THE MOVEMENTS OF THE LOWER JAW.

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This paper presents the results of certain original investigations conducted in the physiological laboratory of the Harvard Medical School under the direction of Prof. Henry P. Bowditch. The results obtained are interesting, as they indicate the exact movements of the jaw, and prove that certain errors exist in all descriptions of this articulation as given by the eminent anatomists and physiologists.

These discrepancies may be briefly noted as follows: —

Monro[1] wrote, "that the mouth could not be opened, if the lower jaw was protruded, without withdrawing it from its advanced position;" this is clearly incorrect, as will be indicated later.

Ferrein[2] was quite accurate in his description, but he wrote that "the condyle advances under the eminence;" in many cases it goes under it and mounts the other side, which he omitted to say.

Humphrey[3] falls into the same error and said that "the condyle advances upon the glenoid ridge and should not go quite to the summit," which in many cases it certainly does.

Morris[4] was in error when he wrote that the condyle itself never reaches quite so far as the summit of the glenoid ridge.

Küss[5] wrote that the lower jaw, as it rises and falls, represents a lever moving around a supposed axis centred at the condyle, which remains in the glenoid cavity in small openings; and in greater separation the supposed axis is placed at, or near, the dental foramen; this is also incorrect, as will be proven later.

Quain[6] states "that the condyle rests on the convex root of zygoma when the mouth is opened. As stated above, in most cases it advances farther forward than he states.

The error of Gray[7] is in the statement that in openings of slight extent, the condyles simply rotate on a transverse axis against the cartilages, whereas

[1] Medical Essays, Edinburgh, 1735.
[2] Collection Academique, Paris, 1785.
[3] Humphrey's Human Skeleton, 1858.
[4] Anatomy of the Joints, Morris.
[5] Lectures in Physiology, Küss, Duval.
[6] Quain's Anatomy, 1883.
[7] Gray's Anatomy, 1887.

the condyles begin to move forward simultaneously with the beginning of opening. Again, he says the condyles simply "glide on to the articular eminence."

The first requisite in the study of jaw movements is to move the jaw and get a permanent record of the movement; the method used was the photographic, the same as that used by Marey and others, and may be described as follows: a bright silver bead was fastened to a wooden pin or dowel, which was firmly inserted between the inferior central incisors; with the subject in a strong sunlight, so that a bright spot should be reflected from the bead, a pure profile or side view was photographed, and the sensitive plate was exposed during the opening of the mouth; the bright spot reflected from the bead during the motion was continuously photographed and its excursion recorded on the negative as a line, giving the actual movement of the place upon the jaw to which the bead was opposed.

The earlier experiments dealt solely with the simple tracing at the symphysis, and while the results obtained with one bead were both instructive and interesting, the more valuable results were found by getting the relative movements of condyle,

FIG. 1.

angle, and symphysis; to get tracings at these points, a light framework was constructed, which

simply reached around the face from the lower incisor teeth, to which it was securely fastened, nearly to the ear; adjusting devices held bright beads which could be placed directly opposite the condyle, angle, and symphysis; the photographing took place as before, each bead making its tracing.

Figure 1 shows the device as applied to a skull; the pin is inserted between the lower front teeth, two of the bright beads being adjusted directly opposite the condyle and angle, the other in front of the symphysis. It is apparent that the jaw and device will move in concert, and that the movement of the beads is, in fact, the same as that of the points opposite to which they are placed.

FIG. 2.

Figure 2 represents the tracings as taken at the three points mentioned.

It now becomes necessary to indicate the methods by which the several tracings were subsequently studied. The picture was enlarged in outline by optical projection, and the tracing of the opening at symphysis was subdivided into convenient spaces; then, by means of dividers, corresponding points

in the tracings at condyle and angle were determined as follows.

