VOL. VII No. 4

The Angle Orthodontist

A magazine established by the co-workers of Edward H. Angle, in his memory. . . . . .

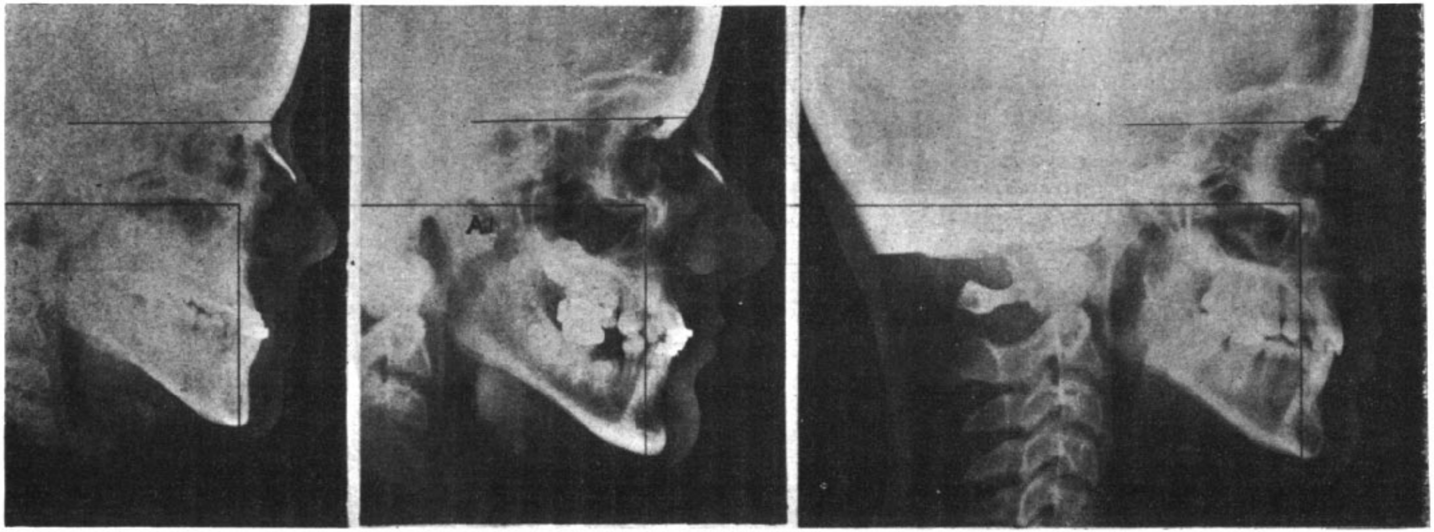
The Face of the Normal Child*

B. HOLLY BROADBENT,** D.D.S., F.A.C.D.
Cleveland, Ohio

Unlike the layman, whose measure of physical perfection is purely linear, the orthodontist stereoscopes the face aware that each surface feature is but a veneer for the fundamentals of anatomy, developmental growth and function. For the face in its internal form and structure contains in a chronological sequence a detailed record of the individual's developmental growth progress from birth to maturity. The skulls of dead children available for study have very largely supplied the data for the splendid contributions of Todd, Keith, Noyes, Hellman, and others. Todd[1], in his pioneering efforts to take the study of anatomy out of the dead house, sounded the keynote of progress when he warned that the measure of dead skulls is largely a record of defective growth, and, that if we are to measure normal growth we must measure it on healthy living children. The author as a student in anatomy under Todd, and subsequently as a protege of his in preparation for the Angle course in orthodontia has enjoyed the rare opportunity to continue anthropometric studies under this master.

At the Angle College, in 1922, Spencer Atkinson, lecturing on diagnosis, instructed the students in the relation of the denture to the landmarks found in the maxilla, and called attention for the first time, in so far as the author is able to determine, to the advantage of the use of a roentgenogram of the face in determining the relation of the first permanent molar to the key ridge† above it. Atkinson warned that such pictures would not always reveal the key ridge. Besides the relation of the teeth to the key ridge they did reveal some of the soft parts as well as the relation of the two jaws to the rest of the face, and the cranial base. It occurred to the author to superpose these facial pictures on the base lines found by connecting such points as the

*Presented before the 28th annual meeting of the Eastern Association of Graduates of the Angle School of Orthodontia, at Cleveland, March 15, 1937.
**Director of Research of the Bolton Study of Development of the Face of the Growing Child, Anatomical Laboratory, School of Medicine, Western Reserve University.
†The key ridge is the prominence below the malar process which divides the canine from the infra-temporal fossa on the lateral surface of the maxillary bone.



A B C

Fig. 1

A and B—Typical laboratory pictures made without the means of exact orientation showing variation in results through lack of standardization of technique. C—Exact profile roentgenogram made with the aid of the roentgenographic cephalometer. Soft tissues of the pharyngeal space are clearly defined before and after removal of adenoid mass (Ad.). Compare B and C.

sella turcica and nasion as well as the ear hole and the eye point, thereby disclosing somewhat more clearly the changes in the teeth and jaws during orthodontic treatment. This experience in using roentgenograms made by the commercial laboratory indicated that their technique was not sufficiently standardized to secure two identical pictures, or a subsequent picture with the same relation of the film and the head to the source of the X-ray.

In Fig. 1, A and B are typical laboratory pictures of a class III Angle malocclusion before and after a period of treatment. Comparing the two enabled us to note the changes not only in the articulation of the teeth that would ordinarily be registered in the plaster models, but the changes in the soft tissue profile and naso-pharyngeal areas[2]. With our first superpositions of tracings on cranial landmarks it was discovered that although normal articulation of the teeth prevailed or had been secured during orthodontic treatment, the developmental trend of the facial parts was not always in the direction of the accepted normal[3]. This is clearly shown in Fig. 2 where the superposition of tracings on the sella-turcica-nasion line of a case before and after 7 months of treatment reveals the continuation of abnormal changes in the relation of the maxilla and mandible to the rest of the head, although the treatment had produced a better articulation of this class II malocclusion.

This pointed to the value and need for a standardized technique, to measure the living head as accurately as the anthropologist surveys the dead skull, and aided in the design of the roentgenographic craniostat[4]. Studies with this instrument demonstrated that skull pictures could be taken identical with those previously made in the relation of predetermined points, and was the forerunner of the design for the head holder shown in Fig. 3. This early model permitted the production of a profile roentgenogram (see Fig. 1, C) precise in its results so that different operators could produce identical pictures. Since the single view registered but two dimensions it was necessary to redesign the machine (Figs. 4 and 5) that not only permitted the production of a standardized lateral roentgenogram, but makes it possible to produce a complementary pair of roentgenograms (Fig. 6), one in the sagittal plane and one in the frontal plane. These are oriented so that they are in fact, a front and side view drawing of the head and face, recording in three dimensions of space most of the internal as well as the external landmarks useful for a measure of developmental growth of the teeth and jaws and orthodontic changes therein.

Researches with this instrument have led to refinement in technique[5,6], and the results have confirmed the necessity of establishing known biometric relations of teeth and jaws to more stable points outside of the face itself. It should be emphasized that this roentgenographic technique does not depend on measurements taken through the covering of soft tissues of unknown thickness. Simon's technique[7] and other modifications of the use of the head spanner have this serious drawback. Measurements with a head spanner and calipers although precise enough for some practical anthropometric purposes limit the orthodontist to a very few useful dimensions of the face and jaws, and their relation to the cranium.

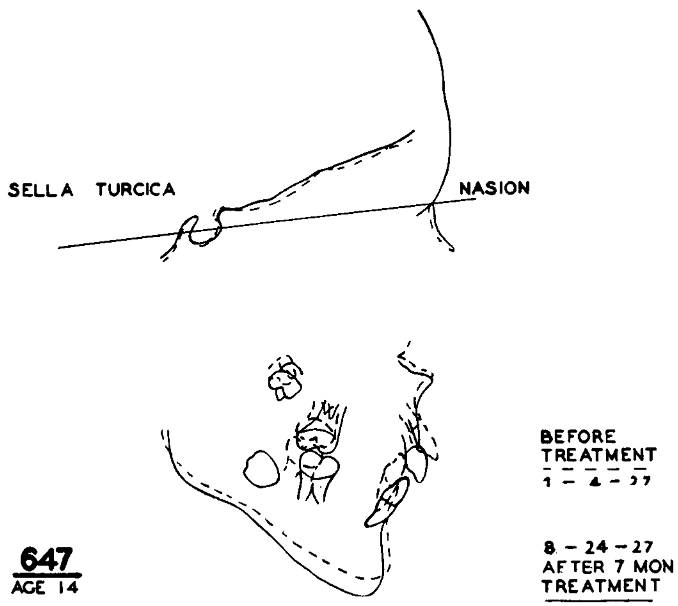


Fig. 2
Tracings of Angle Class II malocclusion before and after treatment accompanied by abnormal development trend in the lower face.

