On the Growth of the Jaws and the Eruption of the Teeth*

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INTRODUCTION

TO ATTEMPT to study the growth of the jaws and the eruption of the teeth at the same time presents the same difficulty as trying to watch the three rings at a circus. There is so much going on simultaneously that many details would be missed. If one wished to see everything at the circus he would have to attend the show at least three times and keep his attention focused on a different single ring each time. In the study of growth and eruption even this would be insufficient because each tooth is a ring unto itself and each growth stage must be analyzed. On the other hand, if one considers the two processes as distinct entities, he is apt to err in the same manner that a student of history does when he studies first American history, then English and then French history. He has them so thoroughly separated that the events of each might just as well have occurred on separate planets. It requires considerable correlation before one realizes that certain epochs in one caused, or were the result of, epochs in another. It is likewise necessary, in the subject under discussion, to attempt some sort of a compromise between these two methods in order that the essential interdependence of the two processes be made clear without the loss of clarity gained by separate considerations.

THE FACE AT BIRTH

Since we shall have occasion to refer to certain relationships between the teeth and surrounding parts, it seems appropriate to set the stage before placing the actors upon it. We shall therefore attempt a description of the face at birth, calling attention to certain structures and relations as they are found at this age. For purposes of clarity we shall divide the head into its two main parts, viz., cranium and face.

At birth the cranium is quite different from what it will be in the adult. Proportionally it is wide, giving it a round appearance. Its anteroposterior dimension is the greatest even at this age, but relatively not as great as it will become. This means that the growth rate has been higher in the anteroposterior direction during intrauterine life and, since this disproportion increases with age, that either the rate remains higher or that the lateral growth stops earlier. Actually, the second has been shown to be the case. The third dimension, height, increases slowly but not as slowly as width. We are thus introduced to different gradients of growth in this part.

The face at birth is at a much lower stage of development than is the cranium. Here width is actually greater than either height or length (depth).

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If one were to state the adult ratio between the face and cranium as 1 to 1, the ratio at birth would be between 6 or 8 to 1 in favour of the cranium. Thus it follows that the face must increase its dimensions at 6 to 8 times the velocity of that of the cranium.

The facial skeleton of the baby seems to be all orbits, and indeed these apertures are closer to their adult size than any part of the face. Between them lies the nose, bounded below by the palate where the middle face seems to end. Although the alveolar process is very indifferently developed, a lateral X-ray taken at this age reveals all of the deciduous teeth in the various stages of development. The upper incisors are found between the floor of the nose and the free border of the alveolar processes, but well behind a line dropped from the anterior nasal spine. From here back the teeth lie at progressively higher levels with the second deciduous molar at or above the level of the nasal floor. Posterior to this tooth and at a still higher level will be seen the crypt of the upper first permanent molar, just anterior to the pterygomaxillary fissure. It should be remembered that the maxillary sinus hardly exists at this age.

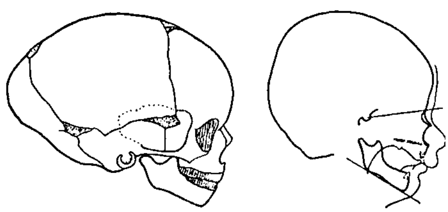

Fig. 1.—(Left) Usual conception of jaw relationship in newborn (after Brash). (Right) Profile tracing of X-ray of infant of 3 months. Jaws are invariably wide apart.

Having considered the maxilla one naturally thinks next of the mandible, but before turning to this bone another matter claims our attention, namely, the tongue. The idea seems prevalent that the gum pads of the upper and lower jaws are in apposition at this early stage. (Fig. 1), but this is not the case. To the contrary, they are wide apart. The tongue occupies the entire mouth cavity and, being proportionately larger than the jaws, it flares out over the alveolar processes and supports the lips from in back. With the jaws in this relation the tongue is not crowded back into the pharynx as would otherwise be the case. Actually, this organ and the mandible are maintained in a position of balance by the pull of a great many muscles running to them from a number of points, and their resulting position is the same now as it will be in the adult. This is shown if one draws a line from the point nasion to the centre of sella turcica and another as a tangent to the lower border of the mandible. When these lines are extended backward until they meet they form an angle. If this angle is read at three months and at seven years in the same individual, the readings will be the same (Fig. 2).

A lateral X-ray of the mandible at birth reveals that the form of the bone is not markedly different from that of the adult except that the portion designated as the alveolar process is absent. At this early age its place is occupied by the gum pad, a thick connective tissue beneath which the teeth lie in open crypts. The teeth in this jaw lie more nearly at the same level than in the upper and slightly closer to the free border. The crowns of all of the deciduous teeth have started to calcify and not infrequently one cusp of the first permanent molar. The presence of this tooth germ is indicated, in the absence of beginning calcification, by a rarefied area in the lower anterior portion of the ascending ramus. The axis of the crypt, which quite accurately foretells the mesio-distal contact line of the crown, is not disposed in the same line as the deciduous teeth. Its mesial end is at about the same level but its distal end is higher, giving the impression that this tooth will have a marked mesial inclination as it erupts.

