The Rest Position of the Mandible and Its Application to Analysis and Correction of Malocclusion

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Diagnosis and analysis of malocclusion will always hold the attention of the orthodontist because it is the most important, most complex, and most difficult phase of the orthodontic problem. It is important because incorrect case analysis can result only in failure, regardless of the treatment plan and appliance therapy employed.

Angle recognized that a logical method of classification of malocclusion was necessary to facilitate diagnosis, and accepted the maxillary first permanent molar as the basis from which to "reason on malocclusion" with the "keys to occlusion" serving as the guide.

Case based diagnosis and classification on dento-facial harmony, and utilized facial casts in addition to models and photographs. This approach has been expanded by Tweed[1] who emphasized facial esthetics and the relation of the denture to the supporting "basal" bone. He says, "My clinical observations have been focused for many years on (1) the position of the mandibular incisors as related to the medullary bone of the body of the mandible — I have in the past referred to this as basal bone or dental base — and (2) the normal facial esthetics and their deviations."

Simon introduced the gnathostatic method relating the dental cast to the face and cranium. This more accurately portrayed the malocclusion on the casts and unquestionably enhanced the analysis of malocclusion.

Broadbent[2] devised a roentgenographic method that permitted not only a more accurate appraisal of the existing malocclusion, but also made possible accurate serial study of the progress of growth previous to treatment. Downs[3] has recently made the first specific clinical application of the cephalometric roentgenographic technic to the analysis of the skeletal pattern of the face and the relation of the denture to the skeletal pattern. He has made cephalometrics a necessary phase of case analysis that will be used increasingly in the future. His observations have been confirmed by additional cephalometric studies of the "norm" by Mayne[4] and Younger[5].

Orthodontists are using today, one or more of the above methods, the ultimate analysis and treatment plan being the result of his evaluation of the patient examination, case history, and analysis interpreted in the light of his experience, intellect and common sense.

The objective of orthodontic therapy must include more than the attempt to duplicate static anatomical characteristics of normal occlusion of the teeth. The occlusion attained must be in functional harmony with other parts of the complex masticating mechanism. The machine is composed of the teeth and their direct supporting tissues, the mandible and maxilla proper, temporo-mandibular articulation, the musculature with its accompanying innervation and vascular supply, and other less important parts. Angle[6] believed this for he wrote, "That as the dental apparatus is only a part of the great structure—the human body—each part and organ of which was fashioned according to lines of design, it must have been intended that the line of occlusion should be in harmony in form and position with, and in proper relation to, all other parts of the great structure, according to the inherited type of individual.''

With the functional objective in mind, analysis of malocclusion must be similarly examined. This method is referred to as the functional analysis of malocclusion, and it is offered not as a substitute, but only as a supplement to the aforementioned methods. By its use it is hoped that the existing abnormality, not only in its form, but the character of its function will be better understood.

The basis for functional analysis is that the musculature is the dominant factor in establishing the position of the mandible. The posture (or rest position) of the mandible is established before any of the teeth have erupted, it is not altered by their eruption, and a stable resting position is maintained after they have been extracted.

The concept that the mandible has a postural or resting position to which it returns following function is not new. Brodie[7] has taught this concept of muscle balance for the past fifteen years, and I quote him directly in saying, ''Man, an upright biped, possesses bilateral symmetry of form which balances him in one plane. Antero-posteriorly, however, his center of gravity lies well back in his body. He is held in an upright position by a balance of all the muscle tensions that come to equilibrium in the vertebral column. This is easily comprehended in the bilateral arrangement where everything is in pairs, but antero-posteriorly it is more obscure. Here the entire load of the organs lies in front of the column so that one would expect him to fall forward, which he invariably seems to do if he loses consciousness. This tendency must be constantly balanced by a group of tremendously powerful check reins, the muscles of the back. These not only resist the forward urge, but also help to maintain the integrity of the vertebral column. In short, the sum total of the tensions in this group of muscles exactly balances the tensions and loads anteriorly. The word tension is used here to accentuate the point that the ensuing equilibrium is of a dynamic rather than of a static nature. All of these muscles are under a condition of partial contraction so that a series of balanced antagonisms results. When action is required, it is just as necessary for some muscles to relax as it is for others to contract. Indeed, the relaxation may induce the beginning of movement.''

He applied this reasoning to the position of the tongue, mandible, and hyoid bone. Following the work of Wright and Kloehn on fractures and his own growth studies, the rest position was recognized as being an integral part of the growth pattern of the head.

Others have also recognized this position. Gosta Lindblom[8] described it in 1932 and in later writings he stressed its importance and pointed out that the ''habitual centric relation'' is very often not coincident with the real (relaxed) centric relation, due to the guidance of the mandible by the occlusal details. In discussing the inadequate methods of securing correct mandibular position in cases requiring restorative dentistry, he states, ''Still more evident will this incompleteness of diagnostic methods be, when we penetrate deeper into the laws of balanced articulation, it being constantly necessary to deal with and take into consideration conceptions such as 'the physiological and physical rest position,' for the lower jaw introduced by Planer, or 'the real and habitual central occlusion position,' introduced by myse'f (Lindblom). It is obvious that in both these cases the condyle must take up different positions in the fossa."

Neiswonger[9] defined rest position in 1934 as "that position of the mandible in which it is involuntarily suspended by the reciprocal coordination of the muscles of mastication and the depressor muscles, with the upper and lower teeth separated, or the neutral position of the mandible." Gillis[10] emphasized its importance in full denture construction in 1941.

The relationship of the mandible at rest position to the maxilla is stable* and it is not altered, except by injury or disease, muscle trismus, the degree of consciousness of the individual, and the normal but slow aging process during the lifetime of an individual. The stability is maintained by the equilibrium of the muscles attached to the mandible, based on the physiological principle of all skeletal muscles returning to their given resting length following functional contraction and elongation. The various muscle groups are coordinated by mutual and reflex innervation to maintain the rest position and to create the various functional mandibular movements. All functional movements begin from this position and the mandible returns to its resting position with the cessation of the functional movement. In deglutition the muscles attaching the mandible to the cranium contract to fix the mandible with the teeth in occlusion so that contraction of the suprahyoid group will result in elevation of the hyoid bone and larynx. To permit this movement the infrahyoid group must relax proportionately. At the completion of the swallowing act, relaxation of the closing muscles of the mandible and suprahyoid muscles permit the mandible, hyoid bone and larynx to return to their resting positions, established by gravity and equalization of the muscular tensions acting upon them. The equilibrium of the muscular tensions is likely to be overlooked because of the differences in size of the muscles. The balance lies in the tension exerted as tonicity rather than in the optimum power of a muscle group.

The statement that the mandibular rest position is stable and that it affords a reliable basis for the analysis of malocclusion would likely be rejected as theoretical reasoning unless substantiated by scientific evidence. Sufficient evidence has been compiled over a ten-year period in studies made in the Department of Orthodontia at the University of Illinois to establish this concept as a fact, therefore, it can be applied to the clinic practice of orthodontia. Clinical evidence of cases so analyzed and treated accordingly affords additional evidence.

In 1931, Broadbent introduced a roentgenographic cephalometric method that permitted the study of the same living individual over a period of years. Since it is roentgenographic, bony landmarks can be used, thus eliminating errors introduced by measuring through soft tissue. The

* The adjective stable is defined as "standing in place; not easily moved, shaken, or overthrown; fixed." The noun stability as applied to mechanics better exemplifies the meaning of stable as implied in the paper, viz., "the state of being in stable equilibrium, or the degree of such equilibrium as measured by the force of which a body tends to return to its position of rest when disturbed."

cephalometer has been described in detail and need not be repeated here. Essentially it consists of a head holding device and two x-ray tubes, films and subjects.

Brodie[11] used this method in his study of growth of the head from three months to eight years.* He observed that the growth pattern is established by at least three months of age. At birth the jaws are wide apart and the tongue occupies the entire mouth cavity, extending over the ridges to support the lips. With the eruption of the teeth and growth of the jaws, the tongue, growing at a slower rate, is gradually enclosed by the teeth and alveolar processes. This is contrary to the opinion that at birth the gum pads are in contact and that as the teeth erupt the jaws are pried apart. Superimposed tracings of headplates made on the same individual over a period of eight years, illustrates the orderly unfolding of the growth pattern (Fig. 1). The floor of the nasal cavity de-

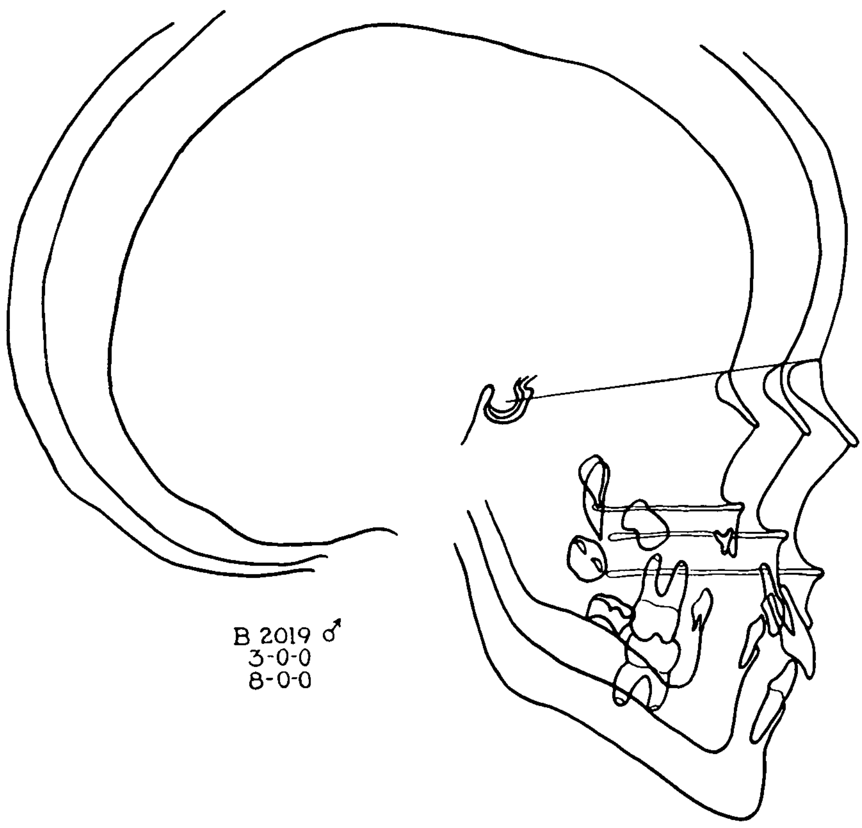

FIG. 1. Superimposed cephalometric x-ray tracings illustrating growth pattern in one individual. (Brodie)

scends on parallel planes as does the lower border of the mandible. In any given individual, the percentage contribution of the various parts of the face were found to be unchanged by growth. His work revealed the im-

