches of the fifth.

Though the observations described in this paper show the existence of ganglionated afferent nerve-fibres in the muscle-branches of the fifth nerve, they leave untouched the difficult question of the peripheral distribution and function of the axons of the mesencephalic root.

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References.

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Davies ('07)—"The Functions of the Trigeminal Nerve," 'Brain,' vol. xxx.


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Sappey ('72)—"Traité d'Anatomie descriptive," vol. iii.

EXPLANATION OF PLATES 33-36.

Illustrating Dr. F. H. Edgeworth's paper "On the Afferent Ganglionated Nerve-fibres of the Muscles Innervated by the Fifth Cranial Nerve; and on the Innervation of the Tensor Veli Palatini and Tensor Tympani."

LIST OF ABBREVIATIONS.


Note.—In fig. 14 the directing line from "int. f. mylohy. n." should pass directly upwards to the group of fibres on the periphery of the nerve, cf. fig. 15.

[Figs. 1-8 are from Macacus.]

Fig. 1.—Right masseter nerve: roots of left fifth cranial nerve divided thirty days previously.

Fig. 2.—Left masseter nerve: roots of left fifth cranial nerve divided thirty days previously.

Fig. 3.—Left anterior digastric nerve, close to muscle: roots of fifth cranial nerve divided thirty days previously.

Figs. 4-8.—Sections from a serial series made through the fifth cranial nerve, the roots of which had been divided thirty days previously. Fig. 4 is the most proximal.
MUSCLES INNERVATED BY THE FIFTH CRANIAL NERVE. 603

Figs. 9-20.—Sections from a serial series made through the fifth cranial nerve of man. Fig. 9 is the most proximal.

Fig. 21.—Diagram representing the paths of the motor and afferent constituents of the muscular branches of the fifth cranial nerve. Motor fibres are represented by a thick dotted line, afferent fibres by a thin dotted line. To show these paths on one plane, the constituents of the mylohyoid nerve are depicted lying internal to those of the ramus medialis; in reality they are more proximal.