Section of Odontology

President—ARTHUR BULLEID, F.D.S., L.R.C.P., M.R.C.S.

[*January* 25, 1954]

The Muscles of the Mandible

By R. J. LAST, M.B., B.S., F.R.C.S.
Professor of Applied Anatomy, Royal College of Surgeons of England

IT is usually very difficult, and in many cases impossible, actually to prove what is the action of a muscle. Although the writers of textbooks of anatomy do not hesitate to state categorically the action of every muscle they describe, they seldom quote any evidence. It does not follow that an eminent anatomist who is very exact in his account of structure is equally correct in his interpretation of function. If errors of factual description of structure creep into a textbook (and rare is the book that is free of them), the author's accounts of function will be correspondingly less convincing. So it would appear that the answer to the question, "What is the action of this muscle?", is not necessarily to be found by consulting an otherwise authoritative textbook of anatomy. In many cases, indeed, the answer is scarcely worth finding, since muscles do not contract alone, but usually in a pattern in harmony with synergic members of their own group and always either against their opponents, which "pay out rope," or by themselves "paying out rope" against gravity.

In some cases, however, it is very important to have an accurate knowledge of muscle action. To the ophthalmologist, for example, the action of each muscle that moves the eyeball is of signal concern, since he must assess the implications of strabismus and diplopia. Likewise to the orthodontist the actions of the muscles that move the mandible must be of equal interest, since the contours of growing bone seem in large measure to be adjusted to the forces of muscle pull. Rix, Ballard, Gwynne Evans and Tulley in this country are among many who have emphasized the importance they place on the role of the muscles that are used in swallowing, and Brodie in the U.S.A. has advanced a conjecture about the supposed role of these same muscles in preserving the balance of the skull on the spine. If orthodontic study is to advance our knowledge of the relationship between muscle action and bone form, it is essential to know very precisely what are the normal actions of the muscles being studied.

The present writer has been singularly dissatisfied with several of the orthodox and accepted statements concerning the actions of muscles in and about the floor of the mouth, and in particular with the usually accepted accounts of what muscles are responsible for opening the mouth. This paper is concerned with an attempt to assess the reasons for the presence and contours of certain muscles, and especially to understand the essential arrangements of the muscle groups involved in natural movements of the mandible, tongue, larynx and face.

The problem of the action of a muscle can be attacked from several directions, some of which are listed here:

(1) Speculative reasoning and deduction, or "armchair anatomy" if the reader prefers that term. This is a dangerous method, for anatomists are notoriously poor at mechanics; but it remains the most commonly used approach.

(2) Feeling the muscle in contraction in the living. This has only a limited application, for many muscles are not palpable.

(3) Pulling on the muscle or its tendon in the dead. This is often impossible (e.g. in flat sheets of muscle like the mylohyoid) and it is usually unconvincing, since the background of tone in opponents is absent and synergists are out of action.

(4) The effects of paralysis. This may give a "negative print" of muscle action; but in a host of cases failure results from the fact that other muscles are employed to produce "trick" movements, and the paralysis is masked.

(5) Stimulation of a muscle or its motor nerve, exposed or not, with or without anæsthesia. This is usually unconvincing, since the background of tone in opponents is absent or diminished under anæsthesia, and synergists are likewise out of action.

(6) Action currents in the muscle during movement:

(a) by surface electrodes, a somewhat rough and ready method, or

(b) by needle electrodes. This is possibly the most accurate method available, although spread of current from near-by muscles cannot always be ruled out. Moreover, action potentials recorded from a muscle during a given movement do not prove that the muscle is responsible *as a prime mover* for that movement. The muscle may be contracting synergically.

(7) Comparative studies. An assessment of the form and function of a similar muscle or group of muscles in a comprehensive series of other vertebrates will often, though not always, throw light on the action in man.

Study of the results obtained from the above methods of approach shows that none gives a wholly objective answer, for analytic and synthetic reasoning are necessary to assess the results of whatever method is used. It becomes doubtful if, after all, the best method is not, in fact, to "work it out for oneself."