* Recently Brodie and Ortiz completed a cephalometric study of growth of the head from birth to 3 months, and it is evident that the rest position of the mandible is established at birth.

portant fact that *mandibular position is established before any of the teeth have erupted and is not altered by their eruption.*

In 1937 cephalometric x-rays were made on a large group of children. At that time the lateral x-ray was made only with the teeth in occlusion. Additional x-rays were made on this group eight years later and included lateral x-rays with the mandible at rest position as well as with the teeth in occlusion. Upon examination of the earlier x-rays, it was found that seventeen of these children did not have their teeth in occlusion. These were compared with the recent rest position x-rays. The super-imposed x-ray tracings of one of these cases is shown in Fig. 2. The angle formed by the projection of the lines N-S representing the anterior cranial base with the tangent to the lower border of the mandible at the age of 9 years, 6 months, is 34 degrees. It was found to be unchanged at the age of 17 years, 8 months. The proportions of the face remained constant, the nasal height representing 49.5% of the total face height at both ages. The linear measurements naturally have increased with normal growth, but the facial proportions are unchanged. In not one of the seventeen children was there

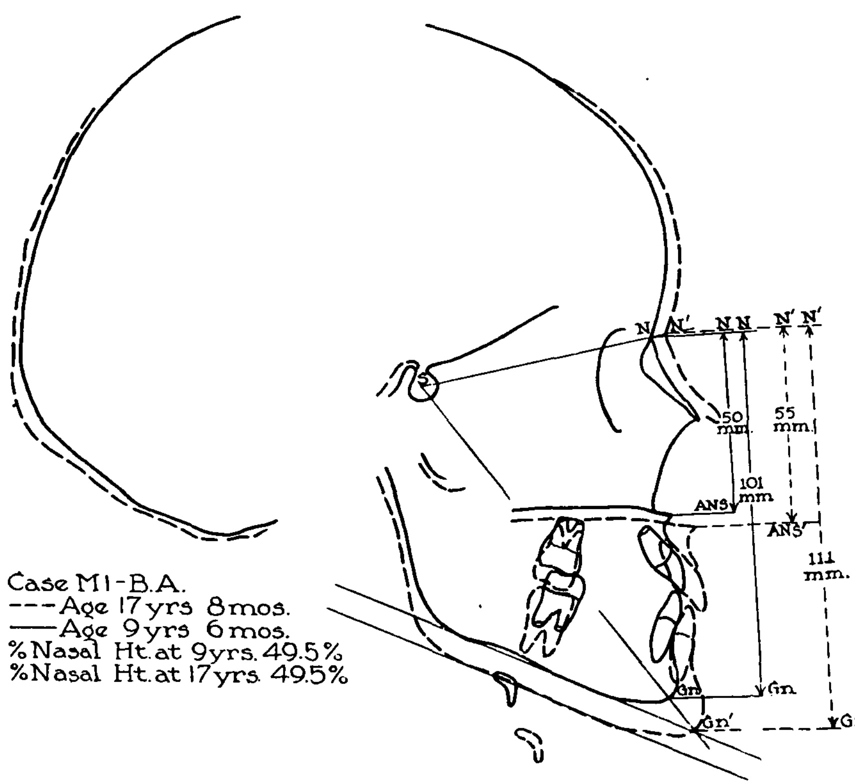

FIG. 2. Superimposed cephalometric x-ray tracings of an individual with the mandible at rest position:
——— 9 years, 8 months.
- - - 17 years.

found to be a difference of as much as one per cent. Table I lists the percentages that the nasal and dental areas contribute to the total face height at the time the initial records were taken. Remember that the teeth were not in occlusion in any of the x-rays[12].

TABLE I

Constancy of Facial Proportions with Mandible at Rest

Case No.	% Nasal Ht. and age	% Dental Ht.	% Nasal Ht. and age	% Dental Ht.
1	49.5 9 yrs. 6 mo.	50.5	49.5 17 yrs. 8 mo.	50.5
4	46.2 7 yrs. 7 mo.	53.8	46.2 14 yrs. 7 mo.	53.8
6	42.7 5 yrs. 10 mo.	57.3	42.8 14 yrs. 9 mo.	57.2
7	40.7 6 yrs. 4 mo.	59.3	40.0 14 yrs. 1 mo.	60.0
10	45.6 7 yrs.	54.4	46.2 15 yrs. 5 mo.	53.8
18	42.6 5 yrs. 6 mo.	57.4	42.4 13 yrs. 8 mo.	57.6
20	44.1 9 yrs. 5 mo.	55.9	44.2 17 yrs. 4 mo.	55.8
21	43.0 9 yrs. 6 mo.	57.0	42.9 17 yrs. 3 mo.	57.1
29	42.0 6 yrs.	58.0	42.1 14 yrs. 5 mo.	57.9
36	40.6 3 yrs. 6 mo.	59.4	40.5 4 yrs.	59.5
43	42.6 6 yrs.	57.4	42.8 13 yrs. 7 mo.	57.2
48	43.4 9 yrs. 6 mo.	56.6	43.7 17 yrs. 8 mo.	56.3
51	39.0 3 yrs. 6 mo.	61.0	39.2 10 yrs. 5 mo.	60.8
52	46.6 9 yrs.	53.4	47.1 16 yrs. 6 mo.	52.9
59	43.5 8 yrs.	56.5	43.3 15 yrs. 5 mo.	56.7
62	42.8 8 yrs.	57.2	43.1 15 yrs. 10 mo.	56.9
69	43.8 8 yrs.	56.2	44.3 15 yrs. 7 mo.	55.7

That the stability of rest position is not related to the presence or absence of the teeth is revealed in two studies. Brodie and Sarnat[13] observed in a cephalometric roentgenographic appraisal of a boy with complete anodontia that despite the absence of deciduous and permanent teeth, the mandible did not alter its form and maintained a constant vertical and horizontal relationship with the maxilla and cranium. Only the musculature could account for the constancy of facial proportions and mandibular position.

Thompson[12] studied the position of the mandible in thirty edentulous adults. Two or more lateral head x-rays were made with the mandible at rest position. The measurements of the total face height N to Gn are reported in that paper. The number of x-rays made on each patient is indicated by the number of measurements. The time interval between x-rays varied from a few days to four years. Since growth was no longer active,

TABLE II

TOTAL FACE HEIGHT (N-Gn) IN EDENTULOUS PERSONS

Case	1	2	3	4	5
30	107*	106.5	107	106.5	
31	118	117.5			
33	133	132.5			
34	119	120	118	120	119
39	126	128	128		
42	111.5	111.5	111.5	111.5	
47	122	122 5	122.5		
48	141	141			
52	131	131.5			
65	125	125			
66	120	118.5	118.5		
67	112	112	113	112	
70	127	128			
71	109	109			
74	120.5	120.5	121		
76	123	123			
78	101	108			
80	116	118	118	118	118
82	136	132	136		
83	128	127.5			

Case	1	2	3	4	5	6	7	8
85	115	115	115	115				
86	127	127						
87	127	126	126	126	126	126	126	
90	125	125						
93	134	131	135					
94	129	124	129	127				
102	124	124.5	124					
103	135	136						
109	110	110						
134	106.5	106.5	106.5	106	106	106.5	106.5	107
137	106.5	106	106.5					
138	102	102	102	102	102	102	102	

* Measurements of total face height (N-Gn) in millimeters.

linear measurements could be used. In a few instances (second readings on 82, 93, and 94) there is variation in the measurements that would seem to contradict the contention that the mandible is stable at rest position. In 82 and 94 the first and third measurements are identical. Remarkable duplication is seen in all the other cases. The evidence of cases 42, 67, 80, 85, 87, 134, 137, and 138 is particularly convincing since each series covered a number of years.

Not only is the rest position highly constant even after traction of the teeth, but it cannot be altered permanently by prosthetic, operative, or orthodontic procedures. A number of years ago a cephalometric study was begun at the University of Illinois to observe the changes that occur after placement of prosthetic restorations. Lateral head x-rays were taken before any extractions were performed, after the extractions, before and after insertion of the dentures, and at six month intervals thereafter. The results of this study have been published in other papers[12 13] but three typical cases will be reported here.

