Normal And Abnormal Function of the Temporomandibular Joint

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The stomatognathic system consists of the mandible and maxilla, the teeth and their supporting tissues, the temporomandibular joints, the musculature, the nerve and vascular supply and other structures. For many years the pathological effect of a malfunctioning stomatognathic system on the teeth and their supporting tissues and the temporomandibular articulation has been clinically observed and described. Karl Boman (1947) asserts that at least one-third of all adults have symptoms of temporomandibular arthrosis.

To further isolate causative factors and to shed more light on the acceptable and unacceptable stomatognathic pattern, it was thought logical to determine if any significant difference existed between one hundred and five (105) various angular and linear measurements on a group of subjects possessing apparently normal temporomandibular joint function and a group presenting a malfunction of the temporomandibular joints.

By means of cephalometric radiography, certain lateral facial measurements were studied and compared. Oriented temporomandibular joint radiographs were used to investigate the form and position of the condyle, fossa and eminence. Both of these radiographic techniques were used to record various mandibular positions and functional paths.

It was hoped that by these means, specific areas of variance would point to a more circumscribed field for detailed future research. An x-ray technique for temporomandibular joints should have the following qualities:

1. Provide an accurate view of the condyle from the mediolateral aspect.
2. Provide an accurate view of the articular fossa and eminence from the mediolateral aspect.
3. Provide an exposure area large enough to include orbitale, nasion and some maxillary and mandibular teeth.
4. Enable the subject to assume a relaxed upright sitting position.
5. Provision for the accurate repositioning of the subject for subsequent radiographic examination.
6. Maintain the same cassette, head and tube angulation for all subjects.

A careful examination of the literature and actual use of many of the techniques indicated that none of them fulfilled all of the above qualifications. Consequently, the development of a new method was undertaken, the basis of which was the technique advocated by Lindblom (1936). The result was a device attached to the back of a Broadbent-Bolton cephalometer and utilizing the frontal or postero-anterior x-ray tube of that cephalometer (Fig. 1). The x-ray tube was tipped down to an angle 19° from the horizontal and directed at the center of a large cassette holder positioned perpendicular to the central rays and providing a 75 centimeter target film distance. To the cassette holder was attached a square sleeve and lock which firmly held a square tubular bar parallel to the floor and at a 15° angle from the central ray. From the bar ex-

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tended a fixed plastic ear plug support, placed as close to the cassette as possible, and a movable support with an adjustable ear rod. A second square sleeve and lock was attached to the cassette holder in such a manner as to enable the positioning of the square tube and ear posts in order to radiograph the opposite temporomandibular joint.

When seated upright and in a comfortable position on an adjustable stool, the subject was so situated that the central rays entered above and behind the ear and exited at the condylar area on the opposite side. The device thus consists of a fixed x-ray tube, a fixed cassette holder and a head positioner.

To eliminate some secondary radiation and to provide greater contrast a Lysholm-type grid was used with 8 x 10 cassettes equipped with fine definition intensifying screens. The General Electric D-3 head delivering approximately 85 K.V.P. and 20 milliamperes allowed an exposure of only three fourths (¾) of a second.

The accuracy of the Lindblom technique has been tested many times and the area of the fossa and condyle outline determined. The present technique, possessing a slightly different vertical angulation and the addition of the head orienting device, was thoroughly tested by Ruskin (1952):

"1. The Donovan orientating device permits accurate duplication of temporomandibular joint radiographs.

2. The center of the condyle and the height of the fossa may be related to an axis within the skull.

3. The angle which the projected section of the condyle describes with the transverse axis has a great range of variability due to individual morphology and angular relationships of the condyle.

4. In every skull examined in this study the junction of the lateral and middle thirds of the fossa formed the lower border of the fossa as seen on the radiographic projection.