Referring to Figure 3, it is evident that the distance between the point marked 0 in the tracing at symphysis and the point marked 0 at the condyle does not change, inasmuch as both points are attached to a device which does not change its length; and though these points may seek different positions when the mouth is opened, the distance between them remains the same; and we find the ends of the tracings at 8 to be the same distance apart as at 0, the beginning. If the dividers are set at the proper distance, we can find, by simple measurement, how far the condyle moves in a given movement at the symphysis, and the motion of the angle is worked out in the same manner. The numbers on the tracings in Figure 3 indicate

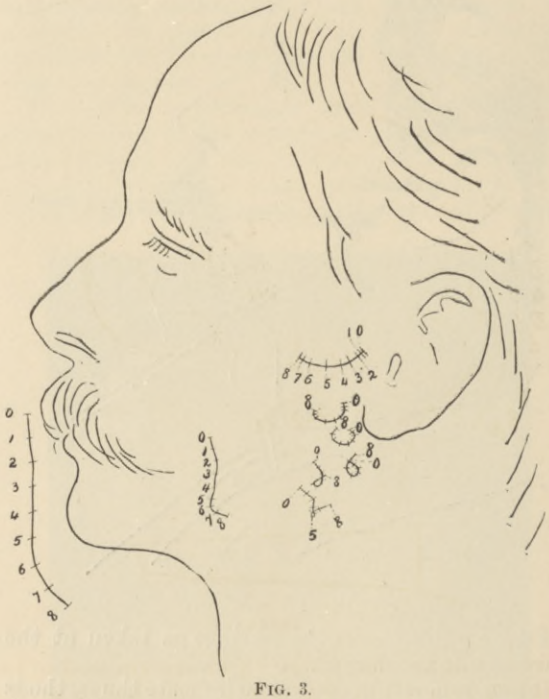

FIG. 3.

the positions occupied simultaneously by the various points of the jaw, the movements of which have been studied.

The tracings at all points in the jaw are readily understood, if we regard their motion as the result

of a combination of a uniform downward and backward rotation round the condyle, with a forward motion of the condyle itself in a curved line, with the concavity upwards, always bearing in mind that this movement of the condyle is, at first, slow, then more rapid and subsequently slow again. It is evident that points in the immediate neighborhood of the condyle will have a movement differing very little from that of the condyle itself, while at more distant points the backward rotation round the condyle will be relatively more prominent, because the motion is on the circumference of a larger circle.

The tracings in Figure 3 illustrate this point. It will be noticed that the tracing nearest to that of the condyle is, like the latter, a curve with its con-

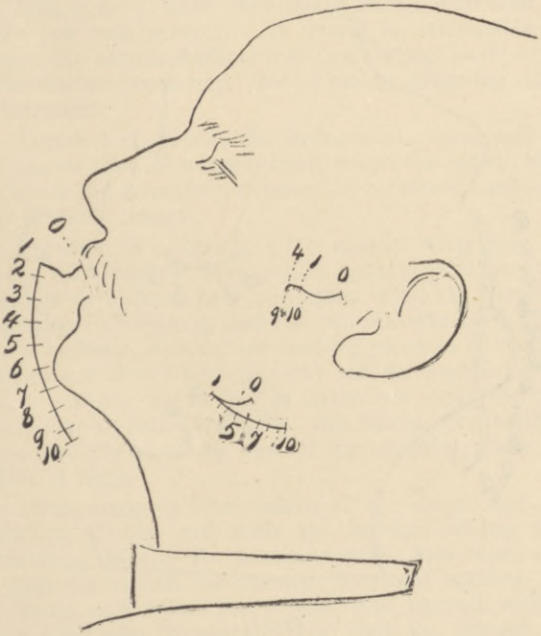

FIG. 4.

cavity upward, but at the beginning and end of the motion, where the movement of the condyle is relatively slow, the rotation round the condyle is able to impress its backward motion upon the tracing. In studying the motion of points in the ramus, successively more and more distant from the condyle, we observe that the backward rotation becomes

more and more prominent as a factor, and the forward movement due to the gliding of the condyle round the articular eminence less and less marked. The fact that this forward movement is most rapid in the middle of its course explains the loop-like character of these tracings, which is retained even so far down as the angle of the jaw.