One (134) required complete upper and lower dentures. Full dentures had been worn previously for a number of years. Four lateral head x-rays showed the rest vertical dimension to be 106.5 mm. The new dentures with the teeth should have yielded a height of 103 or 104 mm. but instead the

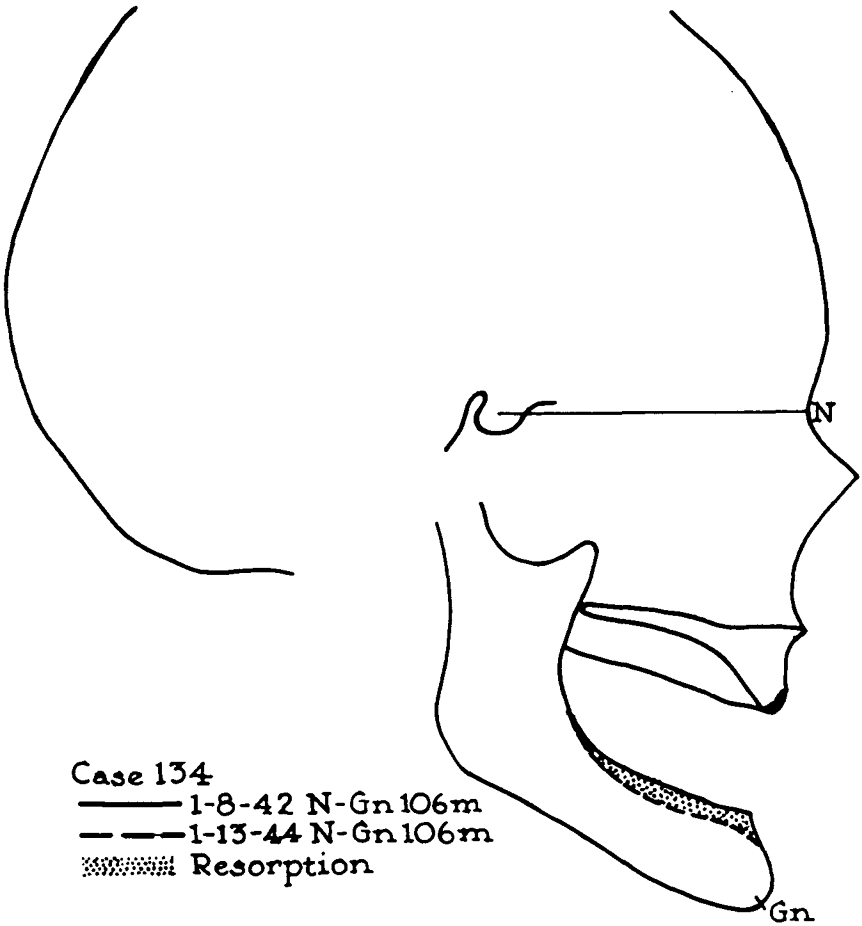

FIG. 3. Tracing of edentulous x-ray superimposed on one made two years later showing bone resorption. The x-rays are identical except for the area of resorption.

''bite'' was opened to 111 mm. with the teeth in occlusion. Ten months later it had closed to 105.5 mm. and in another year to 104.5 mm. The previous rest position was substantiated by additional x-rays that measured 106, 106.5 and 107 mm. Figure 3 shows the resorption that occurred as the occlusal vertical dimension decreased to its level within the rest vertical dimension. This was unnecessary resorption and it occurred because certain muscles had been over-extended.

The next case (46) is one that required upper and lower partial dentures. The vertical dimension with teeth in occlusion before the partials were placed measured 117.5 mm. This dimension was increased to 125 mm. by the partial dentures, a change of 7.5 mm. Coincident with this increase the patient began to complain of soreness in the muscles, clicking and subluxation of the temporo-mandibular articulations. These discomforts, often attributed to closed bite, continued during the time she wore the partial denture. In eight months the occlusual vertical dimension decreased 2 mm.

During this time certain of the natural teeth elongated as they had been taken out of occlusion by the partial dentures "opening the bite". The elongation of those teeth increased the occlusal vertical dimension established by the natural teeth from 117.5 mm. to 121 mm. The case was re-examined twenty-one months later. The occlusal dimension with partial dentures was 122 and with natural teeth 120 mm. The teeth were extremely loose as they could not depress sufficiently to escape from the force created by the over-extended musculature. This was truly traumatic occlusion.

The third case demonstrates that completely tooth supported restorations cannot be expected to withstand excessive vertical dimension. When the "bite was opened" by an acrylic splint covering twelve mandibular teeth, the rest position was exceeded by 4 mm. Ten months later the case was re-examined. Clinically, it appeared to be unchanged except that when the splint was removed the original occlusion could not be duplicated by the patient. No discomfort had been experienced. However, the lateral x-rays revealed that the original rest position had been re-established by depression of the teeth.

The foregoing studies have been presented as they form the basis and evidence proving that a rest position of the mandible exists and that it is a highly stable position. We can therefore accept as fact that the rest position of the mandible is established before any of the teeth have erupted, that it is not influenced by their eruption, and that a highly stable rest position exists after the teeth have been extracted. Furthermore, the rest position cannot be altered permanently by any dental procedure and this includes orthodontics.

When speaking of vertical dimension of the face, we must refer to the rest vertical dimension that does not change except as it increases with growth, and the occlusal vertical dimension that does change as occlusion is altered and is lost when the teeth are extracted. The difference between these two dimensions is the intermaxillary clearance or "free way space". Any occlusal vertical dimension established by dental procedures must harmonize with the rest vertical dimension.

The analysis of malocclusion with the mandible at rest position, in addition to those methods wherein the teeth are in occlusion more accurately portrays the existing malocclusion. This is referred to as functional analysis of malocclusion. The two important factors that comprise this method of analysis are: (1) determination of the size of the intermaxillary clearance that exists between the maxillary and mandibular teeth when the mandible is at rest position, and (2) analysis of the path of closure of the mandible from rest position to that position established by the occlusion of the teeth.

In considering the vertical relations of the teeth it is accepted that a deep overbite is the result of insufficient eruption of the posterior teeth, excessive eruption of the anterior teeth, or a combination of the two. In the rest position analysis the size of the "free way space" and the presence or absence of anterior overbite of the teeth with the mandible at rest position, accurately appraise the condition and show the areas of the denture that are at fault.

Strang[15] approached this method of analysis and he wrote concerning the analysis of closed bite malocclusions that: "In order to determine whether the excessive overbite in the incisor region is due to a combination of infra-occlusion of the molars and premolars and a supraocclusion

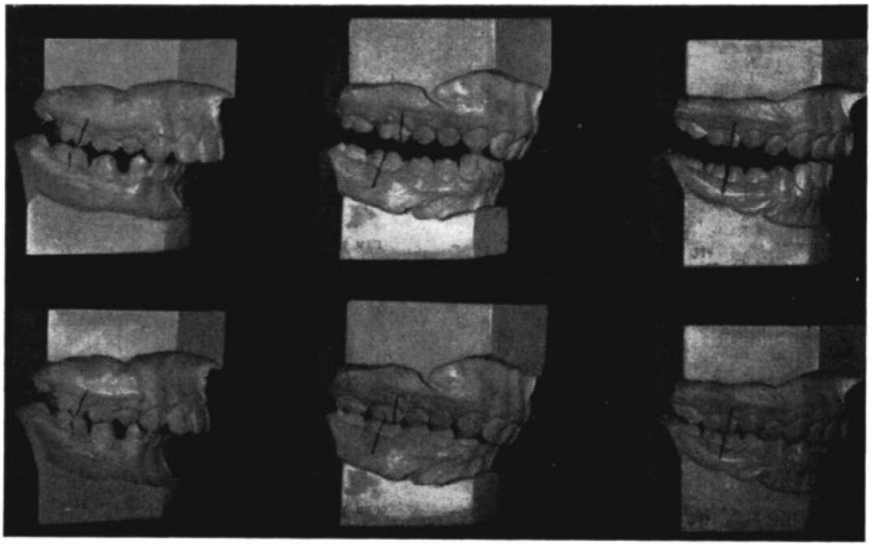

FIG. 4. Casts of three cases of malocclusion related with teeth in occlusion and at rest position.

of the incisors, the writer proceeds as follows. A piece of softened impression compound about one inch square, is placed between the premolar teeth and the lips are closed naturally. The patient is then instructed to slowly close the teeth. The operator watches the face carefully, and when there is harmony in the vertical dimensions of the facial area below the nose with that above, instructs the patient to stop closing the teeth. The jaws are held stationary until the compound hardens. If, upon separating the lips, the overbite has completely disappeared, the faulty area is correctly analyzed as being located in and limited to the molar and premolar region and consisting of the infra-occlusion of these teeth. On the other hand, if some of the overbite remains, it is reasonable to deduce that one is dealing with a case of infra-occlusion of the molars and premolars and supra-occlusion of the incisors." Very likely Strang was duplicating rest position of the mandible with the compound bite.

Figure 4 shows three cases that all exhibit deep overbites when the teeth are in occlusion. In A, the free way space is seen to be small and most of the anterior overbite is still present when the mandible is at rest position. This indicates that the overbite is the result of excessive eruption of the anterior teeth. This case was not corrected successfully and the teeth were loose during the course of the orthodontic therapy since they were continually in traumatic occlusion brought about by the small free way space. In B and C, the free-way space is large, indicating insufficient posterior eruption. The casts related at rest position show overbite to exist in C, indicating that there had not been any over-eruption of the anterior teeth. Some over-eruption of these teeth is observed to be present in B. These three cases represent three different types of overbite and certainly they all require different orthodontic treatment. The difficulties of treatment are in direct proportion to degree of over-eruption of the anterior teeth.