The various parts of the head holding device (Fig. 6), the two ear rods and the nasion rest aid in properly orienting the frontal and its complementary lateral roentgenogram for measurement. Thus it should be clearly understood that the mechanical parts of the apparatus do not form landmarks from which measurements of the head are taken, but serve merely to firmly secure the head in relation to the X-ray film and the source of the X-rays so that identical pictures are produced.

Further investigation yielded the information that conclusively determined that neither the ear nor the eye point were stable enough to warrant their use as landmarks from which to measure changes in the teeth and jaws. Statistical determinations from measurements made on collections of skulls housed in the Western Reserve Anatomical Laboratory[6] and the American Museum of Natural History confirmed the observation that landmarks above the face in the cranial base were relatively much more stable, and therefore more fixed than those in the more rapidly growing lower face. Fortunately this stable area in the cranial base through the mid-plane is as clearly defined in the roentgenogram as are the teeth and jaws. The earliest records of the Bolton Study* indicated that in early infancy and childhood before the growth of the brain case was complete that certain

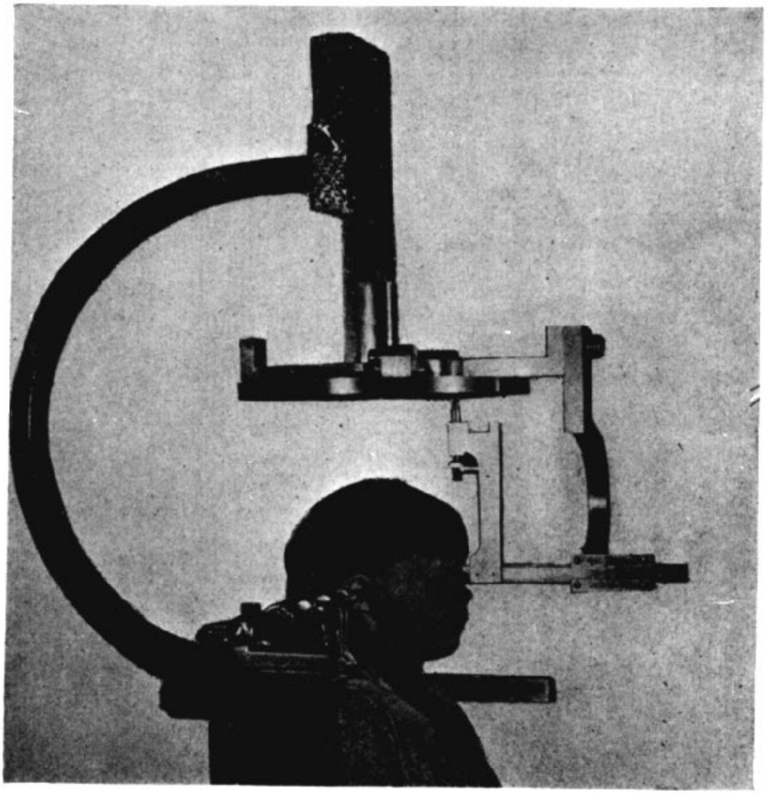


Fig. 3
Head-holder for producing standardized lateral roentgenograms showing the fixation of the head by means of ear rods and nasion rest.

*This study has been made possible through the generosity of Mrs. Chester C. Bolton and her son Mr. Charles Bingham Bolton, and facilities of the Western Reserve University Anatomical Laboratory with its associated foundations grouped together in a study of developmental health and growth in children from birth to adulthood.

cranial areas changed in size at one time, while other areas of the head remained fixed during that same period. These fixed areas offered our initial opportunity to superpose subsequent tracings of the roentgenograms of the same individual on the fixed areas which were common to the two sets of pictures. These common landmarks lying outside of the face permitted an exact measure of the changes in the face below. Recent observations from the data accumulated the last seven years continue to substantiate the stabil-

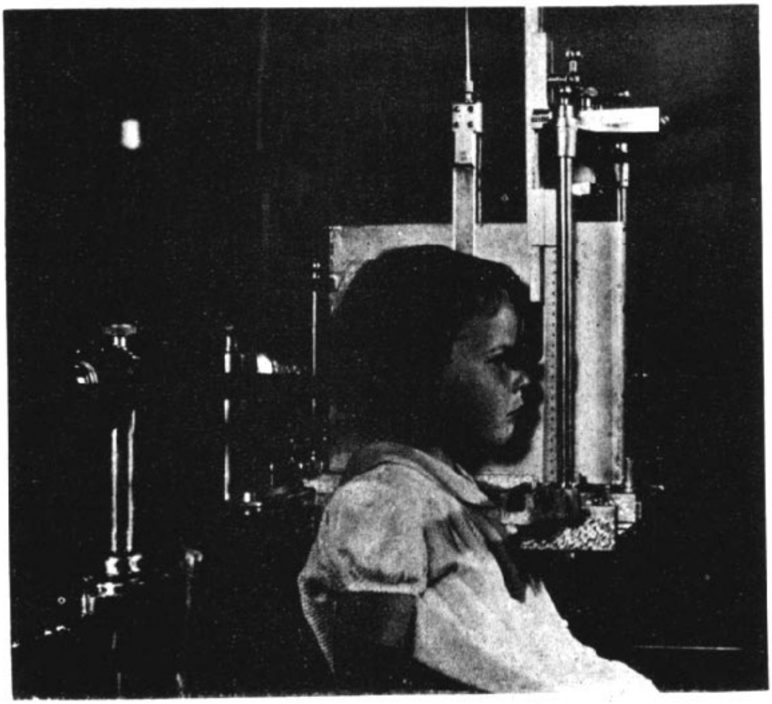


Fig. 4
Child's head adjusted to the roentgenographic cephalometer with the two ear posts inserted into the ear holes and the rest clamped against the root of the nose. Lateral cassette and scale in place for profile roentgenogram.

ity of the Bolton-nasion plane of orientation and its registration point in the sphenoidal area as the most fixed point in the head or face. This plane is determined at its anterior end by the craniometric landmark known as nasion, i. e., the junction of the frontal and the nasal bones in the midplane; its posterior termination is the highest point in the profile of the notches at the posterior end of the condyles on the occipital bone. The right and left condyles on the occipital bone are close enough to the midplane and to the path of the central ray that the X-ray shadow of their outlines is registered on the film as a single image. From this Bolton-nasion plane there is erected a perpendicular to the center of sella turcica (shown in Fig. 7, R). The distance midway on the perpendicular from the Bolton-nasion plane to sella turcica, designated as R, is used as the registration point for registering tracings of subsequent pictures of the same individual and of different indi-

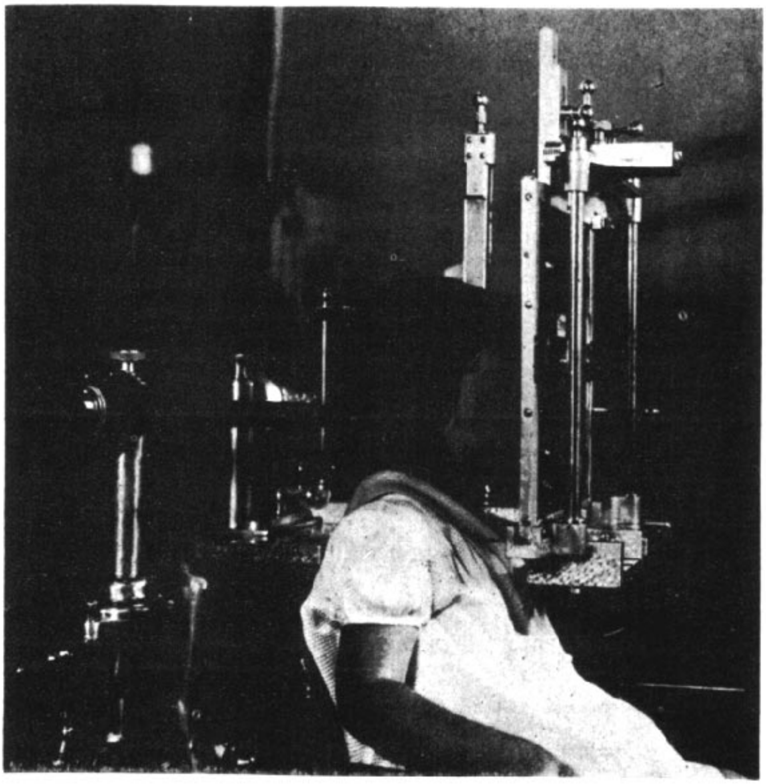


Fig. 5
Child's head retained in the cephalometer as in Fig. 4. Cassette in place for frontal roentgenogram.

viduals as well. The accompanying table in Fig. 8 of the standard deviation and coefficient of variation of several of these base planes at the ages shown lend authority to the above statement. The continuation of the recording of data from the Bolton roentgenograms not only uphold this early observation but point to greater usefulness of this method in clinical practice.