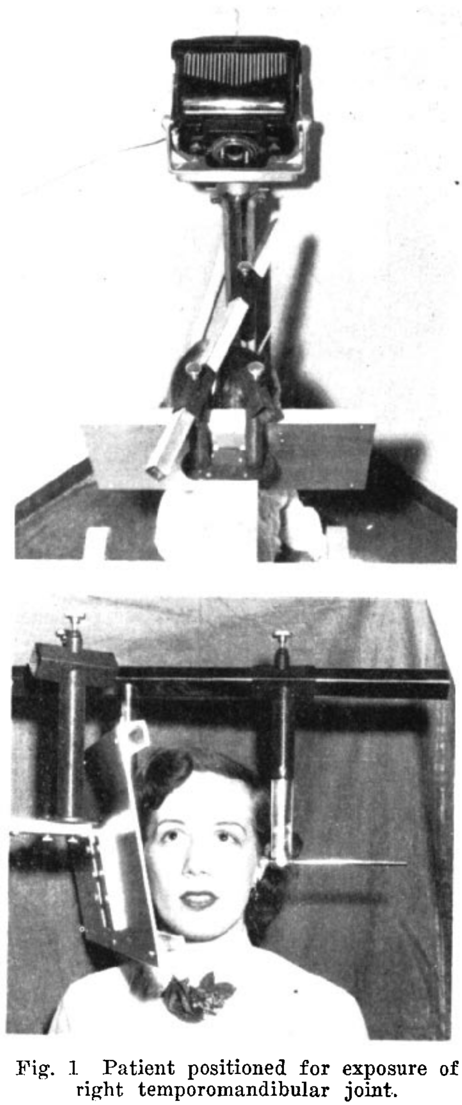

Fig. 1 Patient positioned for exposure of right temporomandibular joint.

5. It is, therefore, not possible to measure the actual distances between points on condyle and fossa from only the temporomandibular joint radiograph.

6. The mediolateral distances between corresponding points on the condyle and fossa compare favorably with the thickness of the sections obtained by

the use of laminagraphy.

7. The distance between any two points on the condyle, measured on a temporomandibular joint radiograph, remains constant during rotation from rest to occlusal position despite the fact that the transverse axis describes a horizontal angle of 15° and a vertical angle of 19° with the hinge axis."

After positioning the subject in a relaxed, upright sitting position in the orientation device, with the Frankfort plane parallel to the floor, the subject was asked to wet his lips, swallow, and then to "unstick" his lips. A few seconds later the first exposure was made and the subject was then asked to "hold still" while the lips were parted and the rest position checked. If the lips were easily parted, the teeth slightly separated and the tongue found creeping between the teeth, the rest position was assumd to be correct. The vast majority of the subjects very readily assumed the rest position; only a very few had to be put through the routine of talking to relax the facial muscles (Fig. 2).

Following the rest position exposure, the subject was asked to close the jaws until the teeth were together in full intercuspal occlusion. After the occlusal position exposure the subject was asked to pull the lower jaw back and repeatedly tap the posterior teeth together on an opening arc of approximately ten millimeters. When the subject had reached the posterior limit of the tapping range, he was asked to hold the jaw at the position of the last tap for the third exposure. At no time did the operator or the subject touch the chin to guide the retrusion of the jaw and in no subject was the retruded position beyond the range of easy opening and closing movement.

The fourth exposure was made with the incisors in an edge to edge position after which the subject was turned

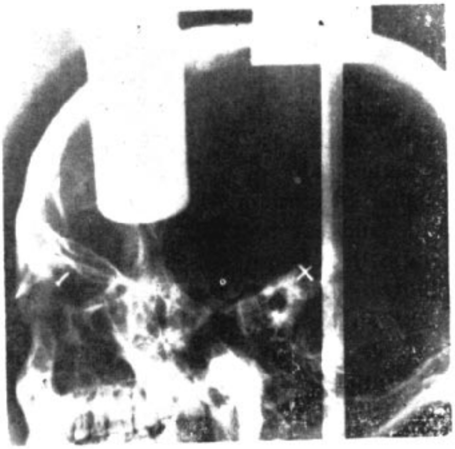

Fig. 2 Region of condyle and fossa and its appearance in shadow outline on temporomandibular joint roentgenogram.

around and the headholder adjusted for the same exposures of the opposite temporomandibular articulation (Fig. 3).

The rest position radiograph was placed over a suitable illuminated tracing box and with a very sharp, hard pencil, various landmarks were traced on a sheet of tracing paper. They consisted of the orbitale point, the center of the outline of the auditory meatus, the outline of the articular eminence and fossa, the outline of the condyle and neck, and several prominent, bony landmarks.