Realizing the pitfalls, and endeavouring to overlook no significant fact, the writer therefore proposes to reason out the actions of the muscles in the groups under consideration. Certain fundamentals will be admitted to be true by everyone. If, for example, it can be shown that a certain movement causes the attached ends of a muscle to be pulled farther apart, for the muscle to be elongated, that particular movement cannot possibly be the action of that particular muscle. On the other hand, if a movement approximates the attached ends of a muscle it is reasonable to assume that the action of the muscle *may be* to produce that movement, if not as the prime mover, at least to take part as an assistant in the movement.

The plan of the argument is based on the following simple premises:

(1) The skull is movable on the spine in all positions of the latter.

(2) The mandible is movable on the skull in all positions of the latter.

(3) The floor of the mouth is movable on the mandible in all positions of the latter.

(4) *There is a separate set of muscles provided for each of these three movements,* and confusion has arisen from failure to place certain muscles in their correct functional group.

THE MOVEMENTS OF THE SKULL

The skull rests on the top of the spine like a ball on a flagpole. Unsupported it would fall forward, for its centre of gravity lies anterior to the occipital condyles. Guy ropes stabilize and, when required, move it. They are the extensor muscles at the back of the neck, opposed by the flexors, which are the prevertebral muscles and the sternomastoids. The fact that the flagpole is a flexible, segmented structure does not invalidate the above statement.

There is a set of balanced extensor and flexor muscles to stabilize and move the cervical spine independently of movements of the skull. It should be noticed that muscles moving the skull will also of necessity cause secondarily a bending of the cervical spine unless such effects are neutralized by the opposing spinal muscles.

Extension of the head is brought about by contraction of the long extensor muscles at the back of the neck, most especially by semispinalis capitis, which muscle if unopposed must also extend the cervical spine. The rectus capitis posterior minor must also have an extensor action of occiput on atlas and it is difficult to picture the reason for the existence of such a minor muscle. No doubt it is a factor in stabilizing the atlanto-occipital joint. It is just possible that it may also be responsible for the slight extension of skull on atlas that accompanies opening of the mouth. It has no effect on the cervical spine, arising as it does from the atlas; if skull extension is produced by any other muscle the secondary extension of the cervical spine has to be balanced by the opposing flexors, a necessity that does not arise in the case of rectus capitis posterior minor. It would certainly seem to be admirably placed to produce that slight and uncomplicated head extension which accompanies depression of the mandible. The muscle is too deep for accurate palpation. If, however, I press deeply into my suboccipital region I fancy I feel a deep resistance when I open my mouth. This may be imaginary and I do not press the point. In any case the matter is of purely academic interest, and need not concern the orthodontist. The rectus capitis posterior major is badly named; it is not erect, but lies obliquely, and is primarily a head rotator.

The opposing flexor muscles consist of the prevertebral group, must less massive than the extensors because they are assisted by the sternomastoids and, in the erect position of the body, by gravity. Longus capitis, formerly named rectus capitis anterior major, is the only long skull flexor in the prevertebral group. The rectus capitis anterior (minor) connects skull and atlas, and would seem to be the opponent of rectus capitis posterior minor. Longus cervicis (colli) and scalenus anterior are flexors of the cervical spine.

For the true opponents of the extensors we must go farther forward, to the sternomastoids. Here are two very powerful flexors. Much ink has been spent discussing the action of these muscles on the skull. Do they flex or extend it? That they pull the cervical spine forward into flexion nobody doubts, but many will have it that they extend the atlanto-occipital joint. It is almost certain that the posterior fibres of the muscles are, indeed, extensors of the skull at the atlanto-occipital joint, at the same time having the secondary effect of flexion of the cervical spine.

Examination of the skeleton, of a dissection, and of the living neck all confirm this idea, for these posterior fibres of the muscle pass up posterior to the atlanto-occipital joint. But the most anterior fibres of sternomastoid, those which arise from the sternal head and pass to the projecting tip of the mastoid process, are flexors of the atlanto-occipital joint.

Lie face upwards on the floor, finger and thumb placed lightly over the *anterior* borders of the sternomastoids. Flex the head against gravity and feel the powerful contraction of the sternomastoids, and do not doubt that they are flexors of the skull as well as of the neck. During this flexion of the head against gravity palpation of the masseters will show that they remain quite relaxed.