Because prolongation of the perpendicular to the registration point R

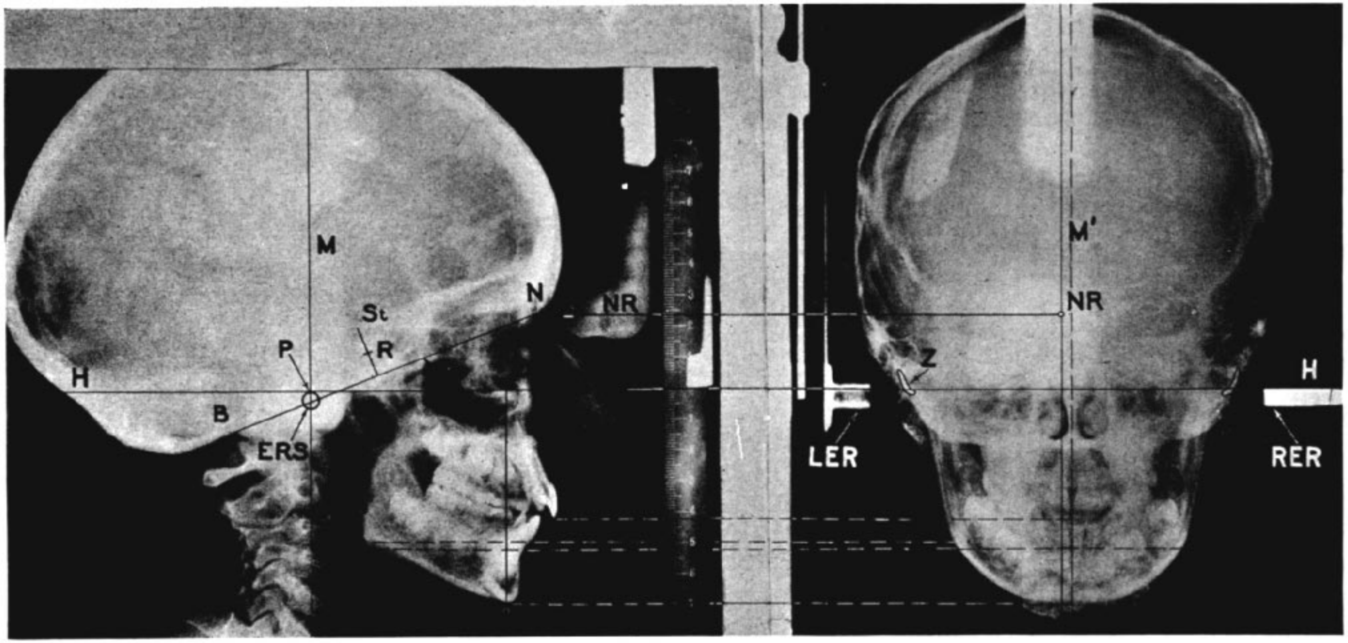


Fig. 6
Typical lateral and frontal orthodiagraphic roentgenogram showing anatomical landmarks in three dimensions of space. B—Bolton Point; HH—Frankfort horizontal plane; N—Nasion; O—Orbitale; P—Porion; ST—Sella turcica; Z—Cross section of Zygomatic arch. The several parts of the cephalometer are indicated as follows: ERS—ear rod support; LER—left ear rod; RER—right ear rod; NR—Nasion rest; S—millimeter scale.

below the Bolton-nasion plane passes through the face at an oblique angle to the plane of occlusion of the teeth, a measure of the changes from this plane and the diagonal Bolton plane is awkward and the measurements therefrom do not lend themselves to easy comparison to the orthodox method and results of the anatomist and the anthropologist, therefore, the Frankfort horizontal plane of the initial record of each child is added and is maintained in a fixed relation to its Bolton plane (see angle A, Fig. 7) permitting the use of the perpendicular orbital plane which passes through the dentition at about right angles. Measurements taken from these two planes are then a record of change from the more constant Bolton landmarks.

Superposed tracings in Fig. 9 of the same healthy individual at the ages of one month and at twenty-four months illustrate in a graphic fashion the great amount of growth during this age range in all directions from the stable point R. By having in the tracing of the one month picture its Frank-

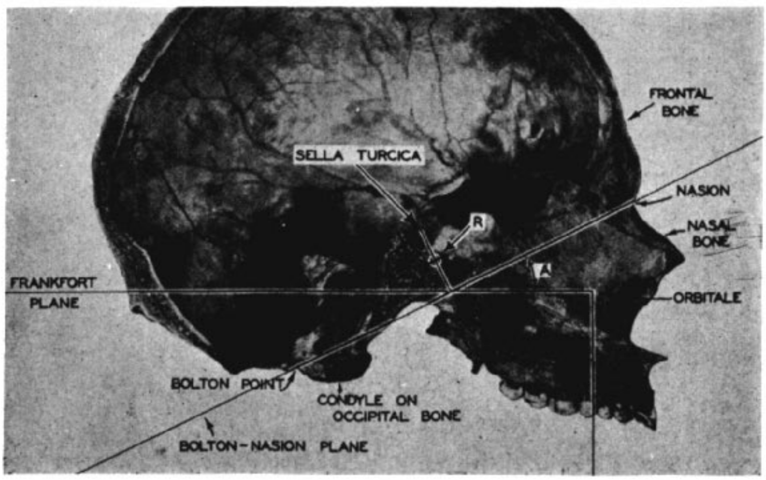
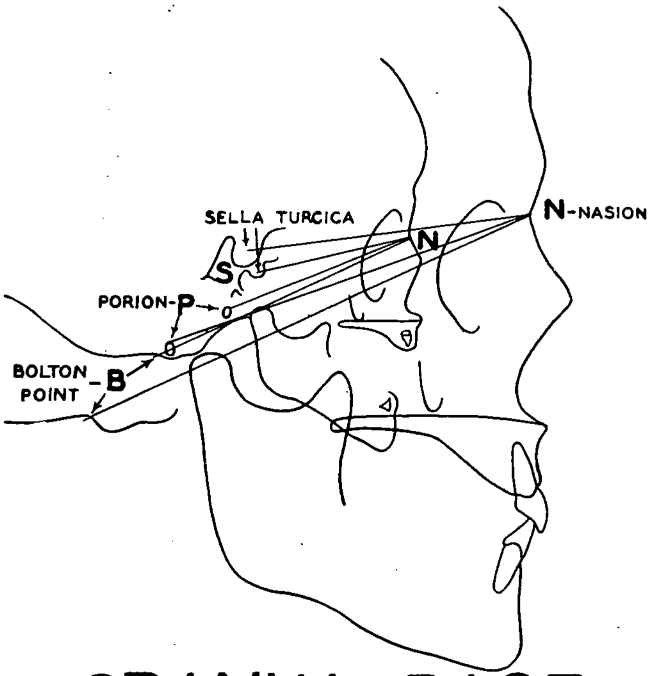


Fig. 7
Median sagittal section of skull showing anatomic and craniometric landmarks and the Bolton Point and Bolton Plane. (Skull 1163 Hamann Museum, in the Laboratory of Anatomy, Western Reserve University Medical School.) (Todd.)

fort horizontal plane and vertical orbital plane as described above, there is obtained an accurate interpretation of the changes in the face below not only in relation to these horizontal and vertical planes but also to the diagonal Bolton-nasion plane. Placing just the initial horizontal and vertical planes in the picture as shown and not including any subsequent Frankfort horizontal or vertical orbital plane, we have a fixed horizontal and vertical base from which to determine with greater ease changes in the face and head. It



CRANIAL BASE PLANES

-50-

Co.V.	50 MALES S.D.	MEAN	B-N WHITE AGE	MEAN	50 FEMALES S.D.	Co.V.
3.7	4.0	108 9	3 YRS.	104 7	3.8	3.6
3.5	4 1	116.2	6	113 5	3.9	3.4
4.3	4.5	122 0	9	118.2	4.3	3.6
4.6	5.6	126.2	12	121 4	5 7	4.7
4.3	5 4	127.0	15			
4.1	5 2	129.0	18			
			PORION NASION P-N			
5.1	4.1	80.6	3 YRS	78.2	3.9	4.9
3.7	3 1	84.8	6	83.4	3.0	3.6
4.2	3.7	89 6	9	87.0	3.9	4.5
4.6	4.3	93.0	12	90.8	4.9	5.4
5.4	5.1	96.6	15			
4.5	4.4	98.4	18			
			SELLA TURCICA NASION S-N			
4.5	2.8	61.3	3 YRS.	59 3	2.3	3.8
4.1	2.7	65.6	6	63.3	2.4	3.7
4.6	3.2	68.3	9	65.9	2.5	3 7
4.8	3.3	69.5	12	67.5	3 8	5 7
5.1	3.6	71.0	15			
4.6	3.3	71.5	18			