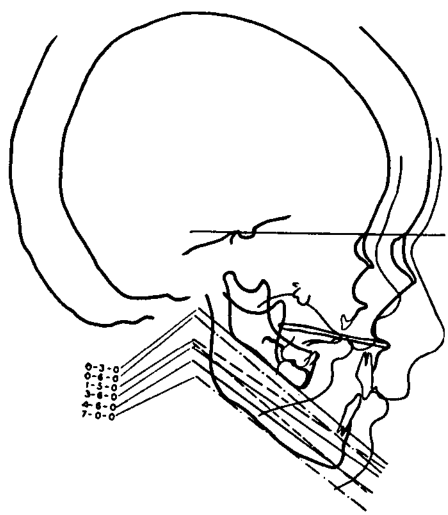

Fig. 2.—Superimposed tracings of X-rays of same individual at 3 months and at 7 years. Note stability of relation of mandible.

The ramus of the mandible is wider, anteroposteriorly, in proportion to the height of the body than it is at later stages because of the absence of a bony alveolar process. The condylar head is ball-shaped and the temporal fossa is shallow and relatively large, permitting great freedom and range of movement.

Our stage is now set; our actors are present, and we are ready to watch the play unfold. But one set of opera glasses (in this case research methods) is not sufficient. We must view it with several since each will be subject to certain limitations, and not until we have examined the same actor from different aspects are we able to decide with any certainty what his role is. In the study of the growth of the face and the eruption of the teeth important information has been derived from microscopy, vital staining, examination of skulls and from the serial X-raying of the same individual throughout the growth period. Of all of these only serial roentgenology permits the study of the same individual over any considerable period of time. Since this method also gives us the most generalized picture we shall examine some of the findings it has yielded before attempting their interpretation.

If one follows the growth of any single individual with serial X-rays he discovers that the pattern of development follows a very regular and orderly course in its progress from the infant to the adult. Furthermore this pattern is fundamentally the same in all animals and strikingly similar in those of the same species. In the human it is established by at least the third month of postnatal life and probably before birth. To attempt to follow each detail or even the progress of the whole at once is impossible. We therefore break it down into various logical divisions and study these first (Fig. 3). The bony nasal cavity is our starting point.

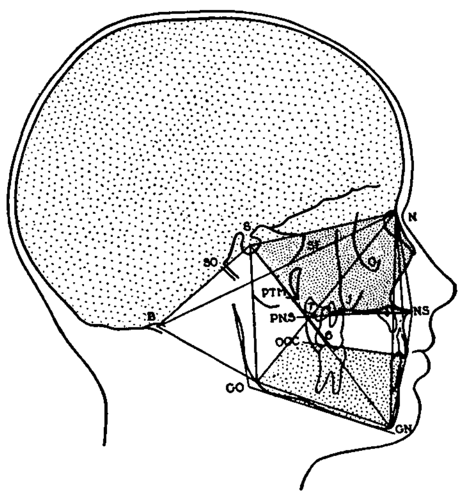

Fig. 3.—Tracing of cephalometric X-ray showing division of head into various areas for purposes of study.

Growth of the Nose

The nose is bounded above by the cribiform plate of the ethmoid bone, which structure also forms the floor of the braincase in this area. Anteriorly it is lengthened by the frontal bone and posteriorly by the sphenoidal body. A line drawn from the centre of the sella turcica on the superior surface of the sphenoid to the fronto-nasal junction (nasion) will be found to follow the boundary closely. The floor of the nose is obviously the inferior border and its length is determined by the anterior and posterior nasal spines. Connecting the anterior ends of these two roughly parallel lines bounds the nose in front for the purpose of our study.

If one studies the behavior of this area by laying out such diagrams for successive stages of growth and either superposing them or tabulating the actual measurements (Fig. 4), he finds: (1) that the line S—N slowly lengthens, resulting in a more forward position of N; (2) that the line connecting N with the anterior nasal spine always forms the same angle with the S—N line indicating that the anterior nasal spine is going forward at the same relative speed as that at N; (3) that the hard palate or floor of the nose descends from the cranial base in such a manner that its successive stages are parallel to each other and (4) that the posterior nasal spine, instead of following the downward and forward movement of the anterior nasal spine, goes straight down-

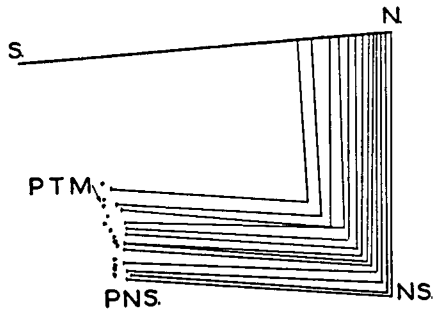

Fig. 4.—Diagrammatic composite pattern of growth of nasal area of twenty-one white males from the third month to the eighth year of life.

ward. (Just posterior to this point one sees the V mark indicating the pterygo maxillary fissure. This marks the junction of the pterygoid process of the sphenoid bone with the tuberosity of the maxilla.) This landmark also travels straight downward, and the significance of this behaviour will be pointed out later.