The muscles of mastication play no part in head movements or in the maintenance of head posture, and the American orthodontist, Brodie, is mistaken in his assumption that they do so.

Brodie correctly extends the human head with the post-vertebral neck muscles, but he incorrectly opposes these anti-gravity extensor muscles with a chain of muscles consisting of the muscles of mastication (temporalis and masseter, which join the mandible to the skull), the suprahyoid muscles that join the hyoid to the mandible (Brodie lumps them all together as though they all share a common action!) and the infrahyoid muscles that join the hyoid bone to the pectoral girdle, and he talks of the reciprocal inhibition of the infrahyoid muscles that accompanies contraction of the temporal muscle and elevation of the hyoid bone in swallowing.

Brodie has three links in his chain of skull-flexing muscles. If one of these muscle links is inhibited (according to the principle of reciprocal inhibition discovered by the "English physiologist Sherrington") surely the whole chain of muscles is correspondingly weakened! It would seem that the head should jerk back willy-nilly into extension every time we swallow. But Brodie, not content with ignoring the flexor muscles of the skull, stops short in attaching his own chain of imaginary skull-flexing muscles to the pectoral girdle. For the pectoral girdle is not fixed. It moves up and down with respiration, with upper limb movements, with abdominal contractions such as defæcation, and so on.

If Brodie wants to oppose his skull extensors with the three muscular links in a chain from skull to pectoral girdle he must surely hold his pectoral girdle down. This is done by the rectus abdominis (far from the usual field of investigation of the orthodontist, though it is an attractive thought that an umbilical hernia might be the cause of malocclusion!). But the rectus abdominis can only hold down the thoracic cage and pectoral girdle if the pelvis is fixed. The rectus abdominis is attached to the body of the pubic bone, and the pubic bone can be held down only by those muscles that connect it with the femur—adductor longus, pectineus and the rest. How can Brodie say that the infrahyoid muscles relax to allow the hyoid bone to ascend in swallowing? It is just as logical to argue that pectineus relaxes for the same purpose. Let the believers in the Brodie conjecture look to the pectinei and adductores longi while they are assessing the causes of malocclusion in their patients, and ponder whether this *reductio ad absurdum* does not indicate that Brodie's premises are quite untenable.

Extension and flexion of head and of cervical spine having been accounted for by the paired semispinales capitis and sternomastoids, with other weaker muscles, it only remains to say that acting singly these muscles are rotators or abductors of the spine and head.

These movements of the skull and of the neck are of little interest to the orthodontist and are mentioned here only to exclude them from the arguments about the mandible and the floor of the mouth, *each of which is entirely independent of head position and movement and is served by a separate musculature.*

The Movements of the Mandible

The resting position of the mandible is one of slight separation of the teeth, by a few millimetres at the incisors. From the resting position or from occlusion the hinge movement of opening is accompanied by a forward movement of the mandibular head from the glenoid fossa down the slope towards the articular eminence of the zygoma. Thus two simultaneous movements take place in the mandibular joint; the hinge movement occurs at the lower, the gliding movement at the upper compartment of the joint. The lateral pterygoid is rightly allotted the function of producing the forward movement, but a considerable collection of muscles are considered responsible for the hinge movement. Those usually named are the mylohyoid, geniohyoid and the anterior belly of digastric, to which are often added the infrahyoid muscles, gravity and even the innocent platysma!

The truth of the matter is that consideration of the movements in the mandibular joint, and the muscles responsible for each movement, complicates what is, in fact, a perfectly simple movement, namely a rotation of the mandible about an axis that passes very nearly through the mandibular foramina. Viewed from the side the mandible rotates like a ship's steering wheel, one spoke of which touches the temporal bone for stability in all positions, making an articulation whose movements are necessarily complex, and study of which blurs the essential simplicity of the picture of mandibular movements. Rotation of a steering wheel is produced by a tangential pull on one or more spokes, and this is precisely what happens to the rotating mandible. The longer the spoke the greater is the moment of rotational pull. The farther the muscle is inserted from the axis of rotation of the mandible the more efficient it will be as an opener of the mouth provided its pull is in the right direction and that it can be shown to be shortened when the mouth is open.