Fig. 8
Chart of base planes with table of average dimensions of fifty males and fifty females showing standard deviation and coefficient of variability.

will be seen that nasion has moved directly forward and slightly upward; that along with the slight increase in the size of the orbit, the eye point (orbitale) has moved forward and downward; the ear hole point (porion) has moved downward and backward, as well as the Bolton point at the posterior end of the Bolton plane. Gnathion, or the chin point, has moved well out from under the brain case, and there has been a marked increase in the vertical length

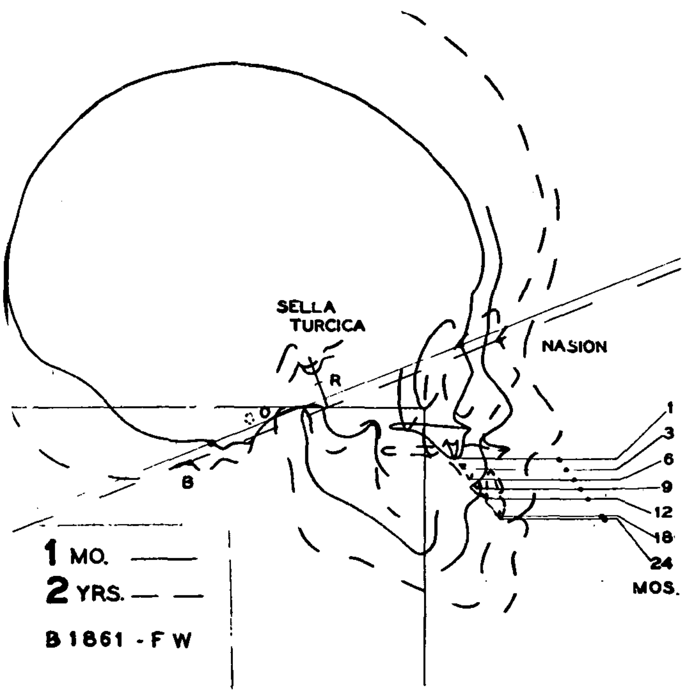


Fig. 9
Tracings from lateral roentgenograms showing normal growth during first two years; the points mark the position of the incisal edge of the deciduous central incisor at the ages shown.

of the face. It is interesting to note the forward developmental growth of the premaxilla in contrast to the relative stability of the posterior termination of the hard palate. Gonion, or the point at the angle of the mandible, has moved downward and only slightly backward. Included between the site of the upper deciduous central incisor at one month and twenty-four months there is plotted the site of this tooth at the ages indicated. This illustrates the orderly downward and forward path that is found in the developmental growth pattern of the face of the normal child*. This orderly process becomes more impressive by comparing it with Fig. 10 in which is shown the tracings of a child of the same age range whose record of ill health has left its marks in the facial pattern. The forward adjustment of the facial mass is retarded more than the growth in vertical dimension during the first nine

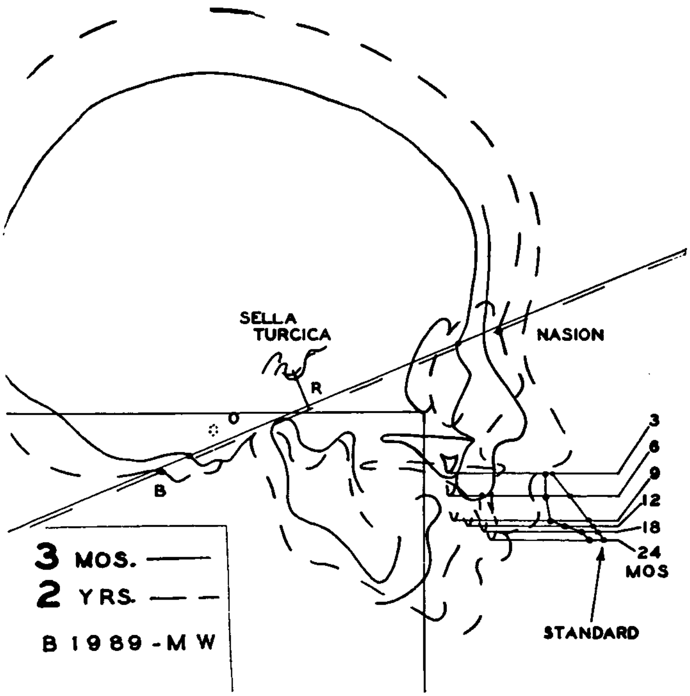


Fig. 10
Tracing from lateral roentgenograms showing defective growth of the face during the first nine months. The points mark the position of the incisal adge of the deciduous central incisor for a comparison of abnormal with normal growth. There is normal vertical growth but retarded anterior-posterior development up to nine mnths.

months, before this individual's constitutional vigor was restored to normal. In noting that the anterior-posterior dimension of the palate has not been retarded in length, it at once becomes apparent that forward adjustment has not occurred, another indication that development has suffered more than increase in size. This interference in development is reflected throughout the adjacent parts. The younger the individual the more profound the effect.

*"By normal we do not mean a child of certain dimensions or particular ability, but a child sound in body and mind, harmoniously developed physically, mentally and emotionally and consistent in developmental progress with his years." Proc. White House Conference on Child Health and Protection, 1930.

Tracings of an individual shown in Fig. 11 are representative of groups of 200 or more children between nine and fourteen and one-half developmental years, the age range of the change from the mixed dentition to the permanent one. The distance between the occipito-sphenoidal suture at OS and the perpendicular to the sella turcica at ST has not increased, for, it is after nine years of age that this suture becomes obliterated, indicating the cessation of growth in this area. There is still, along the line of the perpendicular, growth in the vertical direction. Note however, that the growth in the petrous portion

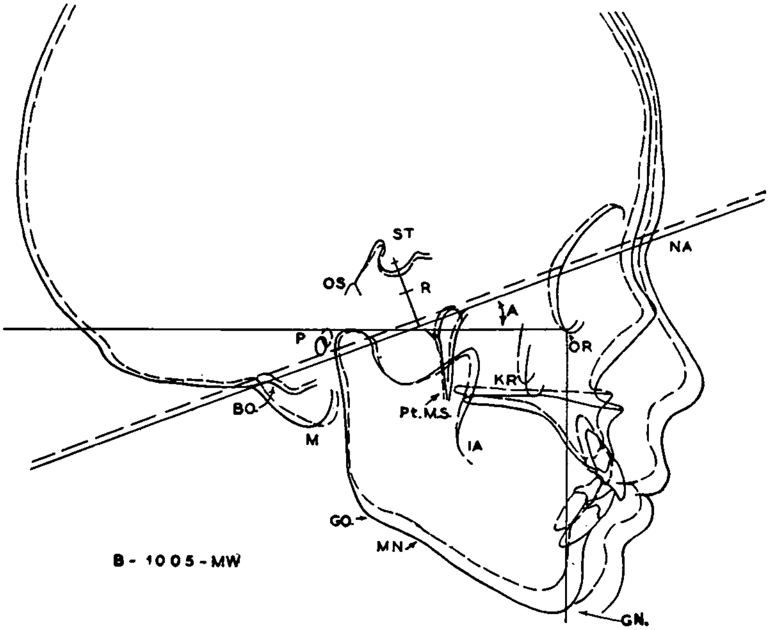


Fig. 11
Tracings of nine and fourteen and one-half developmental years. Note relative stability of Bolton plane during the age range when most orthodontic cases are treated.

of the temporal and mastoid area downward, outward and backward continues to carry the occipital condyle with its Bolton point and the ear hole in that direction. There is a uniform increase in growth in size of the facial parts, with the developmental adjustment continuing in a downward, forward, and outward path in the anterior half of the face. The rate of growth distally at the posterior end of the hard palate has not been great enough to keep pace with adjustment of the maxilla downward and forward so that we have here an opportunity to differentiate between growth and development. It has been interesting to note throughout our study on healthy children, that the hard palate maintains a parallel relation over the entire growth range. The change in position of the eye point, key ridge and maxilla discloses that coincident with the completion of eruption of the twelve year molar, development predominates over growth in this area.