By referring to Figure 3, it will be noticed that the condyle begins to move forward immediately, and even in a small opening of the mouth it performs quite a considerable excursion, contrary to the assertion of Gray and others to the effect that

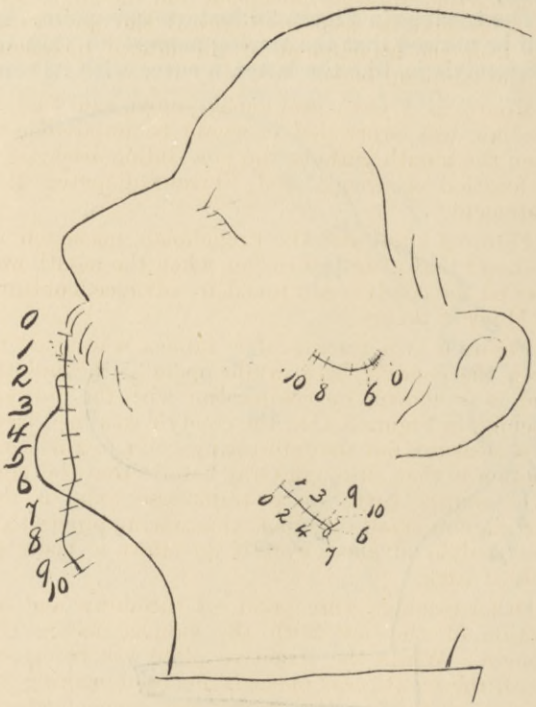

FIG. 5.

in small openings the condyles simply rotate on a transverse axis against the fibro-cartilages.

Again, it is stated by Morris, Humphrey, and others that the condyle never quite reaches the summit of the eminence; most of the tracings show that it does reach the summit and even begins to mount the anterior side, as may be seen by Figure 3.

There are, however, exceptions, and it seems necessary that any assertion as to the action of this articulation should be qualified by the statement that there is considerable individual variation in the relative movements of condyle, angle, and symphysis.

The idea of Meyer[8] that the jaw is suspended or hung in its lateral ligaments is substantially correct, and we can readily see that in moderate opening, when the condyle advances, the movement of the angle is comparatively slight, but when the capsular ligament becomes tense the condyle is kept from farther anterior movement and the angle goes back, as may be seen in Figure 3, the jaw swinging from the attachment of the lateral ligaments on the temporal bone.

Monro, as I have previously stated, said that if the jaw was protruded it would be impossible to open the mouth without the jaw sliding back, or a dislocation occurring, and Ferrein disputed this statement.

Figure 4 vindicates the Frenchman, inasmuch as it shows that after protrusion, when the mouth was opened the condyle continued to advance, contrary to Monro's theory.

Figure 5 is a tracing of a subject who tried to keep the condyle back while opening the mouth, and it is shown, by comparison with the normal opening in Figure 3, that the condyle was held back in a measure, but the interesting point in this connection is that although Gray asserts that the condyle simply turns on a transverse axis in the cartilage in small openings, this tracing proves that the condyle advances even if an effort is made to hold it back.

Other tracings were taken of the down and up motion of the jaw with the subject facing the camera. While the sensitive plate was being exposed the mouth was opened, the bead making its tracing, and when the mouth was opened widest the head was turned slightly, that the tracing of the bead in closing should not be in contact with the opening tracing.

The lines drawn show that the jaw is not depressed or closed in a straight line; the tracings taken contain several curves, which will vary with the same person at different times, on account of

[8] Die Statik und Mechanik des Menschlichen Knochengerüstes. Leipsig, 1873.

the extreme mobility of this articulation and the fact that the condyles do not advance synchronously.

These tracings are interesting to dentists, inasmuch as they show what has to be contended against in taking the "bite" preparatory to the insertion of an artificial denture.

FIG. 6.

To conclude, as Ferrein said one hundred and fifty years ago, the movements of the lower jaw are not well understood, and much that is written of them is at least faulty. Probably some inaccuracies may be explained by the fact that anatomists have made too much use of the cadaver to demonstrate the actions of the articulations, whereas it may be that the contraction of the various muscles cooperating with and antagonizing each other is the important factor in determining the exact movements of the jaw.

If these investigations throw any light upon the movements of the lower jaw, or awaken an interest in the further study of them, something will have been accomplished.