It is thus seen that the growth of this part of the face, at least, is remarkably steady and even, with the posterior portion remaining stable in position

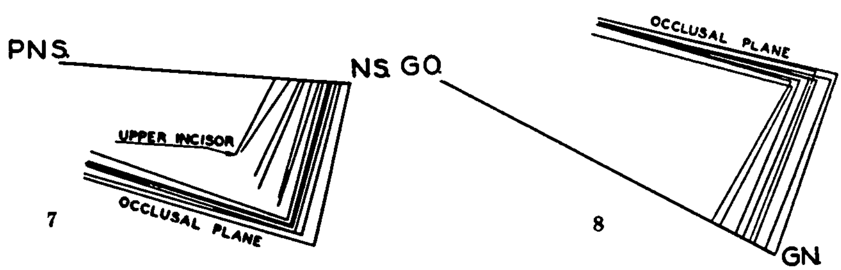

Fig. 5.—Diagrammatic composite pattern of growth of upper dental and alveolar area (left) and of body of mandible in twenty-one white males from the third month to the eighth year of life.

and the anterior going forward. With height being added evenly throughout by the parallel descent of the palate, the anterior nasal spine is given a downward as well as a forward direction. Another important idea of the stability of this area is gained if one measures the distance from nasion to chinpoint and, taking this as total face height, expresses nasal height (N to NS) as a percentage of the whole. It will be found to constitute 43 per cent regardless of age.

Growth of the Upper Dental and Alveolar Areas

This area has a common boundary with the nose, viz.: the hard palate. Its lower boundary is at first the free alveolar border and later the occlusal plane of the teeth. The anterior boundary may be taken as a line from the anterior nasal spine to the tip of the maxillary central, whether deciduous or permanent. The delicacy of the alveolar process prior to the eruption of the teeth is such that it is burned out in the average lateral X-ray headplate. The teeth, however, can be seen clearly and it is upon these that we first focus our attention. Their relative locations at this age have already been described. Their progression towards their functional positions may be studied by using the nasal floor, already shown to be highly stable, as a plane of reference (Fig. 5). Let us first study the behaviour of the deciduous central.

If one accepts the palate as a stable plane and the posterior nasal spine as a fixed point, it becomes obvious immediately that since the entire plane is descending it will be necessary to employ, not the same base each time, but that plane which represents the position of the palate at the stage which is being studied. It should be recalled that the anterior nasal spine is moving downward and forward. In spite of this, a line drawn from this point to the tip of the maxillary incisor will form a constantly increasing angle with the nasal floor at each stage until the tooth goes into function. At this time the angle stabilizes, although the line continues to grow longer. This indicates that the tooth is going downward and forward at a higher rate than is the nasal floor. If one connects all of the incisal points representing the various stages, both before and after occlusion is established, he obtains practically a straight line. This indicates that the constantly enlarging angle of the earlier stages, referred to before, is *not* an indication of greater forward than downward movement but merely a *higher rate* during the eruption period. Actually, the path is the same before and after occlusion is established. What is still more curious is that the permanent incisor behaves in an identical manner. It drops into function on the same line as its deciduous predecessor, and remains on the line although continuing to go downward and forward.

When one studies the behaviour of the upper molars in a similar manner certain differences are noted. Here a line is drawn from the centre of sella turcica to the notch formed by the mesial and distal buccal cusps of the tooth being studied. He may thus read the angular relation of this tooth to the line S–N, or anterior cranial base. Since all behave in a similar manner, we will start with the second deciduous molar because this is the most distal discernible tooth at birth. Here again the angular reading increases with age, but since this end of the base is stable the effect is quite different (Figs. 6 and 7). This tooth drops steadily in a vertical direction, paralleling the downward course of the posterior nasal spine and the pterygomaxillary fissure until it comes into occlusion. The upper first permanent molar follows a similar, but somewhat posterior, path until it comes into occlusion. By this time it is found on a line which connects the chin point with the centre of sella turcica. Henceforth it will always be found on this line. The second and third permanent molars follow similar paths but posterior, of course, to that of the first. Hence we see that once they are in occlusion the molars follow a downward and forward path parallel to that of the incisors.

The selection of a single point on a tooth in determining the direction of its eruption fails to indicate certain other changes accompanying its main movement. When first seen in the X-ray, the occlusal surface of each molar faces almost distally, or toward the pterygopalatine fossa. The frontal picture shows that it also faces toward the buccal. Each succeeding stage finds it orienting itself more in the direction in which it will function, but even when it finally breaks through into the mouth its occlusal surface faces backward and buccally. It will continue this rotary movement for some time after it has come into occlusion.