Those children in the Bolton Study who have a congenital absence of teeth show a reduction in size of the facial mass and an altered relation of the dental arches to their supporting bones in proportion to the number of teeth that are missing. Comparing then Fig. 11 with Fig. 12 it will be noted that congenital absence of a number of permanent teeth has retarded the forward development of the two dental arches on their maxillary and mandibular bases and has created a concave type of profile shown in Fig. 12. In this

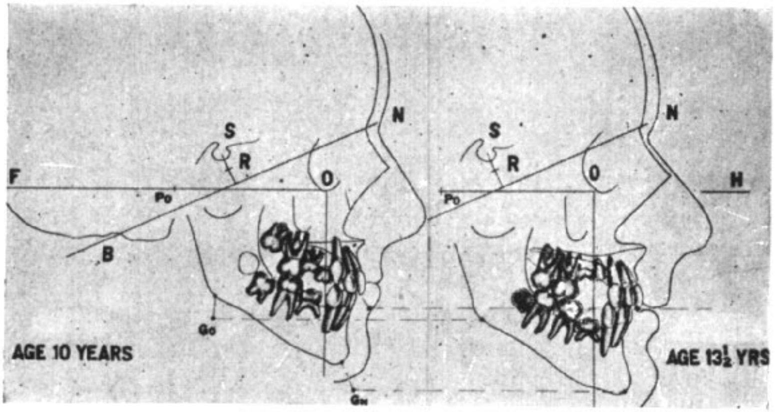


Fig. 12

Tracings from lateral roentgenograms of the same child at ten and thirteen and one-half years, illustrating so-called submerging teeth. There is congenital absence of seven bicuspids and upper third molars with defective vertical-anterior-posterior growth between cuspids and first molars.

case the congenital absence of the seven bicuspids along with the late appearance of one upper first bicuspid and the absence of the upper third molars is no doubt contributory to this defect[8]. This condition (in the bicuspid area) has retarded the development in the vertical dimension of both the maxilla and mandible. In the maxilla this failure in verticle growth alters the shape of the horizontal palate producing a concave one. With the normal increase in vertical dimension anterior and posterior to the retarded area, through the normal eruption of the other permanent teeth, an increase in size of the bones makes the temporary teeth appear to sink into the jaws, a condition that has heretofore been referred to as submerging teeth[9]. From the point of view of the clinician looking into the mouth and noting the change in relation of the occlusal planes, this would seem to be true, however, when these changes are measured with the tracings in the Bolton relation it is determined that the teeth in the retarded area have been left behind while the rest of the dental apparatus and jaws have moved on toward maturity.

Subsequent to the eruption of the twelve year molar, growth predominates over development and it may be noted in Fig. 13 that the increase in length of the palate is again principally at its posterior extremity. The corresponding increase in size in the mandible has taken place in the length of the body where it joins the ramus along a line between the internal angle

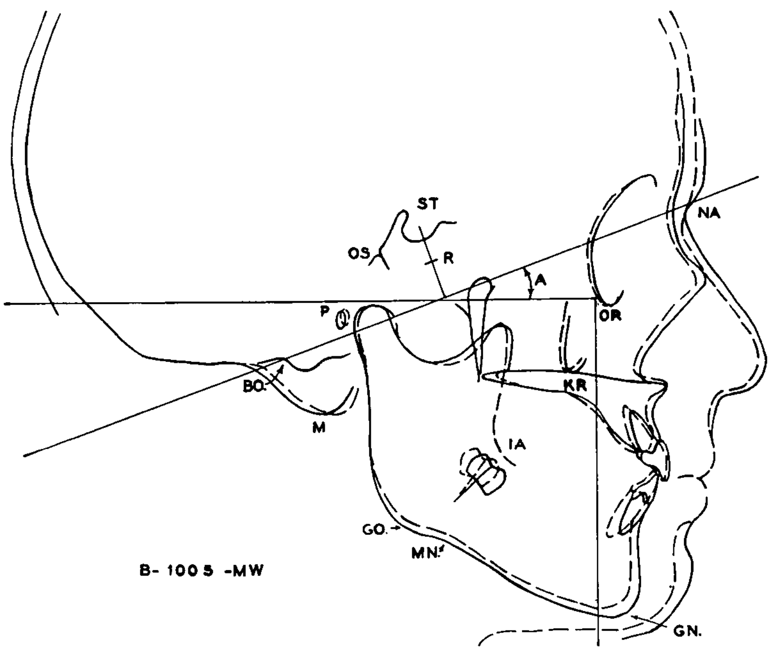


Fig. 13

Tracing of fifteen years and one month and sixteen years and four months. Note the unchanged cranial base planes and continuation of facial growth to accommodate the third molars.

and the mandibular notch.* The area of the mandible along the junction line between the body and the ramus appears to be comparable to the epiphyseal line of the long bones. The alternating influence of developmental growth in this area influences the axial inclination of the last developing

*The mandibular notch marks the junction of the lower border of the ramus where it joins the body. Piersol states "it often presents a concavity which is sometimes very marked; giving it a peculiar outline, it is named the ANTEGONIUM by Harrison Allen."

molars as they pass through the bone to the site where they eventually erupt occlusally into the mouth. Adequate observations prove that the failure in eruption of the third molars, which is often accompanied by the collapse of the mandibular dental arch and bunching of the anterior teeth, is due to failure in optimum developmental growth of the face. Until adulthood is reached, the face continues to grow downward and forward, and the ear hole continues along with the head of the mandibular condyle to move downward and backward.

To piece together the foregoing description of normal developmental growth of the face, there are combined in Fig. 14 representative examples of several stages, from one month to adulthood. This reveals a most significant fact, that growth of the face is not the complex erratic process that it seems to be by similar superposition of tracings from craniostatic drawings of skulls of dead children. Such studies would also bear out the profound effect

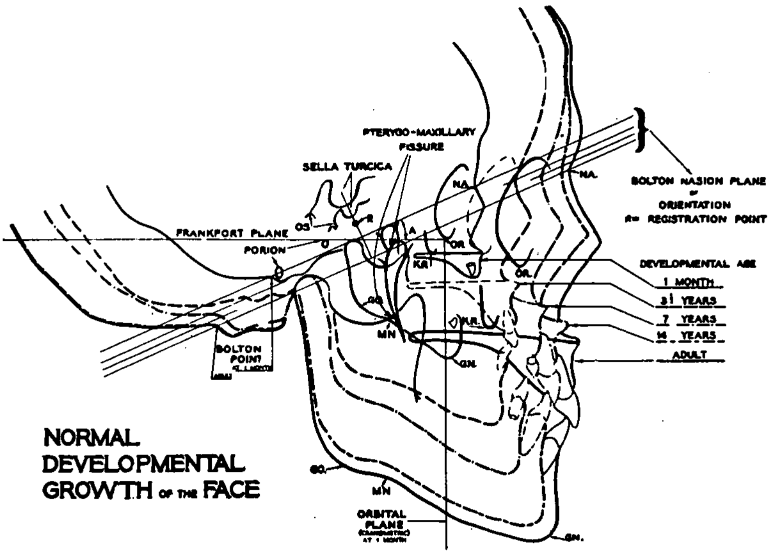


Fig. 14

Normal developmental growth of the face from the Bolton Study records. A—Angle of Frankfort plane of the first record to the Bolton-Nasion plane of orientation. GN—Gnathion. GO—Gonion. KR—Key Ridge. NA—Nasion. OR—Orbitale. OS—Occipito-sphenoidal suture. MN—Mandibular notch.

that ill health has upon dento-facial development, and indicate the paramount importance of the health factor as related to orthodontic and facial growth problems. The Bolton group of healthy girls and boys does not disclose marked differences between the two sexes in the studies of facial development except one of comparative size, and slight difference in adult contour as indicated before, in such areas as the supraorbital ridges and architectural outlines, expressed largely by heavier and more rugged facial features in the male. The modeling of the bones of the face that result in the mature adult pattern decreases in rate with chronological age and carries on in such an orderly fashion that it is difficult to isolate developmental levels without the aid of the dental pattern; by dental pattern I do not mean just the pattern of the teeth that have erupted into the mouth but the all inclusive one rendered visible by the standardized roentgenogram that discloses the developmental stage of each tooth from the appearance of the follicle through the complete calcification and path of eruption to the occlusal plane.