The arc formed by the superior outline of the condyle was continued to form a complete circle, the center of which was marked by a small dot. A template was made of the outline of the condyle and carefully fixed with tape to the outline of the condyle on the occlusal position radiograph. The full tracing was superposed over the eminince, fossa and other landmarks and the position of the condylar "dot" was transferred to the full tracing. The same procedure was followed with the radiographs of the other positions so that the final tracing exhibited the landmarks and the condyle dot at rest position, occlusal position, retruded position and

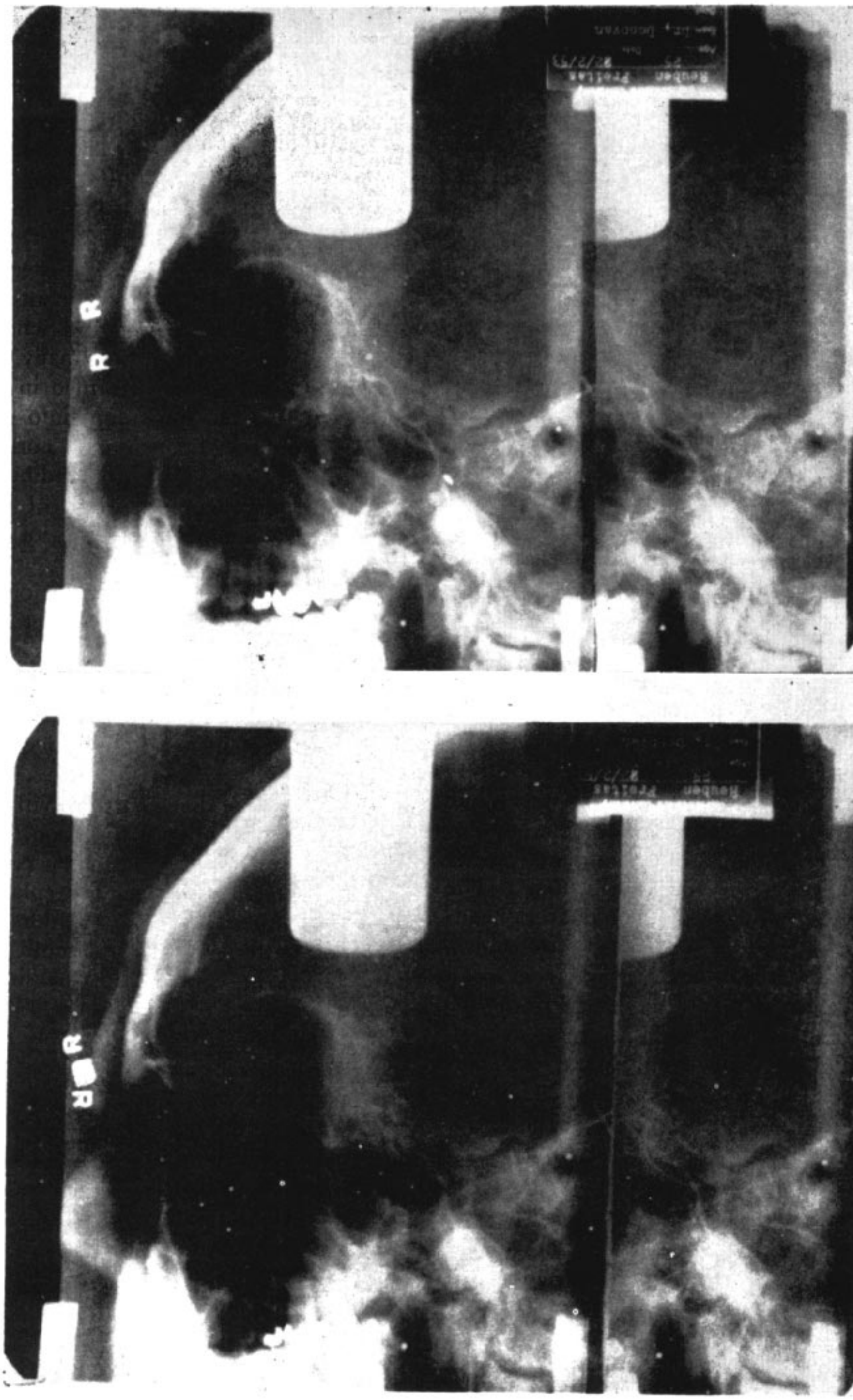

Fig. 3 Roentgenographic series of right temporomandibular joint. Above left, rest position. Above right, occlusal position. Below left, retruded position. Below right, incisive position.