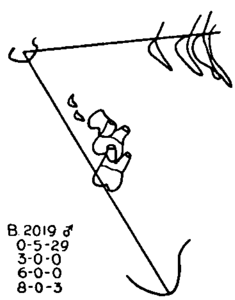

Fig. 6.—Successive tracings of same individual, superimposed on S—N line, and showing course of descent of maxillary first molar before coming into occlusion.

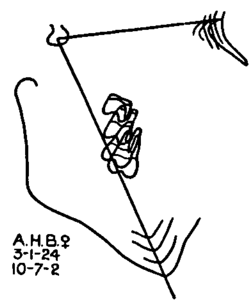

Fig. 7.—Superimposed series of same individual, showing change in course of descent of maxillary first molar after coming into occlusion. From this time on the molar will be found in the same relation to the S—Gn line.

Before going further it would seem desirable to attempt some interpretation of the material already uncovered. We have thus far pointed out the results of growth in the upper jaw as these are seen in progressive X-rays of the same individual. As indicated earlier, one cannot understand more than a single phase of behaviour with a single method of study. The X-ray tells us in this case what has happened to the positioning of the various parts being studied, but is inscrutable on where or how it has come about. For the answer to these two problems we must change our method of study. We must view our actors with different glasses.

In 1736 the observation was made that animals fed madder root exhibited a redness in their skeletons. Subsequent researches showed that only those parts of the bone that were growing took up the dye. These discoveries laid the foundation for the life work of John Hunter who, in 1771, published his "Natural History of the Human Teeth." This was the first account of the growth of the jaws based on scientific observations. Since that early time many investigators have employed vital staining and this method, together with microscopy, has yielded many of the secrets of how and where bones grow. Alizarine Red "S," a derivative of madder, has largely supplanted the use of the root, being easier to administer and to control as to dosage.

Alizarine injection of living monkeys offer the second phase of our study of the face. We seek to determine now where the additions of new bone have been made that have resulted in the changes noted in the X-ray. When one alizarinates a very young animal the entire skeleton seems to take up the dye but this is not actually the case, as can be determined by fracturing or cutting one of the bones. When this is done it is seen that only the surface is stained. But at this early age the various bones are increasing their size rapidly by growth on all surfaces. As age advances it is noticed that the depositing of bone over most surfaces slows down or ceases, as indicated by the disappearance of the staining phenomenon. Certain areas, however, continue to take the dye as indicated by deep colouration. In other words, the bone continues to grow at certain "growth sites" and these may be found long after generalized growth has ceased. They are especially prominent at the growing ends of long bones where they indicate the activity of epiphesial plates in contributing to the length dimension.

These localized areas are not separate and distinct growth phenomena but should be looked upon as accentuated points in the generalized growth referred to above. They mark those sites where growth proceeds at a higher rate and/or continues for a longer time. Obviously they lead to gradual changes in form. If one thinks of a spherical body growing equally all over its surface, it follows that its ultimate form would still be spherical. If, however, one visualizes a focal point at which growth proceeds at a higher rate, it can be readily seen that its spherical form would gradually be changed to one that might be elliptical. Given several such foci, each with a different rate of growth, the possibilities for variation in form become infinite.

If an alizarinated monkey skull is examined at almost any age the red staining will be found at the free border of the alveolar process, indicating a continuing growth at this location. Since it is found even after increases in size have ceased, one can only explain growth at this area as an adjustment to the continual eruption of the teeth resulting from wear. Prior to this advanced stage, however, the growth at the alveolar margin must be looked upon as an important contributor to face height. It seems to be responsible for the entire growth of that portion between the nasal floor or palate and the occlusal plane. In animals below the monkey the alveolar process has been given credit for the major part of vertical face growth by previous investigators. This is not surprising if the difference in faciocranial relations in the long snouted pig and the short snouted monkey are realized. In the pig the alveolar process is almost the sole contributor to facial height. When the axis of the face changes to one that is more vertical, however, it is found that those sites which formerly contributed to length are now so arranged that their activities contribute more to the vertical dimension. This will be considered at greater length later. For the present it is sufficient to look upon the alveolar process as the area which provides first, for the accommodation of the deciduous dentition and the development and housing of its successor, and second, for the eruption of the permanent teeth with their higher crowns and longer roots. This vertical increase would not take care of the three permanent molars, however, whose proper positioning requires a tremendous increase in the length of the alveolar process.

Until the complete eruption of the upper third molar a heavy staining reaction at the maxillary tuberosity will always be found. This structure, it should be remembered, is braced in back against the pterygoid process of the sphenoid bone—a cranial part. It should further be recalled that the pterygomaxillary fissure, or junction between these two bones, was shown by the X-ray to travel straight downward or, in other words, to be fixed in an anteroposterior position. Now if the junction be a fixed point and if a prolific growth is shown to be taking place at the tuberosity it follows that the result would be a forward movement of the entire maxilla. One can compare it nicely to a swimmer kicking himself away from the wall of a tank.