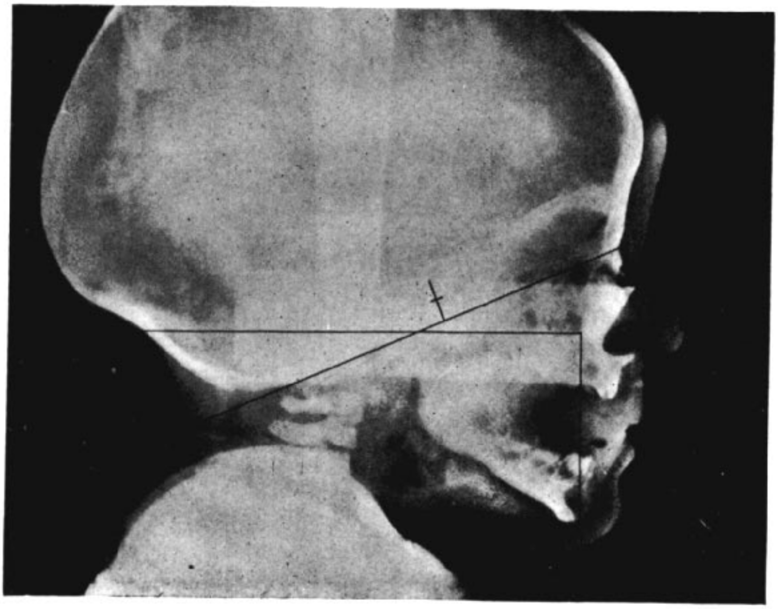


Fig. 15
Lateral roentgenogram of child of three months. Note the relation of the tooth buds to the border of the jaws and the site of the crypt of the first permanent molar and the mandibular notch.

Since it is confusing to include the dental pattern in the composite chart of facial development, we may study to better advantage drawings from roentgenograms of individuals with normal dentition. The roentgenograms of Figs. 15, 16, 17, 18 serve to illustrate four of the most outstanding stages of dento-facial developmental growth. In the infant stage (Fig. 15) of three months before any teeth have erupted into the mouth, there is contained within the maxillae the partially calcified crowns of the deciduous teeth and the follicle of the first permanent molar. Note carefully this profile pattern of the dentition at this stage in relation to the outline or design of the supporting bones. The developing deciduous teeth are contained in the body of the mandible while the site of the follicle of the first permanent molar is in the ascending ramus close to the internal angle and directly above the mandibular notch. The roentgenogram in Fig. 16 is of the same child at the age of three and one half years when the mouth contains the twenty deciduous teeth comprising the mature deciduous dentition. By this time the follicle with its half formed crown of the first permanent molar has moved downward and forward out of the ramus crossing the angle and at this stage occupies a place in the body of the mandible. At the site of origin of the

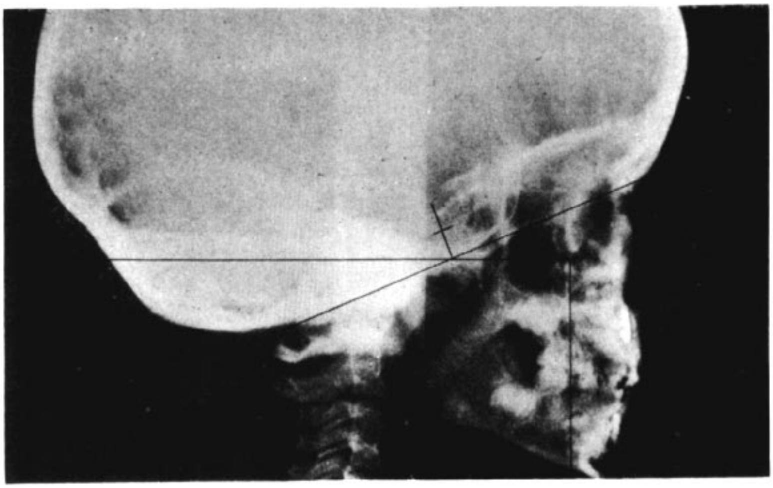


Fig. 16
Profile roentgenogram of the same child as Fig. 15 at three and one-half years. Note the developing permanent teeth and the site of the second permanent molar in relation to the border of the jaw, the mandibular notch and the internal angle. For developmental age apply Bolton standard of calcification—Fig. 20.

first permanent molar in the ascending ramus there appears the follicle of the second permanent molar which subsequently imitates the developmental trend of its predecessor. At this stage all of the crowns of the permanent teeth except the second bicuspids and the third permanent molars have started to calcify. In Fig. 17 the stage of mixed dentition, when the mouth contains an equal number (twelve of each) of the deciduous and permanent teeth, the first permanent molars are in occlusion and the deciduous incisors have been replaced by their successors and as shown in the roentgenogram, the jaws contain the developing crowns of all the unerupted permanent teeth.

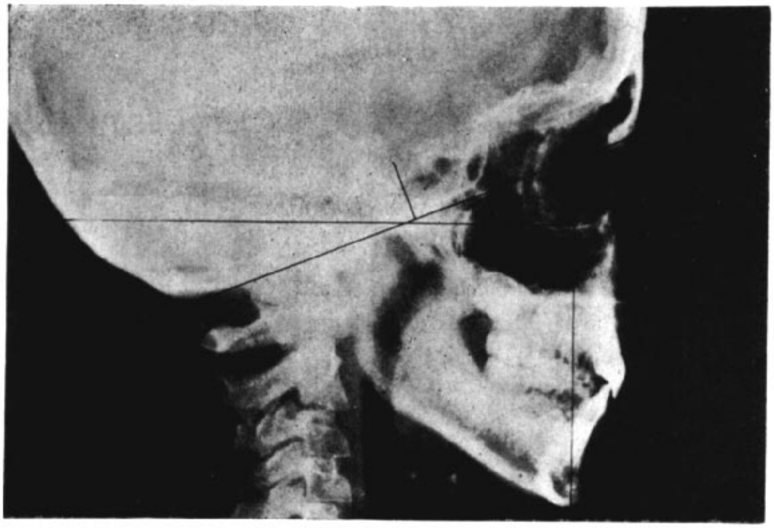


Fig. 17
Profile roentgenogram of child of nine and one-half years with mixed dentition. Note the site of the third permanent molar in relation to the border of the jaw and mandibular notch and the internal angle.

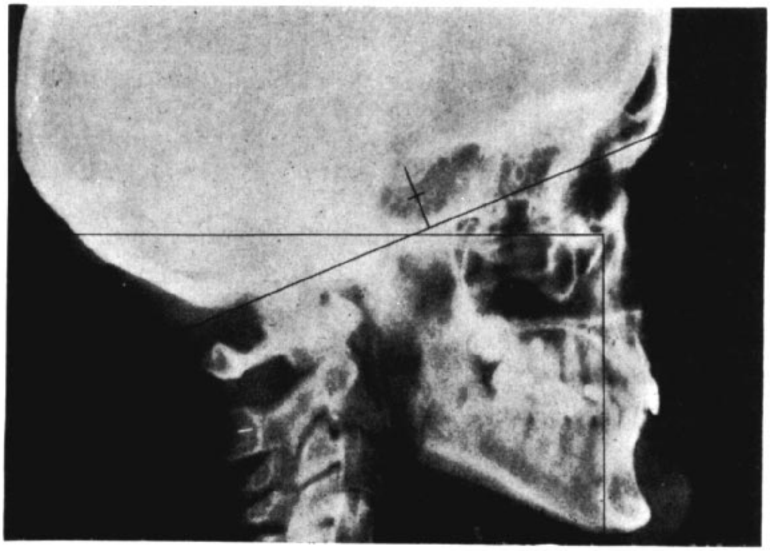


Fig. 18
Profile roentgenogram of young adult (B 2520) eighteen years old, showing normal relation of the erupting third molar for this age.

The developing crown of the second permanent molar has arrived at a position distal to the first permanent molar roots in the body of the mandible, having traversed the path of development of the first permanent molar, across the angle from the ascending ramus. The follicle of the third permanent molar appears about the ninth year in the same site that its two predecessors occupied at birth and three years respectively. This illustration of an individual at nine and one half developmental years discloses the calcified crown of the mandibular third molars that is normal for this age. The roentgenogram in Fig. 18 is one of a young adult who has not quite reached maturity. The permanent dentition is mature with the exception of the erupting third molars. This pre-adult stage was selected to emphasize the fact that in axial inclination the lower third molar as indicated previously, does not reach its full erect position until after it occludes with the opposing third molar at the plane of occlusion. The Bolton records contain serial roentgenograms taken at frequent intervals, usually annually, but in enough instances quarterly, of more than 1,000 individuals between the ages of nine and twenty years that have made possible an animated motion picture wherein is recorded the path of development of the third molars.[10] This record shows the process to be identical to the one through which both the first and second molars have passed. It will be noted in Fig. 18 that the lower third molar is well into the body of the mandible, and now occupies a similar position to the second permanent molar at nine developmental years. The second and first molars as well as the first permanent and second temporary molars may be seen to have similar relations in the earlier stages of development.