What muscles open the mouth?—Picturing the mandible as a ship's steering wheel, it is evident that its uppermost spoke is pulled forward by contraction of the lateral pterygoid. The analogy of the steering wheel fails in one important respect, namely that there is no fixed mechanical axle around which the jaw rotates. Pulling forward the uppermost spoke of a steering wheel produces rotation about its own axle; pulling forward the mandibular condyle produces no rotation, but only protrusion of the mandible as a whole. The mandibular "wheel" is stabilized, not upon an axle, but by its uppermost spoke, the condyle, being held by the ligaments of the mandibular joint; and it is evident that to produce rotation it is necessary to pull in an opposite direction on a "spoke" more or less diametrically opposite. There is a powerful muscle that is admirably placed to perform this very movement, namely the digastric muscle (Fig. 1).

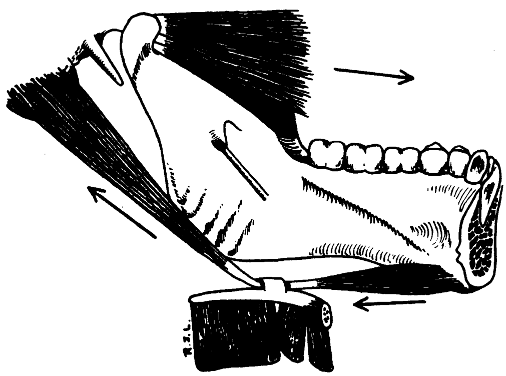

FIG. 1.—The mandible is opened by the rotational pull of the lateral pterygoid and the digastric muscles. The digastric slides freely across the hyoid bone.

The digastric muscle.—As the mandible is moved from the closed to the fully open position the chin not only falls lower but moves backwards. What muscle pulls the chin backwards if not the digastric? The common statement that the anterior belly of the digastric is responsible seems to the writer to be very naïve. What would happen if the posterior belly remained relaxed? Surely the anterior belly would simply pull forward and elongate the relaxed fibres of the posterior belly, and no mandibular movement could possibly result. How could the sternomastoid or any other muscle produce movement if its upper half contracted while its lower half remained relaxed? Both bellies of the digastric must obviously contract with equal force (if not with equal shortening) if any movement is to result. The fact that the two bellies have different nerve supplies has no bearing on this, since the motor nuclei of the pons are connected by longitudinal fibres, as are all the motor nuclei of the brain-stem and spinal cord.

The two bellies of the digastric do not lie in line with each other. Shortening of the contracting muscle must tend to straighten it, and thus elevation of the hyoid bone would occur before any mandibular movement could result. But the upward movement of the hyoid bone is prevented by the action of the infrahyoid muscles contracting synergically. This is the most important action of the infrahyoid muscles. To imagine that the primary reason for the existence of the human digastric is to elevate the hyoid bone is to lose sight of two facts. The first is that the muscle is placed very badly for the mechanics of such a movement and the second is that the hyoid has its own proper elevators, which will be discussed later.

In many mammals the digastric has no connexion with the hyoid bone, but passes from the base of the skull directly into the lower border of the mandible. It is the depressor of the mandible. The tethering of the central tendon in man by a fibrous sling at the lesser cornu of the hyoid bone is a refinement that possesses the great advantage of altering the direction of pull of the anterior belly on the mandible, greatly increasing the moment of rotational pull on that bone.

The mylohyoid muscle.—The floor of the mouth is a muscular diaphragm which forms a highly mobile base for support of the tongue. This is the function of the mylohyoid, and in ordinary action *the muscle has nothing whatever to do with opening the mouth.* The action of the mylohyoid is considered later.

The geniohyoid muscle.—The action of this muscle, too, is considered later. While realizing that it contracts *pari passu* with the anterior belly of the digastric, it is submitted that this muscle acts with others to fix the position of the hyoid bone and therefore of the floor of the mouth, and it is not there primarily as a rotator of the mandible.