Alizarination reveals other growth sites than these, however. Throughout the entire growth period one finds the stain at the zygomatico-maxillary suture, over the floor of the orbit and at the frontomaxillary suture. At all of these sites the dye is deposited mainly on the maxillary side of the suture. Another place where a similar condition is found is at the transverse palatal suture, where the horizontal plate of the maxilla joins with that of the palatine bone to form the hard palate. If we analyze the planes in which these various sutures lie, we can easily comprehend the results of their combined activities. They represent the surfaces of the maxilla that articulate with other bones and their reactions against these other bones will necessarily determine the relations or spatial position of the maxilla.

As has been pointed out, the tuberosity faces posteriorly, as does also the posterior margin of the palatal process. Growth at these sites must inevitably lead to forward translation of the maxilla. The frontal process faces and grows upward against the nasal notch of the frontal bone so that the bone would be forced downward from this site. The zygomatic surface faces and grows upward and backward against the zygomatic bone—the great stress-bearing buttress between the face and the cranium. This suture therefore lies at right angles to the resulting axis of the downward and forward vectors of movement.

From all of this we see that the downward and forward movement of the various facial points, so strongly shown in the serial X-rays, is largely the result of upward and backward growth of the maxilla against the cranium and its processes.

The Growth of the Mandible

Although the mandible is a freely movable bone it forms an integral part of the facial skeleton. It should be remembered, however, that its articulation is not with the face but with the brain case, through the temporal bone. Just as the upper face expresses its own individual growth on the moving stage of the anterior brain case, so the mandible, while growing itself, is carried along by the growth of the posterior brain case. Furthermore, these two parts of the cranial base are moving apart during growth so that while the upper face tends to be carried forward by its stage the mandible tends to be carried backward. A serial roentgenographic study of the growth of the same individual fails to show any evidence of this conflict of forces (Figs. 8 and 9). True, the point at the angle of the jaw travels slightly backward as it goes downward, but the forward and downward movement of the chin point far overshadows this movement in magnitude. Where does the actual deposition of bone take place that brings about these changes in the spatial position of the mandible? Animals at different growth stages are injected intraperitoneally with Alizarine Red "S" in order to study the sites of growth at different ages. We shall consider only three stages, namely, those corresponding to the deciduous dentition, the mixed dentition and the adult dentition in man.

The most striking differences between the three specimens lie in the sizes and intensities of the staining reaction. The mandible of the youngest

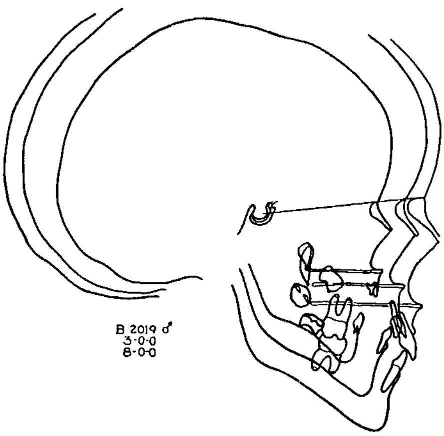

Fig. 8.—Three superimposed tracings of the same individual from 3 months to 8 years. Note that gonion goes downward and backward, while gnathion goes downward and forward.

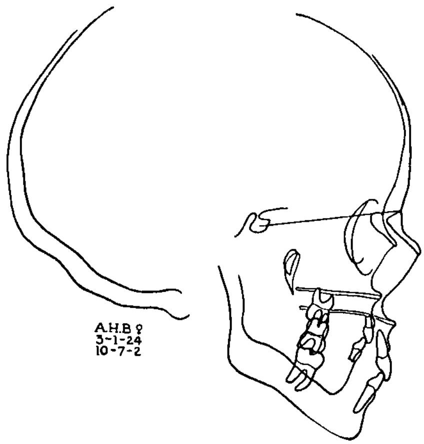

Fig. 9.—Two superimposed tracings of the same individual at 3 years, and at 10 years, 7 months. (Note continuation of same trends as in Fig. 8.)

monkey is found to be heavily stained on all surfaces. Growth is occurring everywhere and at such a rapid rate that a scrutiny of only the surface fails to reveal a definitive pattern of deposition. Only where the bone is extremely thin, as in the sigmoid notch, are alizarine lines discernible. Growth appears to be generalized during this stage.

The animal which corresponds to a six-year human dental pattern is quite different. The generalized type of growth has nearly disappeared, bringing into strong relief certain "sites" of growth. The most apparent of these is located at the head of the condyle where the red staining is intense. Another zone of deposition is present along the entire length of the posterior border of the ramus, the sigmoid notch and along the alveolar crest. Deposition on the inferior border seems to have stopped and only faint traces are noticeable on the lateral surfaces.

The findings on the adult specimen differ from the second only in degree; that is, only the rate of bone growth is diminished, not the mode. There is still growth at the condyle, the posterior border of the ramus, the sigmoid notch and the free alveolar margin. All are less intense and the lateral surfaces exhibit no trace of stain. It is thus seen that the principal *directions of growth* in the mandible are upward at the alveolar process, backward at the ramus and upward and backward at the condyle. This is just opposite to what might be inferred from a study of the serial roentgenograms alone, which show a downward and forward movement of this bone throughout growth.