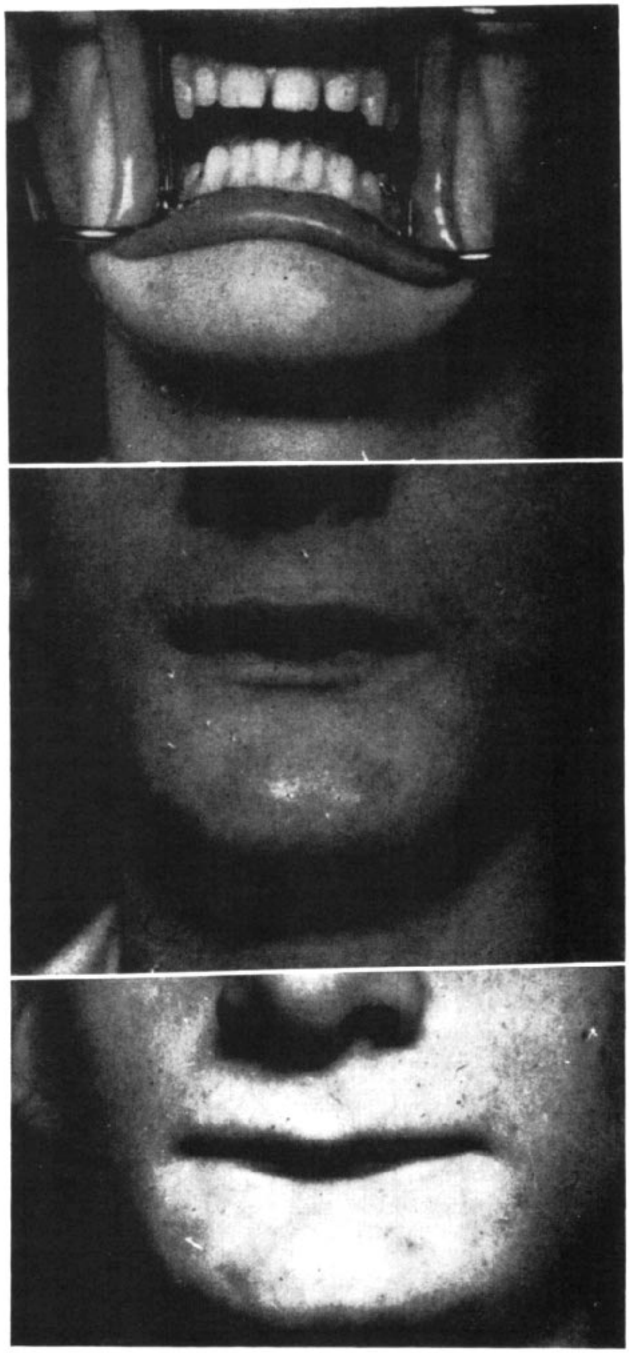

FIG. 5. (*a*) Wide free way space (14 mm.). (*b*) Facial contour with mandible at rest position. (*c*) Facial contour with teeth in occlusion.

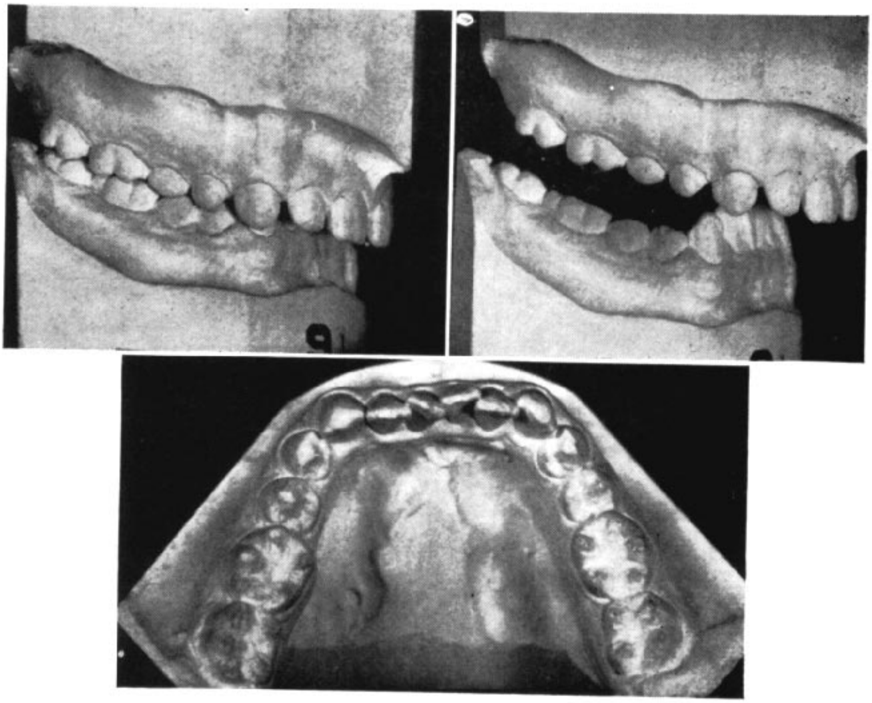

FIG. 6. Models related in occlusion and at rest position, and occlusal view showing shortened arch length.

The extremes in size of the intermaxillary clearance are seen in the following two cases. One (Fig. 5) exhibited a clearance of 14 mm. The rest vertical dimension measured 122 mm. and the occlusal vertical dimension 108 mm. The tongue completely filled the free way space when the mandible was at rest position and extended buccally to contact the cheeks. The models (Fig. 6) show that the arch length in the mandibular incisor area is deficient, and the cephalometric x-rays (Fig. 7) reveal the incisors to be inclined lingually, their long axis forming an angle of 81° with the mandibular plane. Mandibular arch length must be increased by establishing a labial axial inclination of the incisors and the maxillary incisors must be retracted, but not until the occlusal vertical dimension has been increased by 8 or 10 mm. The vertical deficiency is the primary and most acute deformation of this malocclusion. Functional analysis readily reveals not only this discrepancy but also the vertical displacement of the condyles on closure from rest position to the position established by occlusion. An occlusal splint of 10 mm. thickness was tolerated with no discomfort in the musculature or teeth and their supporting tissues.

The other case represents an all too common deformity that occurs in cleft palate cases, and it is now known to be the direct result of injury to growth centers in the maxilla caused by traumatic and excessive surgery rather than the original deformity. This was made clear to me by Dr. Wayne B. Slaughter, and later suplemented by the cephalometric studies on cleft palate patients by T. M. Graber in the Department of Orthodontics at Northwestern Univeristy. The rest vertical dimension in this case is 112 mm. and the occlusal vertical dimension 92 mm. The individual must

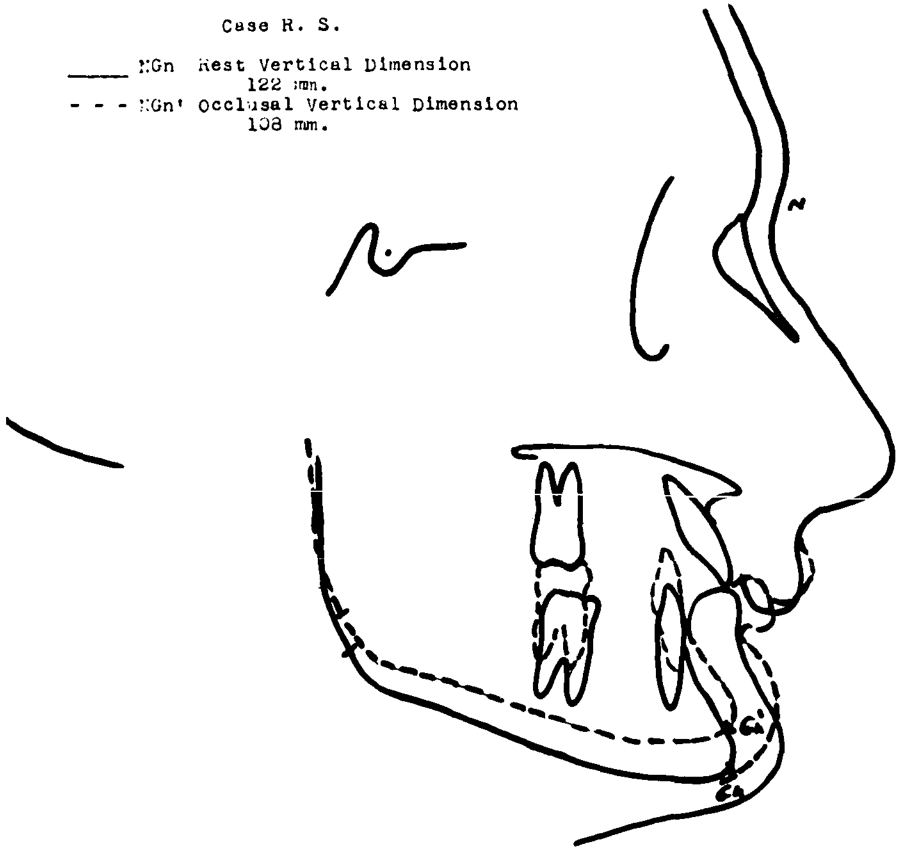

FIG. 7. Tracings of cephalometric x-ray with mandible at rest position and with teeth in occlusion.

overclose the mandible through a 20 mm. free way space in order for the mandible to attain functional occlusion with the maxilla which is deficient in three dimensions. (Fig. 8) Orthodontic treatment cannot restore an occlusal vertical dimension that would harmonize with the rest vertical dimension and this can only be accomplished by placing a full denture over the maxillary teeth. An occlusal vertical dimension of 108 mm. was established and this allowed a normal free way space of 4 mm. to exist when the mandible is at rest position.