The essential difference between the anterior belly of the digastric (Fig. 1) and the geniohyoid muscle (Fig. 2) is that the tendon of the digastric runs freely through a pulley; the powerful digastric muscle depresses the chin by pulling from the mastoid process, without any effect on the antero-posterior position of the hyoid bone. The digastric asks only that the hyoid bone be held down, and there is a strong group of infrahyoid muscles to do that. Geniohyoid can only depress the chin if the hyoid bone is held back, and there is only a relatively feeble stylohyoid muscle to do that.

Gravity.—In the erect position it is apparent that depression of the chin is assisted to a slight extent by gravity, but it is wrong to suggest that gravity is of any real importance in the picture of mandibular movements. Several reasons support this view:

(1) Opening the mouth is just as easy when lying upside down. Watch a newborn child crying while held upside down by its legs to drain mucus or liquor amnii from its throat.

(2) A nursling lying with its face pressed sideways against a soft breast, its own light mandible supported in a firm mass of muscle and fat, could not open its mouth as briskly and quickly and widely as it does when sucking were gravity a relevant factor.

(3) The normal rapid chewing movements of the adult at his repast are too swift and of too great an amplitude to be due to gravity.

(4) Watch anyone speaking. The mandibular opening is, again, much too rapid and too well controlled to be due to gravity.

(5) Allow the muscles of mastication to relax completely and the jaw to droop. The mouth is only half open; to take a good bite from an apple a conscious mouth opening effort has to be made.

(6) What separates the teeth when they are stuck together by chewing gum, toffee or like substance? Gravity?

Platysma.—This muscle can be seen in action in an exhausted runner nearing the finishing post. While other muscles, such as risorius and the depressors of the lower lip open the lips, the platysma is an accessory opener of the jaw. But in normal movements of the mandible it is never in action. It can be called an accessory muscle of mouth opening in the same way as the sternomastoid, for example, can be on occasion an accessory muscle of respiration, but neither action has a place in the picture of *normal* movements.

Accessory muscles of mandibular depression.—All over the body we see each movement served by its own set of muscles, but in many situations it happens that additional muscles, not normally concerned in the movement, can be called upon to act as accessory muscles. This is well illustrated in the case of the respiratory excursions of the ribs. Normal tranquil respiration is carried out by the intercostals and diaphragm alone; forced breathing is performed by many other muscles not normally concerned at all in the respiratory act. For example, the scalenes, sternomastoid, pectoral muscles and serratus anterior act as accessory muscles of inspiration in dyspnœa, while rectus abdominis and the abdominal flank muscles act as accessory muscles of expiration in coughing, sneezing, asthma, &c. In the same way, under *abnormal* conditions, accessory muscles can be used to assist the lateral pterygoids and digastrics to rotate the jaw into the open position; such muscles are the geniohyoid, those few fibres of mylohyoid which are attached to the hyoid bone together with the depressors of the hyoid bone, and even the platysma.

In passing one might remark that the openers of the lips, when all contracting together and simultaneously with contraction of the orbicularis oris, can as accessory muscles assist temporals, medial pterygoids and masseters to close the mandible by stretching as a sheet of contracted muscle between upper and lower jaws. But it would cause much confusion to place the levators and depressors of the lips in a list of muscles supposed normally to close the mouth.

Closing the mouth.—The writer agrees with the conventional accounts of the muscles responsible for closing the mouth. Retraction of the mandibular condyle is brought about by the posterior fibres of the temporalis and the mandible is rotated into occlusion by the rest of temporalis, the masseter and the medial pterygoid. The temporalis, masseter and medial pterygoid have nothing whatever to do with the head poise. The head is held in balance by its own musculature, which has already been discussed.

Lateral movements of the mandible.—It has already been stated that the mandible rotates around an axis that passes through each ramus near the mandibular foramen. But this axis does not remain fixed in relation to the skull. The mandible does not close like the hinge of a rat trap, but approaches the maxilla with a sideways movement that is essential to both cutting and grinding. The muscle balance which is responsible for stabilizing and moving the mandible is a mechanism that can be adjusted to allow asymmetry in the amount of forward movement of the condyles. Such asymmetry allows the mandible to be slewed to one or other side. The pterygoids, both lateral and medial, are essentially the muscles responsible for these lateral mandibular movements, the lateral pterygoid in opening and the medial pterygoid in closing the jaw. The grinding motion of the molars is a combination of lateral with some antero-posterior movement of the mandible, and this is produced by the pterygoid muscles of right and left sides contracting alternately while upward pressure of the mandible is maintained by temporals and masseters.