When all of the findings on upper and lower face are considered together it is possible to derive from them certain other facts not obtained by direct observation. It will be remembered that the nasal floor (palate) descends from the cranial base in such a manner that the original angular relation between them remains unaltered. As the face increases in height the nose is found always to contribute 43 per cent of this height. In a similar manner, the upper alveolar process and teeth descend from the floor of the nose without disturbing their angular relation if we consider the occlusal level of the teeth as another plane. Hence, we have two anatomical

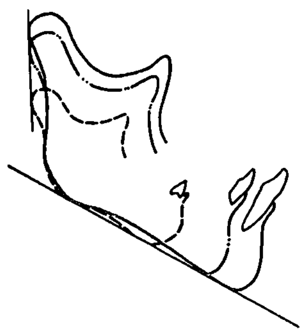

Fig. 10.—Three tracings of the same mandible showing method employed to study the angle.

parts, nose and upper denture, each of which contributes an increment to height, which increments are summated at the occlusal plane. Since the occlusal plane marks the junction with the mandible it can be seen that all of this growth would result in a pushing downward of the mandible, away from the cranium, to which it is attached. Further than this, the mandible itself has been shown to be increasing in vertical height by additions to its superior or alveolar margin, and this would again have the effect of forcing this bone down. But we have seen that the lower border of this bone behaves like other planes above it; that is, its angular relation with the cranial base is not disturbed by growth. We can therefore infer that the condyle must be growing at a rate that is equal to the sum of all of the other increments in order to adjust the mandible to the growth of the middle face. One other factor contributes to this adjustment however. The glenoid fossa is seen to go downward and backward during growth but its rate is so slow that it is able to contribute only a fraction of that added at the condyle. From the fact that there is a slight backward vector to this movement of the joint, it can be realized that the anteroposterior growth of the mandible must be in excess of that of the maxilla in order to compensate for the backward migration of the fossa.

The combination of methods employed in this study, namely, serial roentgenology and alizarination, yields another surprising finding. If one superposes the tracings of successive X-rays of the mandible on a line representing a tangent to the lower border (Fig. 10), it is found that lines representing the posterior border of the ramus will also superpose. This means simply that the angle formed by the ramus with the posterior border remains constant throughout growth, instead of becoming more acute as has been taught in the past (Fig. 11).

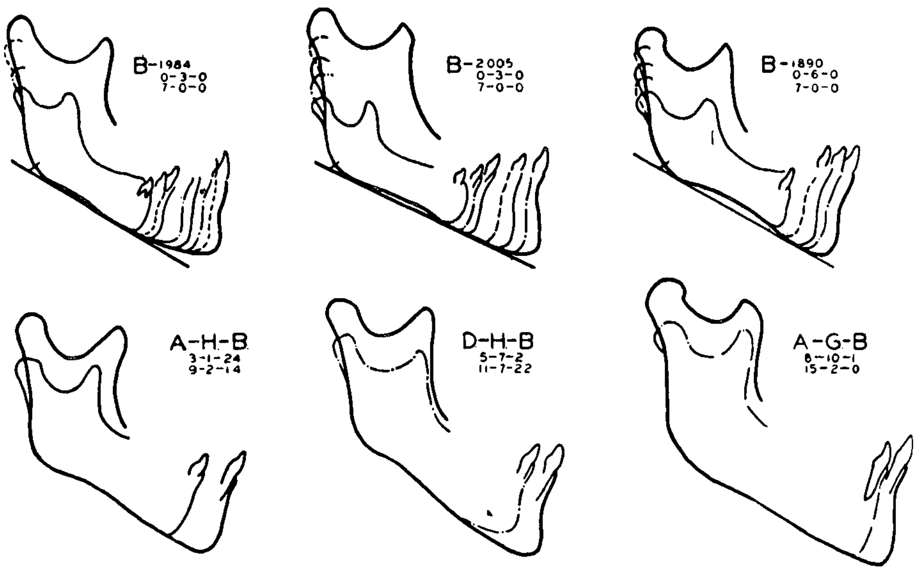

Fig. 11.—Superimposed series of tracings of mandibles of six different individuals of different age ranges.

The Growth Pattern and the Eruption of Mandibular Teeth

In an effort to study the eruption path of the mandibular teeth various measurements were made on the tracings of successive X-rays of the same individual. As stated earlier in the paper, the first appearance of a developing tooth germ is indicated by what appears to be an area of rarefaction in the bone. At a slightly later date the beginning of calcification of the cusp tips appears, followed by an extension of calcification until the entire crown is delineated. In the case of the mandibular six-year molars, these areas appear first in the ramus at a level considerably above that of the unerupted second deciduous molar. This is the picture at three months of life. Successive X-rays reveal a rapidly changing relation. As the deciduous molar starts its eruptive migration it reaches the level of the crypt of the first permanent molar, which, by this time, is found at the inner angle of the mandible, or that area where the alveolar process meets the anterior margin of the ramus. Some time later we find the second deciduous molar at a higher level than that of the six-year molar and this tooth, its crown pretty well completed, has now assumed a position well within the body of the mandible. Viewing the above described series of tracings side by side, or even superposing them on a cranial plane of reference, gives the impression that the six-year molar, starting in the ramus, has burrowed its way downward and forward to assume a new position in the body of the mandible. Such is not the case.