The second phase of functional analysis is the evaluation of the antero-posterior and lateral position of the mandible. Sufficient scientific and clinical evidence has been presented to confirm the opinion that the rest vertical dimension of the face is an integral part of the growth pattern and that it is independent of the teeth. Just as the vertical position of the mandible is established by an equalization of muscular tensions, so are the horizontal positions, antero-posterior and lateral. Observing the path of closure from rest position to occlusal position and evaluating its degree of normality and abnormality are the criteria for determining whether or not the occlusal position represents the true mandibular centric position.

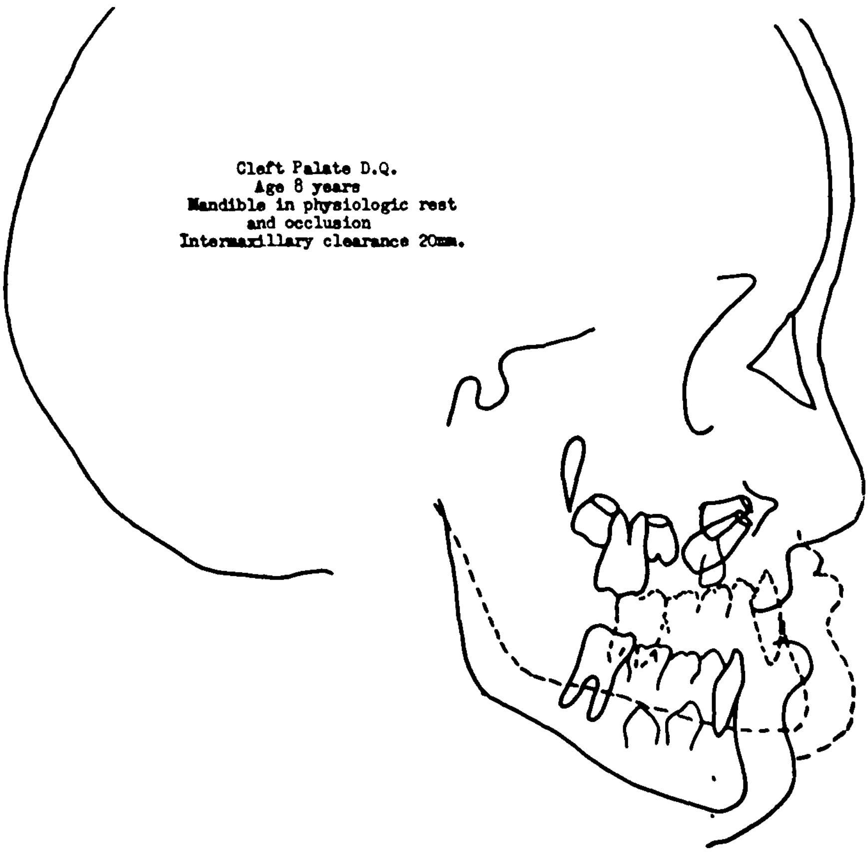

FIG. 8. Tracings of cephalometric x-rays of an individual in which a cleft palate deformity was closed by excessive surgery.
——— rest position
- - - occlusion

Normally the path of closure is almost a hinge movement with the axis located somewhere in the condyle or lower half of the temporary-mandibular joint[12]. There is little movement of the condyles other than rotary. The mandibular incisors and the chin point swing upward and forward. The molars move on a smaller arc than the incisors since they are nearer to the approximate axis. The normal path in an individual with a normal occlusion is shown in Figure 9.

The normal path of closure is not confined to normal occlusion, and its presence or absence is a significant feature in the analysis and classification of malocclusion. The normal path is observed in Case R. S., a Class II, Division 1 malocclusion (Fig. 10). There is no displacement of the mandible indicating that this case is a full, or rather, a true Class II malocclusion. The distal relationship of the mandible at rest is a balanced muscular position and the teeth, while in positions of malocclusion, do not deflect the mandible from the normal path of closure.

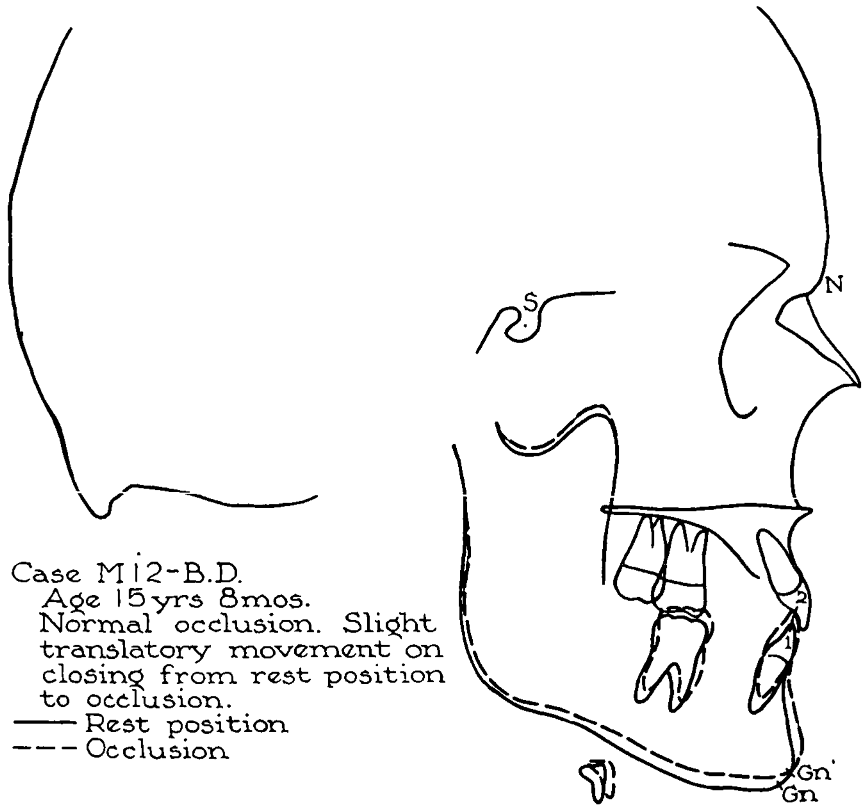

FIG. 9. Tracings of cephalometric x-rays with mandible at rest position and with teeth in occlusion illustrating normal path of closure.

It has been recognized that the mandible may assume an accommodated or convenience position created by the occlusion of the teeth. This occurs more frequently than is generally believed. The mandible may be deflected psteriorly, anteriorly, or laterally by one or more teeth that are not in positions that harmonize with the closing musculature and temporomandibular articulation. The position of the mandible, with teeth in occlusion, is far less stable than that of rest position, hence the incompleteness of any method of analysis that considers the teeth in occlusion only is evident.

Functional analysis shows clearly that the occlusal relations of the teeth do not portray the true character of the malocclusion.

Case L.P. (Fig. 11) is observed to be a Class II, Division 2 malocclusion until it is examined at rest position. The casts related at rest position show the mandible to be held almost in a Class I relationship to the cranium. The path of the closure is abnormal and the mandible is bodily displaced upward and backward by the deep overbite.

Recently this problem was restudied with an accurate temporo-mandibular articulation x-ray technic by Boman[16] and Blume[17] in the Department of Orthodontics at Northwestern University Dental School. Using the Lindblom[8] technic (Figure 12) temporo-mandibular joint x-rays taken at rest position and with the teeth in occlusion were made in addition to the

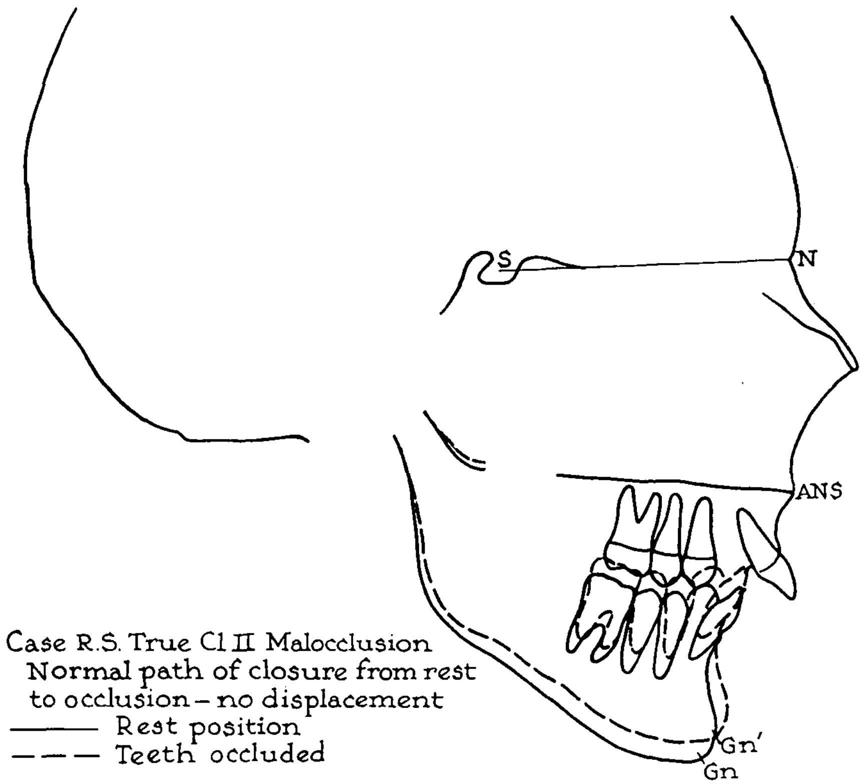

FIG. 10. Normal path of closure in a Class II, Division 1 malocclusion.