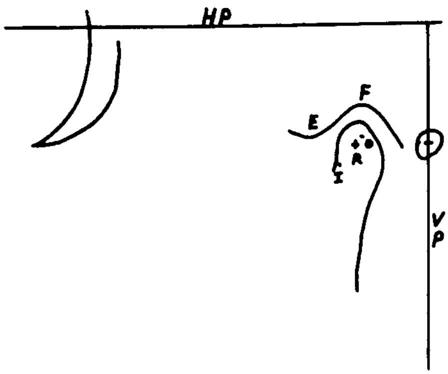

Fig. 4 Temporomandibular joint tracing. HP, parallel and 24 mm. superior to orbitale-auditory meatus line; VP, perpendicular to HP through center of auditory meatus; F, most superior point on fossa outline; E, most inferior point on eminence outline; I, condylar axis dot at incisive position; R, condylar axis dot at physiologic rest position; O, condylar axis dot at occlusal or intercuspal position.

incisive position (Fig. 4).

Since the introduction of the Broadbent-Bolton cephalometer by Broadbent (1931), it has been the most popular method of choice whenever an accurate radiographic cephalometric technique was required. It has been explained frequently in the literature and only a brief description is necessary here. The cephalometer consists of a fixed head-holding device with ear rods and a nasion marker situated adjacent to a cassette holder. Five feet from the median plane is an x-ray tube so positioned that the central rays are perpendicular to the median plane and enter the skull at the ear rods. The device offers an extremely accurate means of obtaining oriented cephalometric radiographs.

After positioning the subject in a relaxed, upright sitting position in the orienting device, with the Frankfort plane parallel to the floor, the rest position was obtained in a manner similar to that described in the temporomandibular radiography section. An occlusal position exposure and an incisive position exposure were also obtained in a manner already described.

From the rest position radiograph, a template of the mandibular outline and the teeth was made. If the condylar outline was not discernible on the rest position radiograph, it was obtained from the incisal radiograph.

The subjects investigated consisted of dental and dental hygiene students at Northwestern University Dental School. A history was obtained and finally, an oral examination was performed in order to classify the individual into one of two groups: (1) apparent normal function of the temporomandibular joints and excellent occlusion of the teeth, or (2) abnormal function of the temporomandibular joints.

Cases classified as normal function of the temporomandibular joint met the following requirements:

1. Interdigitation of buccal teeth including second molars.
2. Contact of incisors in an adequate overbite and overjet.
3. Symmetrical dental arches with no teeth in buccal or lingual version.
4. One tooth in each quadrant could be missing, but it had to be replaced with a satisfactory fixed restoration.
5. The pattern of attrition could not be excessive or confined to any single tooth or segment of teeth.
6. Upon closing the jaws crisply into the intercuspal position a single clear tap was heard.
7. No single tooth or segment of teeth could give indications of premature contact or unusual mobility.
8. Smooth function of the temporomandibular joints with no symptoms of clicking, crepitus, pain, excessive tiredness, tenseness or strain.
9. The various components of the stomatognathic system had to function with comfort and ease, causing the subject no concern or distress.

The malfunction group exhibited the following characteristics:

1. Clicking, crepitus or pain of the temporomandibular joints during the habitual range of mandibular movements.

2. The only dental requirement was that the subject have contacting teeth in every dental arch quadrant.

All those subjects not meeting the requirements of either group were eliminated from the present investigation. The two groups consisted of 200 white subjects of mixed descent, 141 males and 59 females. The normal function group contained 74 males and 26 females, while the malfunction group contained 67 males and 33 females; their ages ranged from 18 to 38 years, with a mean age of approximately 24 years.

Observations made from the radiographic and clinical examinations were not correlated until the radiographs were traced and evaluated.

General Discussion

The masses of figures that appear in the appendix or, for that matter, the raw data from most investigations are extremely bewildering and almost impossible of interpretation in themselves. Statistics enable the investigator to summarize the results in meaningful and convenient form. A general picture of the results is provided.

Unfortunately, all too often an individual is placed in this general picture and appears to be entirely out of place. In fact, most individuals, when compared to the general picture, look out of place. Individuals are properly compared to group values only with the realization of the limitations imposed by individual variation and an analysis of all known contributing or compensating factors.

It must be emphasized that the present study was undertaken to determine areas of difference between a group of 100 subjects presenting apparent normal function of the stomatognathic system. The reason for the differences and a comprehensive analysis of each difference is at the present only of incidental interest. The application of findings to individual cases or situations is also not within the scope of the present project.