Movements of the Floor of the Mouth

The floor of the mouth, the mylohyoid, is a muscular "diaphragm" whose resemblance to the pelvic floor is very striking. In each case a flat sheet of muscle slopes downwards from a curved bone into a mid-line raphe. When the muscle is relaxed the gutter between the two sides is at its deepest; contraction of the muscle raises the floor and makes the gutter more shallow. The main difference lies in the relative fixity of the pelvic floor. The mid-line raphe of the pelvic floor is attached posteriorly to the tip of the coccyx and is there fixed in relation to the pelvic wall. The mid-line raphe of the oral floor is attached posteriorly to the hyoid bone and is thus very mobile in relation to the mandible. The hyoid bone can be moved forwards and backwards, upwards and downwards, and rotated around a transverse axis. Put in other words, the floor of the mouth can be lengthened or shortened antero-posteriorly, and can also be elevated or depressed with relation to the mandible. Such mobility confers a like mobility on the tongue, which possesses great intrinsic mobility of its own. The mobility of the floor of the mouth greatly increases the range of excursion of all the tongue movements. The position of the hyoid bone along the antero-posterior range is determined by the relative lengths of the geniohyoid and stylohyoid muscles (Fig. 2). Each of these muscles has a secondary

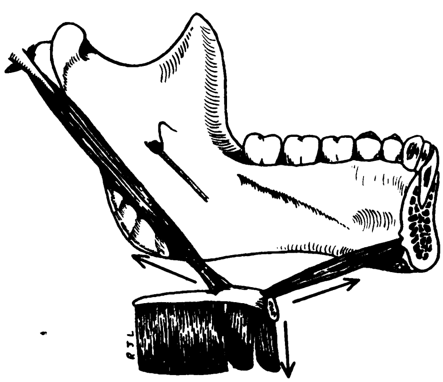

FIG. 2.—The antero-posterior position of the hyoid bone (i.e. the length of the floor of the mouth) is determined by the stylohyoid and geniohyoid muscles, both of which are fixed to the hyoid bone.

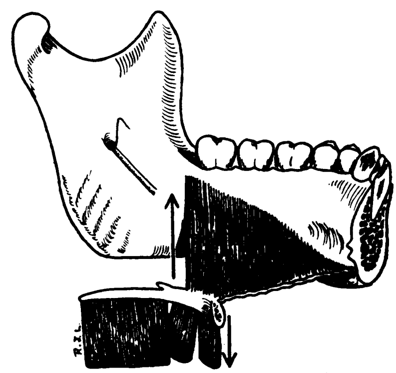

FIG. 3.—The vertical level of the hyoid bone is determined by the mylohyoid and infrahyoid muscles.

elevating effect similar to that of the digastric. This is counterbalanced by the depressing effect of the infrahyoid strap muscles. Sternohyoid and omohyoid act directly as depressors, while sternothyroid acts directly via the thyrohyoid muscle.

The vertical position of the hyoid bone is determined by the upward pull of the posterior fibres of the mylohyoid muscle, balanced by the opposing infrahyoid muscles (Fig. 3).

The principal elevator of the hyoid bone is the mylohyoid muscle. In other words, the floor of the mouth is its own elevator. The mylohyoid is a sling lying under the tongue, and when it contracts it lifts the tongue upwards. Tongue movements are essential to normal speech and mastication, but they accompany also a simple uncomplicated opening of the jaw. It is almost impossible to keep the tongue in the same position relative to the mandible while the mouth is opened; the tongue is protruded, retracted, heaped up or flattened according to the purpose required, and depending largely on whether nose or mouth breathing occurs.