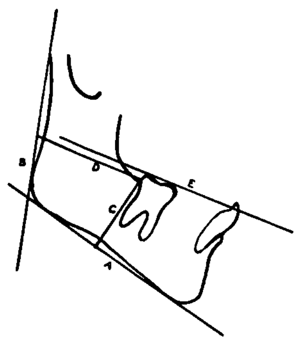

Fig. 12.—Method employed by Elman to study the relation of the mandibular first permanent molar to the mandible. Lines D and C were measured and plotted. (See Fig. 13.)

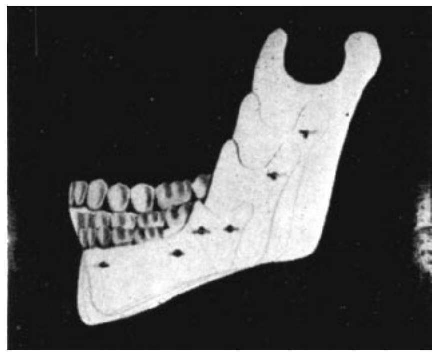

Fig. 14.—Author's model assembled to show eruptive course of teeth in relation to mandible. Note that eruption is practically vertical.

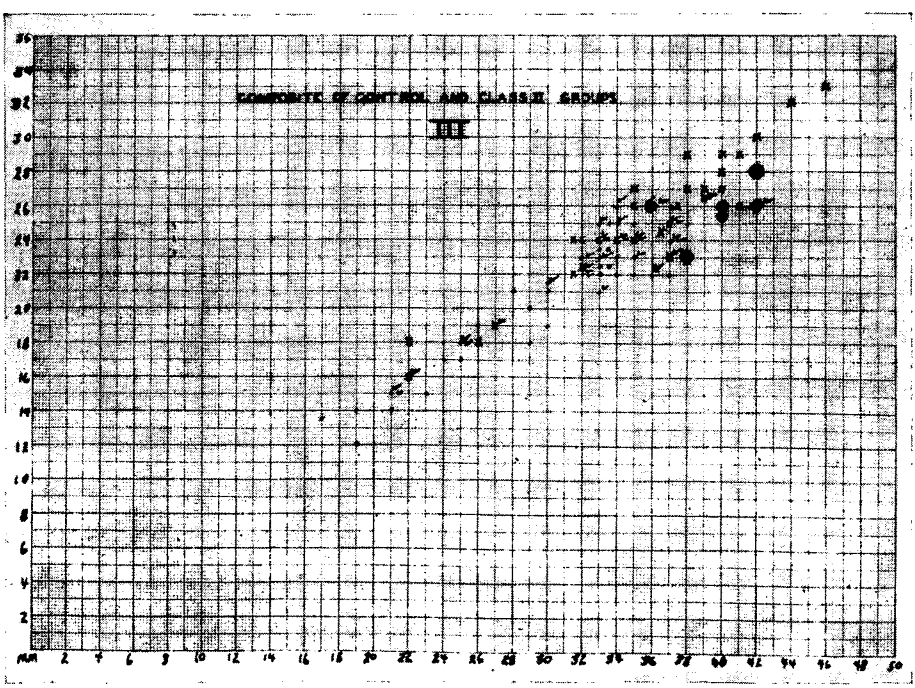

Fig. 13.—Scatter diagram showing relation of mandibular first molar to mandible in 118 individuals ranging from 3 to 26 years in age.

Distance of the Last Molar Tooth to Distal Border of Ramus

(3 months to 7 years)

Case No.	1893	1897	1932	1941	1984	2005	2009	2027	2035	2070	2165	Mean
AGE												
0-3-0												
0-6-0	21.25											
0-9-0												
1-0-0												
1-6-0	28. e	38.5 d		38. d	38.5 d	39.5 d	44. d	40. d		39. d	39. d	
2-0-0	31.5	39.		40.75	40.	31. e		32.25 e	41.25 d	40.75		
2-6-0		29. e	31.25 e	33. e	30.5 e	35.5	36.25 e	35.5 e	43.	32. e	33. e	31.84
3-0-0	34.	31.5	35.	34.5	32.75	36.5	36.	36.75	34. e	33.5	34.	
3-6-0	34.	33.25	35.75	36.5	34.	38.	36.25	38.25	34.25	35.5	34.5	
4-0-0	37.		36.25	36.75	35.25	38.5	37.	39.	36.25	37.5	34.5	
4-6-0	37.25	35.75	37.	39.	37.	40.	38.75	41.75	37.5	39.	36.5	
5-0-0	28.25 6	37.	39.5	39.5	36.5	41.	41.	43.		40.	38.	
6-0-0	31.5	40.	40.5	42.5	28.5 6	32.5 6	42.	44.5	41.	32. 6	28.75 6	31.65
7-0-0	32.	30. 6	32. 6	34.25 6	30.5	34.25	35. 6	35. 6	32. 6	33.	32.5	