The drawings in Fig. 19 are mounted in the Bolton relation. The solid horizontal and vertical lines, that represent the Frankfort and orbital planes of the first record, form more convenient landmarks from which to note the migration of the face from the fixed point R and plane of orientation BN. The patterns in mandibular development described above, may be reviewed in drawings A, F, and H, noting particularly the site of the developing permanent molar series to the design of the mandible at these ages. This series of eight drawings corresponds in age to the Bolton standard of time of beginning of calcification as it is recorded by this roentgenographic technique and summarized in the table in Fig. 20. Soon after the middle of the first year the calcification of the upper and lower permanent central incisors, and only the lower permanent lateral incisors is recorded in the bone at the sites shown in Fig. 19B. Note particularly the relation of the developing upper central incisors to the premaxillary area and to the erupting deciduous teeth. Before the end of the first year (Fig. 19C) the beginning of the calcification of both the upper and lower permanent cuspids is seen and it is not until several months later that the upper lateral incisors appear (Fig. 19D).

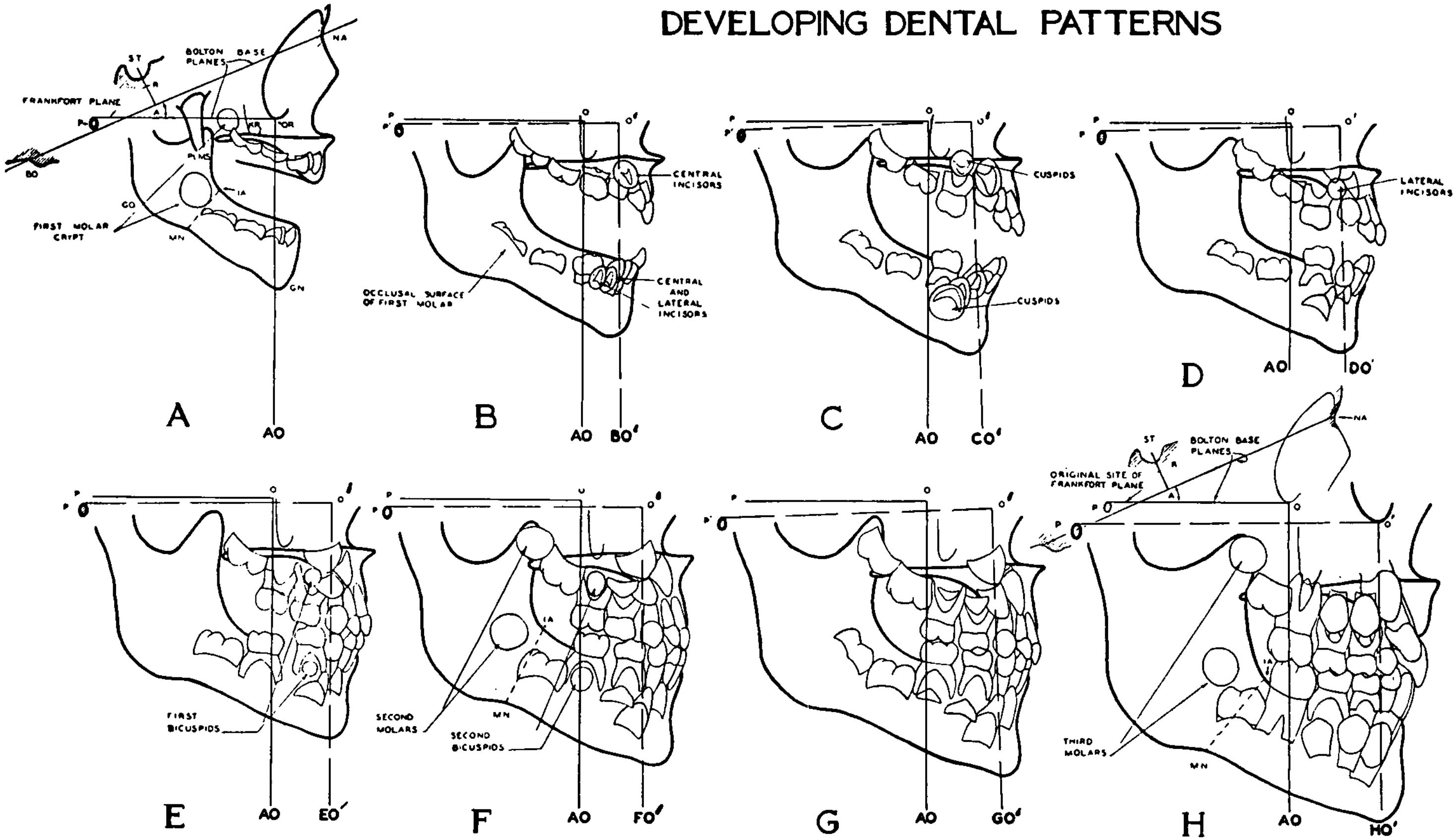


Fig. 19
Profile dental patterns in relation to the supporting structures.

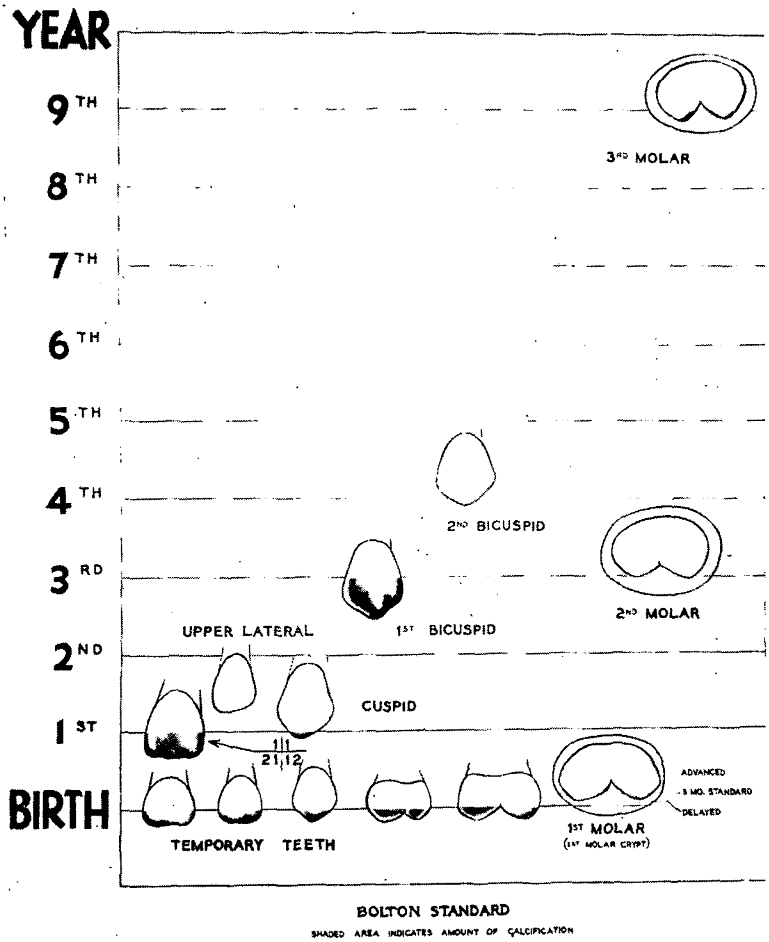


Fig. 20
Bolton Standard of Calcification. Shaded area shows amount of calcification at various ages as recorded in the standardized roentgenograms.

The follicles in which these upper lateral teeth calcify are distal to the central incisors and below the tip of the developing upper cuspids. This order of appearance of the permanent incisors and upper cuspids was first described by Kronfeld.[11] The growth of these teeth and their development in relation to the maxilla is a most interesting and instructive process. Their shifting in relative position when measured in relation to the horizontal palate at its anterior termination, or in relation to the orbital plane of each particular stage, is recorded in roentgenograms of the same individual. These reveal that the migration forward of the developing permanent tooth crowns at certain times takes place at a greater rate within the bone than the forward movement of the erupted deciduous teeth. In other words, these developing buds, in their forward migration, pass forward above the deciduous root ends and subsequently there appear distal to them, the crowns of the first bicuspids. Note that at the beginning of calcification the upper permanent cuspids are distal to the orbital plane (CO Fig. 19C), of the individual at that particular