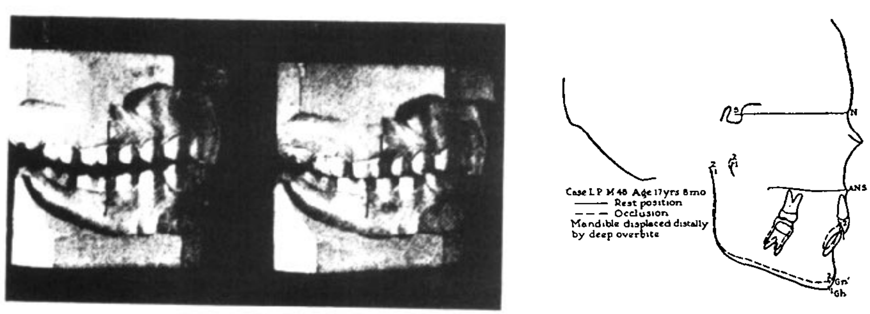

FIG. 11. Cephalometric x-ray tracings and casts related at rest position and in occlusion. Note the posterior-superior path of closure.

usual cephalometric x-rays on two groups of children. One was the control group and consisted of 25 individuals with excellent occlusion. The other was comprised of 21 children that exhibited typical Class II, division 1 malocclusion when examined with the teeth in occlusion. The paths of closure in the normal group approximated an almost hinge movement with the axis located in the vicinity of the condyle. The composite of the tem-

FIG. 12. The temporo-mandibular articulation x-ray device of Gosta Lindblom. Note that the patient's head is in an upright comfortable position.

poro-mandibular joint x-rays are shown in Figure 13. The paths of the closure of the malocclusion group (Figure 14) varied from the normal closure on some to extreme posterior superior displacement of the condyle on others. Seven appeared to have a normal path of closure and those exhibited a Class II tooth relation at rest position as well as when the teeth are in occlusion. They are true Class II malocclusions. The remaining fourteen showed displacement in varying degrees so that at rest position the case might be said to be a full Class I or partial Class I in varying degrees. The displacement that occurs in a large percentage of cases of this type of malocclusion (Class II) probably explains the difference in clinical response that has always been observed by practicing orthodontists, and often attributed to growth, types of appliances, and particular methods of treatment. Certainly the true Class II malocclusion (normal path of closure from rest position to occlusion) will not respond as rapidly as one that exhibits a considerable amount of displacement. On the other hand, all displacement cases do not respond readily. They are not identical cases and they require different treatment. Again, only a functional analysis will reveal the true nature of the malocclusion. Furthermore, the entire concept of the changes that supposedly occur in the temporo-mandibular articulation as a result of orthodontic therapy must be reconsidered in the light of these recent findings concerning the position of the mandible.

Certain clinical observations may indicate the presence of mandibular displacement. These are observations of the mandibular functions of speech and deglutition and the presence of an abnormal pattern of attrition. In the instance of posterior displacement, the mandible will be seen to be functioning in a forward (Class I) relationship during speech but when the teeth are occluded they assume the static Class II relationship.

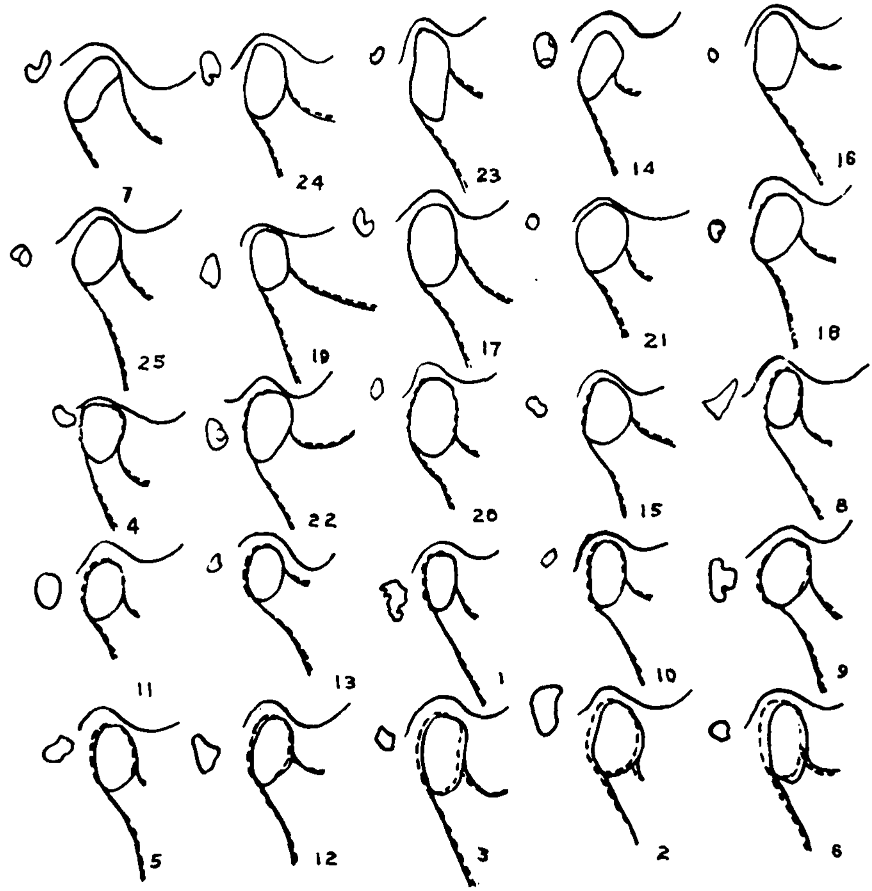

FIG. 13. Superimposed rest position and occlusal condyle tracings showing slight movement at condyle. (Boman)

In these cases the swallowing is strained and the patient usually "sucks and swallows" without occluding the teeth. After elimination of the displacement these individuals swallow freely and easily with the teeth in occlusion as they are now performing this function with the musculature in balance, and they do this naturally without instruction in normal deglutition. One patient, a dental student, described his swallowing experiences before and after an appliance that established a normal occlusal height and prevented the mandibular displacement was placed. He reported the following: "Previously, when liquids of low viscosity were swallowed, there was an accompanying 'gluggling' sound. The initiation of the swallow reflex muscular phase seemed abrupt and was low in the pharynx so that air was gulped with the fluid. At first, with the appliance in place, there seemed to exist a state of confusion, i. e., the swallow reflex response to food in the oral pharynx seemed to be hesitant. Soon swallowing was a pleasure never before experienced by the patient. The muscular phase of the swallowing reflex seemed at time to carry through in a smoothly synchronized manner, initiation being at a higher level." The changes experienced by this patient were not the result of instruction in the cor-

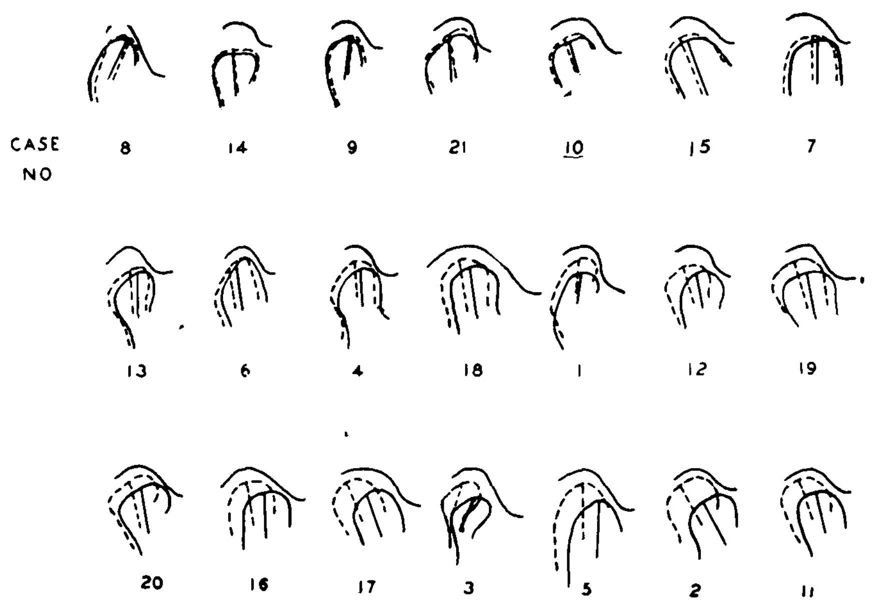

FIG. 14. Superimposed rest position and occlusal condyle tracings showing varying degrees of movement that occur in Class II, Division 1 malocclusions.

rection of an abnormal swallowing habit, but rather, by restoration of a normal occlusal vertical dimension with the consequent establishment of muscle coordination in function. A comparable illustration of disturbed muscle balance would be the attempt to write holding the arm extended. The penmanship produced from this strained muscle position of the arm would not be as legible as that produced when the arm is resting comfortably on the desk.

Once we accept the fact that the occlusal relationship of the teeth may be one of mandibular displacement, it is evident that the static analysis of casts, head x-rays or the patient, is not sufficient. It is now realized that merely by occluding upper and lower casts in the hand and observing individual tooth relations, a proper diagnosis is almost impossible except in the simplest cases. Furthermore, even these may be deceptive because an apparently excellent occlusion judged in this static manner may not actually function normally. A functional diagnosis will therefore go beyond a consideration of the movement of individual teeth or groups of teeth and consider efficiency of the masticating mechanism (viz., teeth and supporting tissues, mandible and maxilla, temporo-mandibular articulation, musculature, and nerve and vascular supply) as a whole[18].

The following cases were analyzed in the functional method and were treated accordingly.