The hyoid bone is moved by its own muscles so that it takes up its appropriate position in all positions of the mandible; the muscles that so move it are not the primary movers of the mandible. Depression of the mandible is usually accompanied by contraction of the mylohyoid, but the contracting mylohyoid does not *produce* the mandibular movement. In the same way, depression of the mandible is usually accompanied by opening of the lips, but it would be absurd to argue that the dilator muscles that open the lips produce mandibular movement, even though they contract simultaneously.

Thus it is evident that the hyoid bone is movable in all directions from its position of rest, and in practice it turns out that hyoid movement in respect to the mandible accompanies the slightest movement of the tongue. In speaking and chewing the hyoid is never still. Its greatest excursion takes place during swallowing. Here the floor of the mouth is elevated to its highest, reducing the volume of the mouth to the minimum, so that the tongue must go back, propelling the bolus into a pharynx drawn up and open, waiting to receive it. The posterior part of the tongue is not only pushed back passively by the elevation of the floor of the mouth, but is pulled back actively by the stylo-glossus muscle. Thus is accomplished the first or voluntary stage of swallowing.

The Role of the Tongue in Swallowing

When the mylohyoid contracts the tongue is not pushed upwards as an inert mass. By the active contraction of its own musculature the tongue adapts its shape to the requirements of the action being performed. When the tongue is in fact inert, speech, mastication and swallowing are all very adversely affected. This is seen in idiots, or in cases of bulbar palsy where the hypoglossal nucleus is involved. The assumption that the tongue is relatively passive during the mylohyoid stage of swallowing seems to the writer to be a fallacy in the present-day assessment of the effects of swallowing and tongue movements in the production of malocclusion.

During continuous drinking of liquid from a vessel, swallowing is performed with teeth and lips apart, yet no liquid is squirted back into the vessel. This action of the tongue, in which complete control of the liquid bolus is obtained without assistance from the teeth, is surely the ideal swallow. It is the usual swallow in many native races, particularly in those who masticate with the lips parted, and it is referred to below.

It should be noted that when contraction of the mylohyoid forces the tongue up against the palate there is necessarily an increase of pressure within the mouth. This increased pressure can only be sustained if the mandible is held up. Thus the elevators of the mandible contract with appropriate force not only during mastication of a soft bolus between the tongue and the hard palate, but also while the tongue is pressed upwards during the mylohyoid phase of swallowing. Brodie draws attention to this simple fact, and to the reciprocal relaxation of the infrahyoid muscles; but Brodie's mistake lies in ignoring the flexor muscles of the cervical spine and of the skull, and in assuming that the swallowing muscles are muscles of head posture.

Movements of the Larynx

It is of great importance to the protection of the human larynx that its inlet be simultaneously updrawn below the protective shelf of the posteriorly bulging tongue as the bolus passes into the pharynx. This explains the attachment of the larynx to the floor of the mouth, via the hyoid bone and the thyrohyoid muscle; as the floor of the mouth ascends the larynx ascends with it. In addition the larynx has its own proper elevators, those muscles wrongly styled "pharyngeus", the stylo-pharyngeus, salpingo-pharyngeus and palato-pharyngeus, each of which has most of its fibres inserted into the thyroid cartilage and only a few into the side wall of the pharynx. They, as well as the thyrohyoid, draw the larynx up in swallowing.

Movements of the Face

The muscles supplied by the facial nerve are called the "muscles of facial expression" in almost every current textbook of anatomy. True it is that their varying degrees of contraction produce those small alterations of facial contour to which by experience we are highly sensitive, but the muscles are not there primarily to produce facial expressions. They are arranged as circular sphincters and radial dilators around the facial orifices (eye, ear, nose, mouth). In man the sphincter and radial dilators are best developed around the mouth. Contraction of the orbicularis oris compresses the lips into the smallest possible circle. The orbicularis is surrounded by muscles that radiate away like the spokes of a wheel; these muscles are the opponents of the orbicularis. When they all contract simultaneously they stretch open the lips into the widest possible circle. A fact of especial importance to the orthodontist is that the facial musculature is applied over a convex skeleton of bone. Contraction of the muscles causes pressure upon the underlying bones and teeth. The lips press backwards upon incisors and canines, the modiolus and the buccinator press inwards upon premolars and molars. These pressures are counteracted by that of the floor of the mouth and the tongue within the teeth, and during mastication the bolus is moved and returned between the occlusal surfaces of the teeth by reciprocal contraction of the facial muscles on the one hand and the floor of the mouth and tongue on the other. The buccinator and tongue are important muscles of mastication.