If a four-sided figure is constructed by connecting points S, N, M, and Go, a general pattern of facial form is obtained. The line SN represents the anterior cranial base, the line NM the anterior facial height, the line M Go, the lower border of the mandible and the line Go S, the posterior facial height (Fig. 5). The "t" ratios for the four sides are all at the 1% level of significant group difference and it is interesting to note that the ratio increases progressively from the lower

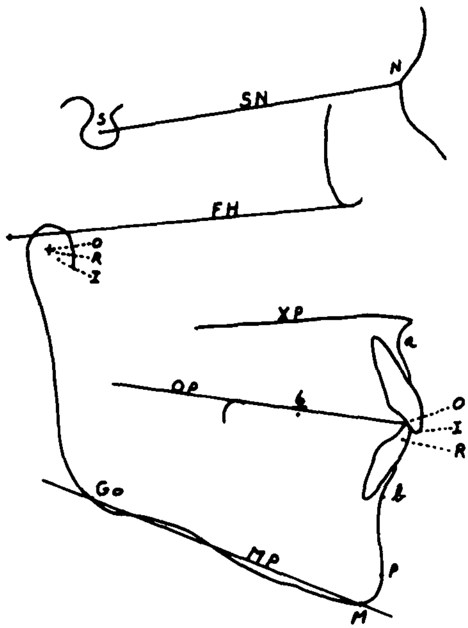

Fig. 5 Tracing of lateral cephalometric radiograph. XP, maxillary plane; O, occlusal reference points; R, rest position reference points; I, incisive position reference points.

border of the mandible to the anterior facial height, the anterior cranial base, and to the highest ratio at the posterior facial height measurement. The malfunction group presents a facial outline that is smaller overall than the normal function group.

The malfunctional mean face is smaller in height and depth. The maxilla is in a more superior position, but is in the same relative horizontal position with the maxillary apical base (angle SNa) almost identical with the normal function group.

Group differences are even greater when considering the mandibular position. It is obvious from the means that the mandible occupies a more superior position in the malfunction group. There is also evidence that the mandibular apical base is in a more posterior position.

The smaller facial height is due in part to the characteristically smaller mandible as evidenced by mandibular length, ramus height and lower border length. The mandibular plane to SN is also steeper in the malfunction group and the angle of the mandible (C Go M) is more obtuse.

Angle aNb is a measure of the relation of the maxillary apical base to the mandibular apical base. The mean aNb of the malfunction group is larger than the mean of the normal function group, a result of the smaller SNb angle and the shorter distance between point a and point b.

A short a to b distance is usually an indication that an overbite or a protrusive denture exists. Measurements of the dental area show that a deeper, mean overbite exists in the malfunction group. This is perhaps due to a slight overeruption of anterior teeth, but principally to the superior position of the mandible.

Overjet is also higher in the malfunction group in spite of the presence of a more vertical inclination of the maxillary central incisor. The vertical incisor does not result in a less prominent incisor, but seems to be the situation of a more anterior position of the root apex.

Frankfort plane, maxillary plane and occlusal plane offer no significant mean difference.

It will be recalled that the facial pattern measurements were taken from the cephalometric radiograph tracing representing the occlusal position of the jaws. The evidence indicates that the mandible at the occlusal position is higher in the malfunction group than the mandible at the occlusal position in the normal function group. Further analysis when the mandible is in various other positions throws more light on the differences between groups.

Condylar position at rest in the malfunction group is at the same height, but slightly anterior to the condylar position at rest position in the normal function group.

At the occlusal position, the condyle in the malfunction group is at the same relative horizontal position, but much higher than the condylar occlusal position in the normal function group.

In the incisive position the malfunction group presents the condyle at the same relative height, but in a more anterior position than the corresponding condylar position in the normal function group.

The retruded position exhibits a higher and more anterior position in the malfunction group than the normal function group.

Thus, actual total linear condylar change from rest position to occlusal position, rest position to incisive position and occlusal position to incisive position is much greater in the malfunction group. This is especially true of the movement from rest position to occlusal position.

Most of the difference in total linear

movement of the condyle from rest to occlusal position is accomplished by vertical rather than posterior movement of the malfunction group, although the posterior movement ratio is also significant.

The difference in total linear movement from rest position to incisive position is due to more horizontal movement of the malfunctional group condyle, and the difference from occlusal position to incisive position by more of both horizontal and vertical movement in the malfunction group.

The normal function group exhibits more superior and posterior movement than the malfunction group when changing from occlusal position to retruded position, although the mean retruded condylar position of the normal group never reaches the height that the malfunction occlusal position condyle does, but does move farther posteriorly than the mean occlusal position of the malfunction group.