(6 months to 8 years)

Case No.	2019	2130	2078	2173	2207	2108	2058	2049	2017	2125	Mean
AGE											
0-6-0											
0-9-0											
1-0-0											
1-6-0		38. d	47. d	35. d			36. d		36. d		
2-0-0		39.	31. e	37.		40. e	28.5 e		37.5	28. e	31.1
2-6-0	34. e	30.5 e	36.25	32. e			32.			32.5	
3-0-0	38.	31.	37.5	33.	32.5 e	32.5 e		34.25		34.	
3-6-0	38.	33.5	39.	33.5	35.	35.	35.	34.	32.	35.	
4-0-0	37.5	34.	40.	33.5	35.5	36.	35.	35.	32.	36.	
4-6-0	40.	35.	40.75	34.25	36.5	36.5	37.	35.	34.	37.	
5-0-0	41.	36.		36.	38.	37.5	39.	38.	35.	38.	
6-0-0	43.25	38.25	31. 6		40.	39.	28.5 6	39.5	35.5	28.75 6	30.65
7-0-0	32.5 6	29. 6	34.25	27.5	41.	41.	30.	29.5 6	27.6 6	31.25	
8-0-0	35.	31.	36.	30.5 6	33. 6	32. 6	32.25	31.	28.	33.5	

Distance of the Last Molar Tooth to Distal Border of Ramus

(6 years to 14 years)

Case No.	255	1681	2471	2600	2798	2384	2037	2032	22[illegible]4	2216	Mean
AGE											
6-0-0			29.25 6				27. 6	28.25 6			
7-0-0	28.25 6	32.5 6		32.75 6	31.25 6	30.75 6			30.75 6	32.	30.27
8-0-0											
9-0-0											
10-0-0											
11-0-0											
12-0-0			29.5 7								
13-0-0	29. 7	32. 7		33. 7	32. 7	[illegible].25 7	27.5 7	27.25 7	28.5 7	30.5 7	29.95
14-0-0											

"d" denotes first deciduous molar
"e" denotes second deciduous molar
"6" denotes first permanent molar
"7" denotes second permanent molar

Fig. 15

Going back to our alizarine findings we remember that the alveolar process is a rapidly growing part of the mandible. The deciduous teeth lie beneath this margin and, were it not for the eruption process, would be covered by an ever increasing thickness of bone. The teeth, however, driven by a little understood force, migrate upward at a faster rate than the bone is growing so that they ultimately meet and pass the free margin. We say they "erupt" into the mouth. This rapid migration of the deciduous teeth and the vertical growth of the body of the mandible are responsible for the illusion that the first permanent molar is sinking into the bone. Actuallv it is doing something quite different, as will be seen shortlv.

The impression that this same tooth is moving forward is explained in a similar manner. The mandible is growing in length by additions to its posterior border, which growth would increase the anteroposterior width of the ramus to an equal extent. This does not occur because the anterior margin of the ramus is trimmed back by resorption at a rate that is only slightly less than that of the deposition in back. In this manner the molars that make their appearance first in the ramus are slowly uncovered by the retreat of its anterior margin without having to migrate at all.

Subjecting the mandible and its molars to actual measurements yields interesting information regarding the relationship between them. If, for instance, one measures the distance of the last molar in occlusion from the posterior margin of the ramus, on a line parallel to the occlusal plane and as soon as possible after occlusion with its antagonist has been established, he will obtain the same reading for the second deciduous and first and second permanent molars (Table 1). In other words, each succeeding molar erupts at the same distance from the posterior margin.

If one erects a perpendicular from a tangent to the lower border of the same tooth point employed above (the distal contact) (Figs. 12 and 13), he finds that regardless of age or of stage of eruption the ratio between the two measurements is always the same and may be expressed as follows:

Distance of tooth anterior to ramus : distance of tooth above lower border x 3 : 2.

Since this ratio is obtained whether one measures it at three months of life or at twenty-six years, it follows that the six-year molar, although appearing to sink down and go forward, would seem to be going upward and forward in relation to the mandible (Fig. 14). A similar study of the mandibular incisor shows that this tooth seems to follow an upward and forward course.

Actually these teeth are not going forward at all, except in their relation to the cranium. Growth is occurring at superior and posterior craniofacial junctions, resulting in a downward and forward movement of the bones that house the teeth. If we dissociate the maxilla and mandible from the cranium and study only the tooth-jaw relations, we find that eruption is in an almost vertical direction (Fig. 15).

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