There seems little doubt that inequality of pressure between these opposing forces can result in shift of the teeth in one or other direction. Whether this is the only, or even the chief, cause of malocclusion is not clear. Once malocclusion exists for any reason in the young it will tend to persist or increase by reason of muscle pressures, for a sloping tooth is in unstable equilibrium and separation of the teeth allows greater protrusion of cheek or tongue between them.

That unbalanced muscle actions due to faulty habits can cause malocclusion is almost certain. It is illustrated in a most striking way in certain Abyssinian races, notably the Amhara and Tigrean, whom the writer had opportunity to study closely over a period of four years. Most of these people have gross malocclusion of the type Class II Division I (Angle). They have narrow, highly-arched palates, large central upper incisors that slope forwards with great prominence, and malerupted or impacted wisdom teeth are very common. It is quite rare to find an individual with normal occlusion. So protuberant are the upper incisors that it is only by conscious effort that the lips are held in apposition, and in the relaxed position the upper lip rides up to expose the central incisors, thus giving a false impression of smiling. Equally universal is the habit of chewing with the lips open, the action being accompanied by audible clicking and sucking tongue movements, and *swallowing is usually performed with an open mouth.*

This masticatory habit is universal throughout life, from babyhood to old age. The forward movement of the tongue is unopposed by the lips; conversely the modiolus lies with unwonted pressure against the premolars to prevent the vestibular contents from escaping through the open lips. The incisors are pressed forwards by the tongue, the premolars and molars are pressed inwards by the cheeks. This acquired dental characteristic is not transmitted. The young babies have normal faces with well-arched gums in good contact, but the dental deformity appears in early childhood and progresses into adult life.

These universal chewing habits seem to me to be the undoubted cause of the universal malocclusion, and I cannot help feeling that in Europeans a potent cause of malocclusion may lie in similar faults in chewing rather than in swallowing. Swallowing is a momentary event, chewing a much more prolonged affair, and the forces applied by the tongue and cheeks are much greater in chewing than in swallowing, especially in chewing the harder varieties of food. Perhaps it is fallacious to argue that we swallow more often in twenty-four hours than we chew, because the forces applied to the teeth and alveolar processes are so much greater in chewing, especially if the lips are parted. For with parted lips the forward thrust of the tongue is unopposed.

In the uninhibited Abyssinian, who swallows with teeth and lips widely open, there is, indeed, no forward thrust of the tongue in swallowing, but only in chewing.

In the well-trained European there is a different state of affairs, for if the lips are kept together malocclusion, however caused, encourages an "infantile" type of swallow, for the tongue and lips now meet between the parted teeth. To argue that a persisting infantile type of swallow is the original cause of the malocclusion seems to the writer to be highly speculative and unconvincing, confusing effect with cause.

SUMMARY

(1) Skull movements on the spine are produced chiefly by semispinalis capitis, longus capitis and sternomastoid. The muscles of mastication play no part in these movements.

(2) Opening of the mandible is produced by the digastric and the lateral pterygoid muscles.

(3) The floor of the mouth is shortened by geniohyoid, lengthened by stylohyoid, raised by mylohyoid and lowered by the infrahyoid strap muscles.

(4) Malocclusion is just as likely to be produced by faulty chewing movements as by faulty swallowing movements.

BIBLIOGRAPHY

BALLARD, C. F. (1951) *Dent. Rec.*, **71**, 85.
BRODIE, A. G. (1950) *Amer. J. Orthodont.*, **36**, 831.
GWYNNE-EVANS, E. (1948) *Dent. Rec.*, **68**, 5.
RIX, R. E. (1946) *Dent. Rec.*, **66**, 103.
TULLEY, W. J. (1953) *Dent. Rec.*, **73**, 741.