In the incisor region, the malfunction group exhibits a longer incisal guidance path and a wider interocclusal clearance or freeway space.

Results so far indicate that the malfunction group is characterized by a shorter face, when measured with the teeth in occlusion, a more superior and posterior position of the mandible and condyle in the occlusal position, longer movement paths, greater overbite and overjet, wider interocclusal clearance, little or no retrusion posterior to the occlusal position and many other factors.

Further investigation into condyle inclination, form and size revealed no significant group differences. A slightly higher position of fossa and eminence was evident in the malfunction group, but the horizontal fossa and eminence position showed no significant group difference. Rather than being deep and narrow as so often described in the literature, the malfunction group means presented a slightly shallower fossa.

As for the condylar position in the fossa, the malfunction group exhibited a condylar occlusal position much closer to the top of the fossa and much deeper in the fossa than the condylar occlusal position in the normal function group. The rest position condylar position did not show any significant group differences.

The incisal glide path from occlusal position to incisive position did not give a significant group difference, but there was a very significant difference between groups in the measurement of the path of closure from rest position to occlusal position. The malfunction group has a mean value much steeper than the mean for the normal function group, indicating a vertical of upward and backward path of closure.

Results of this investigation very definitely tend to substantiate the major portion of the theories advanced by Thompson and Sicher, and even more positively cast doubt upon the efficacy of the use of the occlusal position of the retruded position as the optimum reference position in the treatment of malfunction of the stomatognathic system.

SUMMARY

To further isolate causative factors and to shed more light on the acceptable and unacceptable stomatognathic pattern, one hundred and five (105) various angular and linear measurements were compared between a group of subjects possessing apparently normal temporomandibular joint function and a group presenting a malfunction of the temporomandibular joints.

By means of cephalometric radiography, certain lateral facial measurements were studied and compared. Oriented temporomandibular joint radiographs were used to investigate

the form and position of the condyle, fossa and eminence. Both of these radiographic techniques were utilized to record various mandibular positions and functional paths.

The results indicate that many differences exist between the normal function group and the malfunction group. These differences are most conveniently summarized by listing certain characteristics of the malfunction group.

1. The mean face is smaller in height and depth.

2. The maxilla is closer to the SN line.

3. The mandibular occlusal position is closer to the SN line.

4. The mandible is smaller overall with a steeper mandibular plane angle and a more obtuse mandibular angle.

5. Mandibular apical base is in a more posterior position resulting in a greater a-b difference.

6. There is less vertical space between the mandibular apical base and the maxillary apical base.

7. More overbite and overjet is present.

8. The maxillary central incisor is more upright.

9. The condyle at the rest position is at the same height but slightly more anterior.

10. The condyle at the occlusal position is approximately the same depth, but considerably higher.

11. The condyle position at the retruded position is higher and more anterior.

12. There is a longer path of movement from occlusal position to incisive position and from rest position to occlusal position.

13. There is very little retrusive movement beyond the occlusal position in very definite contrast to the ability of the normal group to easily retrude beyond the occlusal position.

14. A longer incisal guidance path is present in the incisor region.

15. The interocclusal clearance is wider.

16. There is little, if any, difference in fossa and eminence position, shape, size or inclination.

17. The condyle in relation to its position in the fossa is much higher and deeper in the fossa at the occlusal position.

18. The condyle at rest position does not present a significant group difference in its relation to the fossa and eminence.

19. The path of closure is steeper.

The above are characteristics of the malfunction group in contrast to the normal function group.

In another phase of the study, correlation coefficients were computed within the normal function group. The results indicated marked relationship between many of the measurements. The intimate relation of the mandibular and maxillary apical bases, inclination of maxillary incisor, angle NSM, and the mandibular and occlusal planes was especially evident.

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REFERENCES

Boman, K. "Temporomandibular Joint Arthrosis and Its Treatment by Expiration of the Disk," *Acta chir. Scandinav.*, Supplementum 118, Stockholm, 1947.

Broadbent, B. H. "New X-ray Technique and its Application to Orthodontia," *Angle Ortho.*, 1: 45-66, 1931.

Lindblom, G. "Technique for Roentgen-Photographic Registration of the Different Condyle Positions in the Temporomandibular Joint," *Sv. T. T.*, 4: 273, 1936.

Ruskin, R. "An Evaluation of a Technique and Its Implication in Interpretation of Radiographs of the Temporomandibular Articulation," *Thesis*, N.U.D.S., Chicago, 1952.