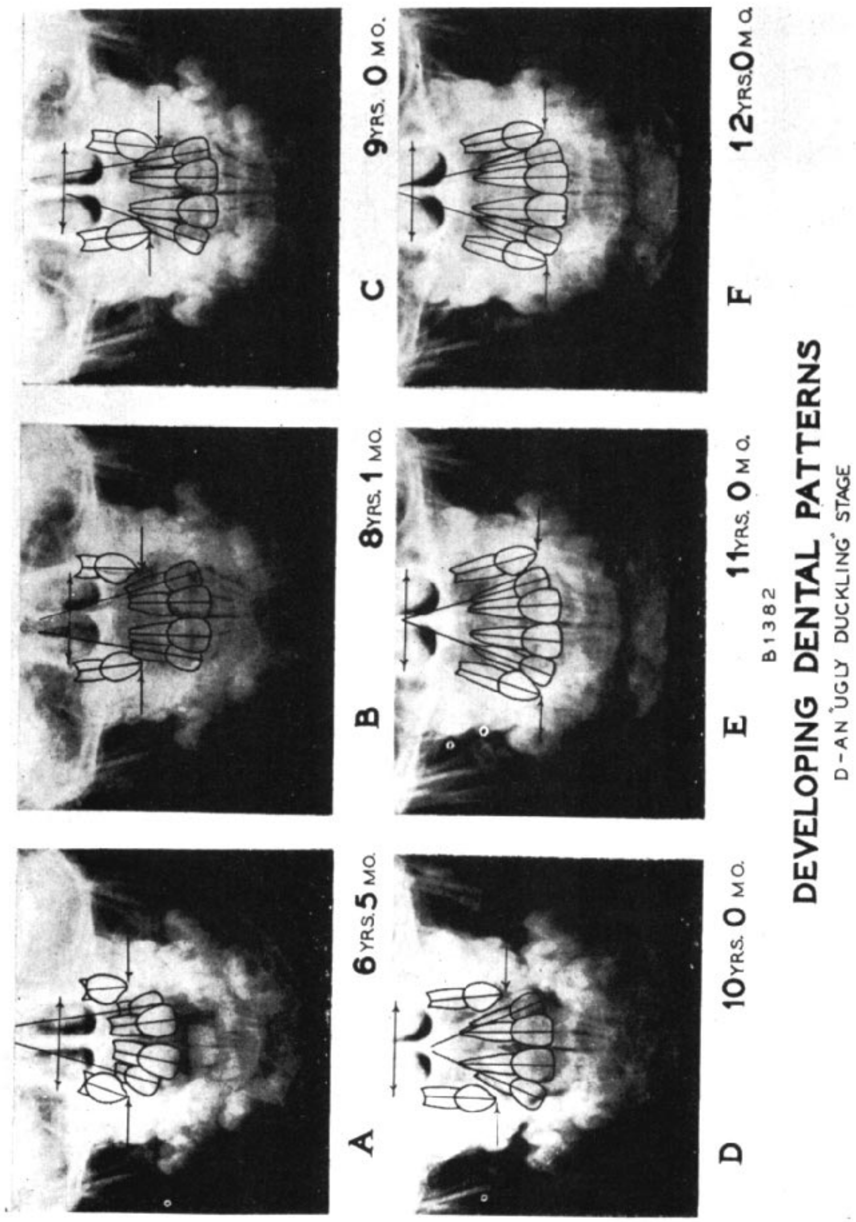


Fig. 21
Frontal roentgenograms of same individual at six and one-half, eight, nine, ten, eleven and twelve years, showing change in inclination of all incisors and cuspids, and path of eruption.

stage, while the site of the orbital plane passes through the distal third of the deciduous cuspid crown. This relation of the deciduous cuspid to this orbital plane remains practically the same throughout the temporary dentition (compare with H). The forward migration of the upper cuspid within the maxilla as measured by its relation to these facial landmarks is very clearly shown by comparing drawings C, D, E, F, G, and H. At two and one half years (Fig. 19E) the follicles of the first bicuspids have appeared

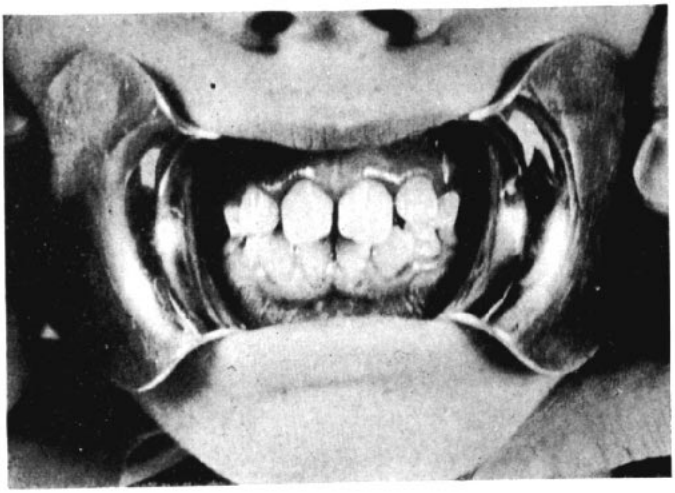


Fig. 22
Normal inclination of lateral incisors during an "Ugly Duckling" stage of developmental growth in the mixed dentition.

between the roots of the first deciduous molars. At the third year (19F) the second permanent molar bud appears, and approaching the fourth year there begins to calcify, between the roots of the second deciduous molar, the crown of the second bicuspid. It is not until eight and one half developmental years is reached that this technique reveals the follicles in which the third permanent molars calcify. The increasing obliqueness of the craniometric Frankfort and vertical orbital planes shown in the broken lines of each diagram for its particular age stresses the value of the use of the more stable cranial base planes for a measure of facial growth.

A detailed study of these changes in the relations of the teeth during developmental growth presents patterns that are so unlike those in the adult normal that they are very easily mistaken for abnormalities (compare Fig. 22 with Fig. 23). Since the crowns of the permanent teeth reach their adult size before they erupt they appear on eruption to be too big for the juvenile mouth. The shedding of the baby incisors and the eruption of their successors mark the advent of the one very striking example of these "ugly duckling"

Fig. 23
Normal inclination of incisors in the adult stage.

stages.[12] This stage when viewed from the frontal aspect as in Fig. 21, after the age of six and one half years finds the upper centrals erupting in a relatively short period of time and usually with a separation at the midline. The upper permanent laterals follow and the centrals move together into approximal contact. The growth in lateral dimension of the supporting structures especially the area at the level just below the floor of the nose where the upper cuspids are developing, is relatively slower, which forces the lateral incisors into a fan-shaped pattern that becomes more pronounced until the time when there has been sufficient gain in lateral growth in the apical base. Coincident with the eruption of the cuspids this lateral dimension increases to permit the more erect position of the incisors. These details and additional ones may be found in Fig. 21 which is a series of pictures taken of the same child at the ages noted thereon.

With a better knowledge of these important steps in the process of the eruption of the teeth and with a clearer understanding of the developmental stages through which the individual progresses toward maturity it follows that the present day needs of the orthodontic patient may be more adequately determined. This presupposes that the orthodontist should in most cases observe the trend of development, thus opening up a field of diagnosis from a truly scientific basis which heretofore has been only remotely approached.

REFERENCES

1. T. Wingate Todd—The Orthodontic Value of Research and Observations in Developmental Growth of the Face. Angle Orthodontist 1:67, 1931.
2. T. Wingate Todd, B. Holly Broadbent, Oscar A. Turner—Growth of the Pharyngeal Tonsil. Anat. Rec., vol. 58, 1933-1934.

3. Frederick B. Noyes—Dental Histology and Embryology. Lea and Febiger, Phila., 1915.
4. B. Holly Broadbent—A New X-ray Technique and Its Application to Orthodontia. Angle Orthodontist 1:45, 1931.
5. B. Holly Broadbent—Chapter 9 "Measurement of Dento-Facial Changes in Relation to the Cranium" in Practical Orthodontia by Dewey-Anderson, 5th edition, pp. 184-204. C. V. Mosby Co., St. Louis, 1935.
6. B. Holly Broadbent—Investigations of the Orbital Plane. Dental Cosmos 69:797, 1927.
7. Paul W. Simon—On Gnathostatic Diagnosis in Orthodontics. Internat. Journal Orthodontia 10:755, 1924.
8. T. Wingate Todd—Skeletal Adjustment in Jaw Growth. Dental Cosmos, December 1926.
9. Frederick B. Noyes—A Case of Submerging Temporary Molars. Angle Orthodontist, 4:265, October 1936.
10. B. Holly Broadbent—The Use of X-ray Silhouettes in Tracing Facial Growth (Abstract) Journal of Dental Research vol. XIII, no. 2, April 1933, pp. 151-153; Proc. Edward H. Angle Society of Orthodontia, April 1932; Southern Soc. Orthodontists, November 1932; A.A.A.S. (Dental Section) December 1932; N. Y. Soc. Orthodontists, March 1933; Proc. Pacific Coast Dental Congress, July 1935.
11. Rudolf Kronfeld—Postnatal Development and Calcification of the Anterior Permanent Teeth. J.A.D.A. vol. 22, September 1935.
12. B. Holly Broadbent—The Orthodontic Value of Studies in Facial Growth. In: Physical and Mental Adolescent Growth. Proc. of Conf. on Adolescence, Cleveland, October 1930, pp. 37-39.