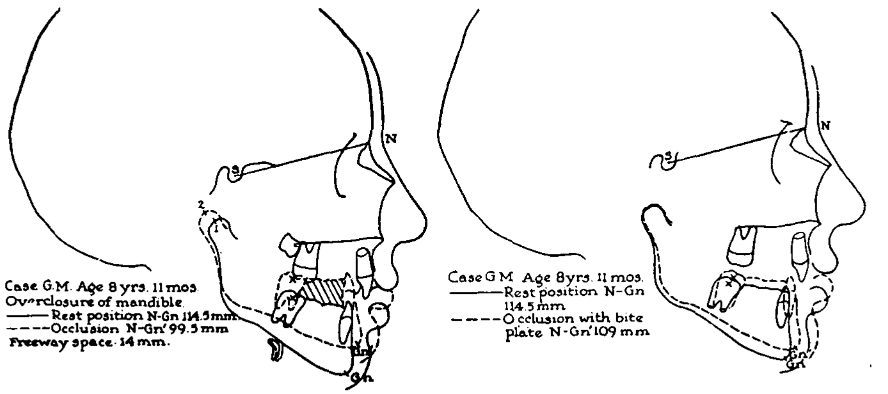

FIG. 15. a. Superimposed tracings of cephalometric x-rays with mandible at rest position and with teeth in occlusion. b. X-ray tracings with bite plate in position.

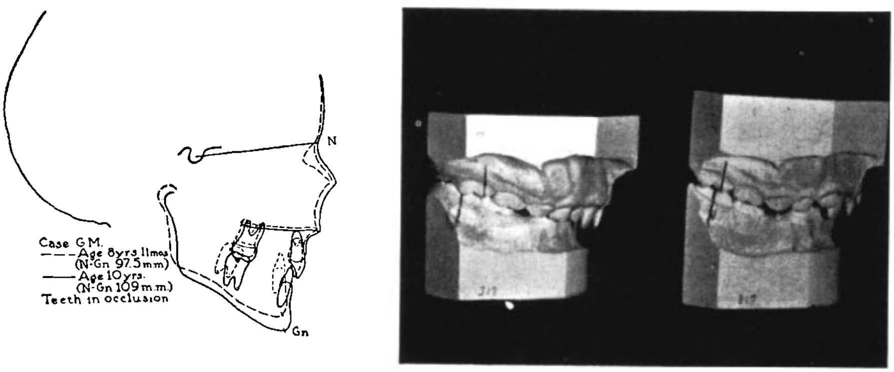

FIG. 16

a. Superimposed x-ray tracings showing changes that occurred in the occluded mandibular position with bite plate treatment and growth.

b. Occlusal change that occurred in approximately one year. Note that the extent of the Class II relation is reduced.

CASE G. M.

Age 8 years, 11 months

Angle Classification — Class II, Division 2.

Functional Analysis — Class I malocclusion with a free way space resulting in functional overclosure and posterior displacement of the mandible.

Figure 15a shows the cephalometric x-ray tracing of the mandibular rest position and occlusal position. The rest vertical dimension N-Gn measures 114.5 mm., and the occlusal vertical dimension N-Gn, 99.5 mm. The path of closure through the extremely wide free way space is upward and backward. B illustrates the rest position and the mandibular position established by an anterior bite place N'-Gn'. The change that occurred in approximately one year is seen in Figure 16a, the cephalometric x-ray, and 16b, the models. Note that the mandible now maintains a further forward position. This should not be interpreted as repositioning of the

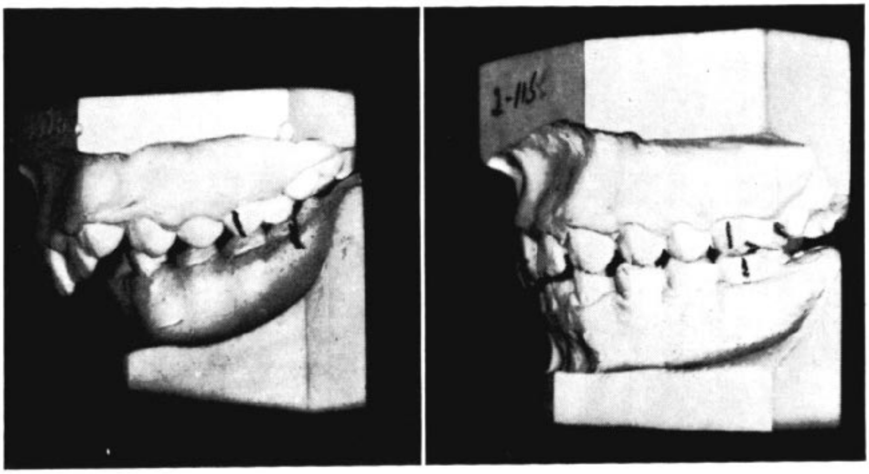

FIG. 17. (*a*) Class II, Division 2 malocclusion with very deep overbite. (*b*) Result after 2½ years of orthodontic (?) treatment.

mandible, but rather as a decrease in the amount of over-closure and displacement that occurred when the teeth were occluded. The occlusal vertical dimension at 10 years of age, an increase of 10 mm., is the result of the new occlusal position of the mandible and growth, but growth alone would not have altered the original pattern except for size. The bite plate was continued until the remaining deciduous teeth were shed and then an edgewise arch appliance was to have been placed to correct the details of tooth relationship. This period of appliance therapy was anticipated to be not over six months, but it could not be completed as the patient moved to another city.

In contrast to the treatment plan based on the functional analysis, another similar case in which the treatment was planned from observing the models and patient with teeth in occlusion only is presented. Fixed appliances were placed and adjusted to move the maxillary teeth distally and to depress the maxillary incisors. The patient was subjected to at least 2½ years of "pushing and pulling" to attain the occlusal result shown in Figure 17b. The completed dental x-rays revealed an extreme amount of root resorption on the maxillary incisors which may be the result of traumatic orthodontic treatment. Furthermore, the maxillary incisors were subjected to "jiggling forces" as they were moved lingually by the pressure of the appliance and labially by the force of functional occlusion.

Later examination of the patient revealed a wide free way space, posterior displacement of the mandible during function, and "clicking" of both temporo-mandibular articulations. I can criticize this case freely as it was of my own doing, and it was the result of failure to apply a functional analysis and correct treatment plan.

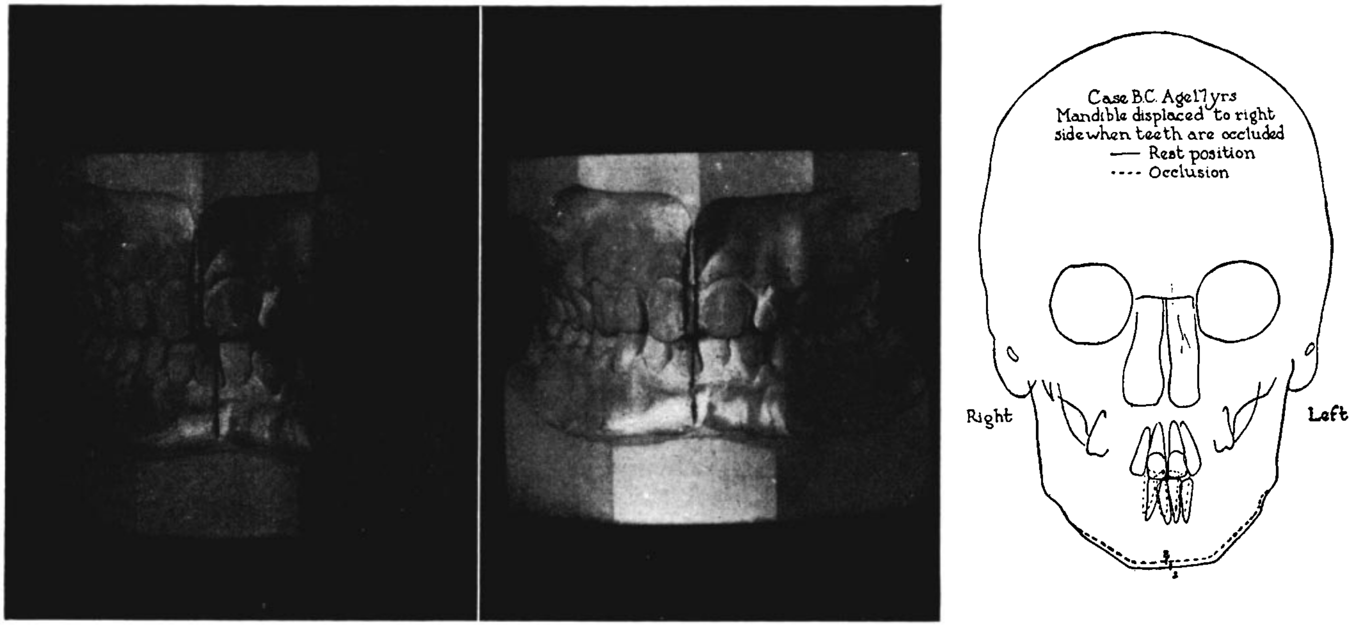

FIG. 18. Case B. C., Class I malocclusion. a. Rest position. b. Occlusion. c. Tracing of frontal cephalometric x-ray showing the right lateral mandibular displacement.

CASE B. C.
Age 17 years

Angle Classification — Class I with shortening of arch length.
Functional Analysis — Class I malocclusion with average free way space but with premature contact resulting in right lateral displacement of the mandible during functional closure from rest position to occlusion of the teeth.

The patient sought a consultation because of pain, clicking and locking of the left temporo-mandibular articulation and not because of malocclusion of the teeth. Orthodontic therapy had been carried out a few years previously. Static analysis with the teeth in occlusion revealed an apparently good occlusion of the posterior teeth with crowding of the anterior teeth. The usual examination of requesting the patient to move the mandible into right and left lateral and protrusive positions would not beget helpful information. Such cases as these receive the overworked diagnosis of arthritis with the assurance that the occlusion is fairly good.

The functional analysis showed the free way space to be average in size. The mandibular midline does not harmonize with the maxillary because of malposition of the teeth on the basal bone. At rest position the mandibular midline is deviated toward the left and in normal closure it would move upward and forward without deviation. However, occlusal interference in the buccal segment causes the mandible to shift to the right (Figure 18, a, b, and c.) The tooth movement necessary to eliminate the functional displacement is shown in Figure 19a. It was necessary to move the mandibular right buccal segment buccally and the maxillary left buccal segment buccally. The tracings of the frontal cephalometric x-rays made after treatment show that the displacement has been corrected. The symptoms of the temporo-mandibular disturbance were eliminated and have not reoccurred in the three years that have elapsed since the tratment was completed. The "arthritis" as is usually the case, was the result of abnormal function of the articulation forced upon it by malocclusion. It is interesting to note that many of these conditions develop during the course of orthodontic treatment.

CASE M. M.
Age 21 years

Angle Classification — Class III, mutilated.

Functional Analysis — Class I malocclusion with wide free way space resulting in mandibular overclosure and initial contact in incisor area causing forward mandibular displacement.

Static analysis with teeth in occlusion suggests poor growth of the maxilla and overgrowth of the mandible (Figure 20a, broken line). At rest position facial balance is excellent, the free way space is very wide measuring 8.5 mm (Figure 20a, solid line). The rest vertical dimension is 111 mm and the mandible must overclose to an occlusal vertical dimension of 102.5 mm during function.

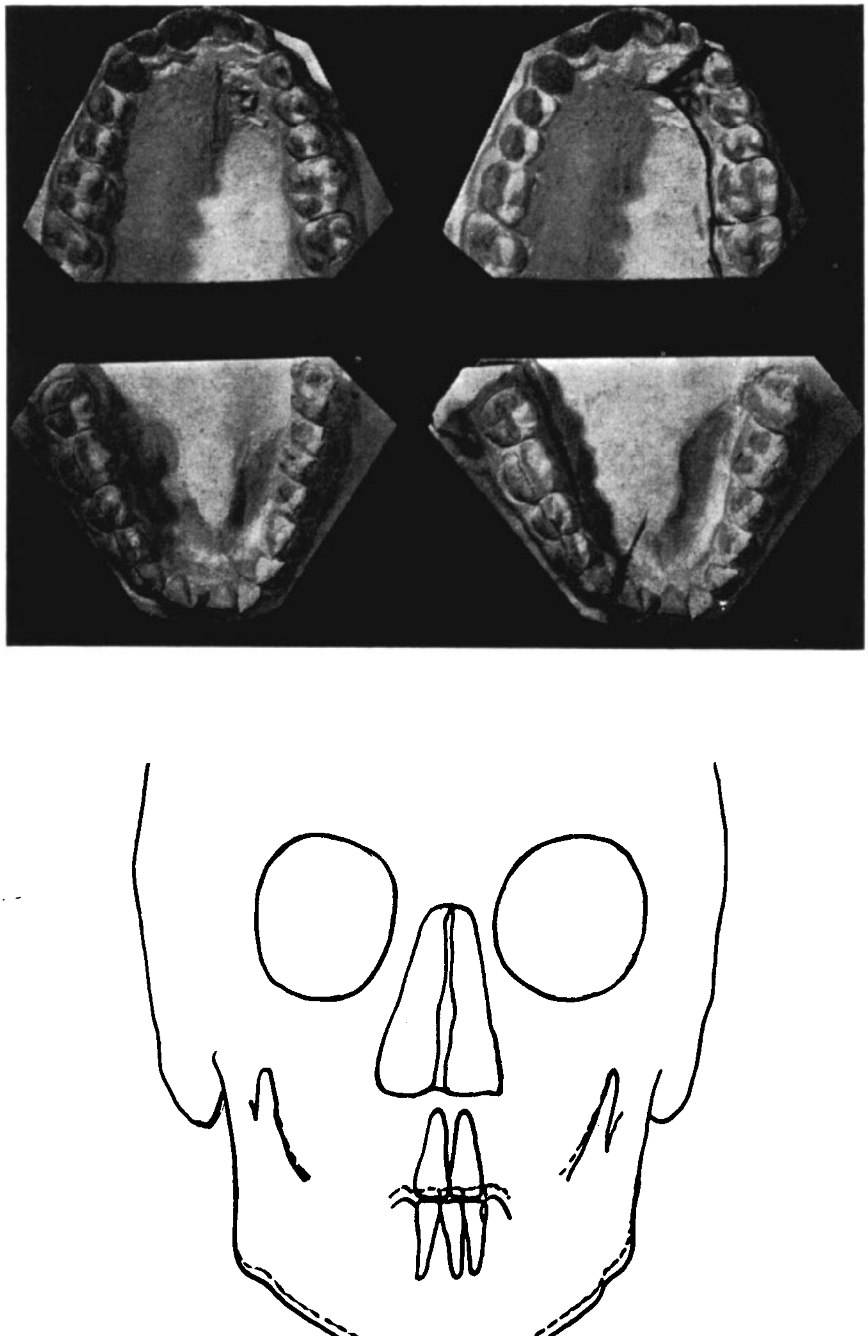

Fig. 19. Case B. C. a. Sectioned casts illustrating tooth movement necessary to correct the functional displacement. b. Tracing of frontal cephalometric x-rays after treatment. Normal path of closure.

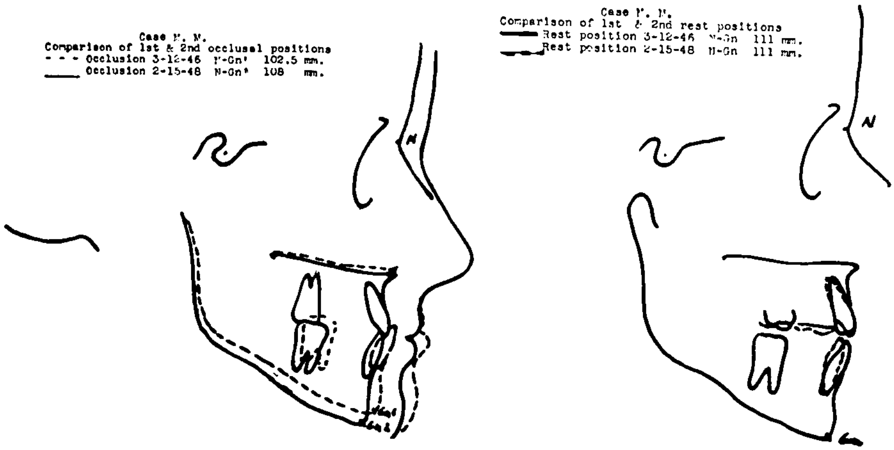

FIG. 20. Case M. M. Closure from rest position to occlusion: a. Before treatment. b. After treatment.

The objectives of the orthodontic treatment were: (a) move the maxillary incisors labially and the mandibular incisors lingually and (b) to permit eruption of the posterior teeth. This was accomplished; however, the reduction of the free way space from 8.5 mm to 3 mm was done primarily by restorative dentistry (Figure 21a and b). Since the patient was an adult the face did not increase in height and the first and second rest vertical dimensions are identical, 111 mm (Figure 21b) although the occlusal vertical dimension has been increased by 5.5 mm. Note that the facial contour with teeth in occlusion after treatment (Figure 21a, solid line) now resembles and harmonizes with the facial contour before treatment when the mandible was at rest position (Figure 20a, solid line). The changes in this case are in the conditions that existed when the teeth were in occlusion.

These cases were selected because they represent posterior, lateral and anterior mandibular displacement. These conditions must be recognized before treatment as they will very often influence the treatment plan. Furthermore, we must realize that mandibular displacement can develop during the course of orthodontic treatment.

There is much that is not known about the mandibular rest position and its variables. More will be learned now that something is known and stated for acceptance or constructive criticism. Again, much is not known about functional analysis except the realization that static analysis of the malocclusion or finished product of orthodontic therapy is inadequate. Our understanding of function as it incorporates all of the parts of the complex mechanism that we influence, for better or worse, will expand as our thoughts are directed toward this end.

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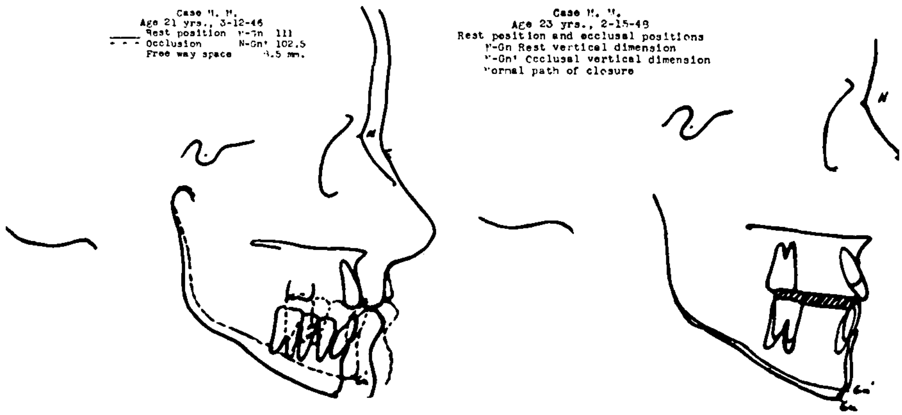

FIG. 21. Case M. M. a. Comparison of first and second occlusal cephalometric x-ray tracings. b. Comparison of first and second rest position cephalometric x-ray tracings.

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