The Facial Goniometer: An Instrument for the Direct Measurement of the Frankfort-Mandibular Plane Angle and the Gonion Angle

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In recent years orthodontists have become more aware of the importance of making craniofacial measurements in the examination of the orthodontic patient. A careful analysis of these linear and angular measurements is of practical value in recognizing an abnormal growth pattern, and also helps to determine the prognosis of the case. In addition, these measurements serve to indicate the probable need for the extraction of teeth, and the correct position for the mandibular incisors in treatment, according to the 90° ± 5° formula of Margolis[1]. They also furnish a clue as to whether, with the reestablishment of a normal tooth alignment, one can hope for a concomitant improvement in the facial profile. These considerations are of paramount importance in the evaluation of each orthodontic case and should, if possible, be determined at the initial examination of the patient if a provisional or preliminary diagnosis is required of the orthodontist. A more complete examination, including lateral cephalometric radiographs and oriented photographs, can be made later, if the patient should decide to undergo treatment.

The need for the measurement of the Frankfort-mandibular angle in the everyday practice of orthodontics is stressed in this article. This measurement is of profound clinical importance in evaluating inherent growth dysplasias, and in determining the prognosis and the probable need for extracting teeth. Another advantage in using this measurement is that it can be taken quickly during the first visit of the patient in a relatively simple manner. The orthodontist, after he measures the Frankfort-mandibular angle and has evaluated its clinical significance, may then inform the patient of his findings, and of any unfavorable factors which might be present.

The Frankfort - mandibular plane angle is obtained by measuring the angle formed by the Frankfort horizontal plane as it intersects a line tangent to the lower border of the mandible. In 1946 Tweed[2] first described this angle and gave a practical clinical interpretation of it for orthodontists. It is today an accepted and valued adjunct in our daily practice. Downs[3] has included this angle as among the most important measurements taken in his method of cephalometric analysis. Later, Johnson[4] described the Frankfort-mandibular angle as an additional valuable guide in interpreting the lateral cephalograms taken on orthodontic patients. He also found that a direct relationship exists between the size of the Frankfort-mandibular angle and the gonion angle. Salzmann[5] and Strang[6] have also recognized the importance of this angular measurement by including a detailed description of the Frankfort-mandibular angle in recent editions of their textbooks.

TABLE I. THE FRANKFORT-MANDIBULAR ANGLE IN DIAGNOSIS, CLASSIFICATION, PROGNOSIS AND TREATMENT.

	FRANKFORT-MANDIBULAR PLANE ANGLE.			
	20° - 30°	30° - 35°	35° - 40°	40° - 55°
Growth pattern	Normal to slightly abnormal	Slightly Abnormal to abnormal	Abnormal	Markedly abnormal
Prognosis (esthetics, efficiency, permanency, longevity.)	Excellent to good	Good to fair	Fair to poor	Poor to nil
Positioning of mandibular incisors according to 90° ± 5° formula	At 20° set +5° At 25° set +0°	At 30° set —5° At 35° set from —5° to —10°	Set from —5° to —10°	Set from —5° to —10°
The extraction of teeth	Extraction indicated in more than 50% of cases	Extract in practically all cases	Extract in practically all cases	Extract in *selected* cases only. (Extracting often will complicate case.)
Measurement from tragion point to apex of Frankfort-mandibular angle	10″ to 3½″	3½″ to 1½″	½″ or less	½″ or less

The outline contained in Table I will aid the orthodontist in making a rapid, diagnostic appraisal of the case after a measure of the Frankfort-mandibular plane angle has been made. It must be stressed that the final decision on the need for extracting teeth should be made only after the findings in Table I are supplemented and collaborated by an examination of the patient's orthodontic models, cephalometric radiographs and photos. If, in addition to other positive clinical findings, an examination of the orthodontic model reveals the presence of an excessive amount of tooth material in relation to the basal arches, the extraction of teeth is necessary.

METHODS FOR THE MEASUREMENT OF THE FRANKFORT-MANDIBULAR ANGLE

1. Cephalometric radiographs
2. Photostatic photographs
3. Direct facial measurement

To determine the Frankfort-mandibular angle on a lateral cephalometric x-ray, two lines must be drawn. The upper line is drawn from the lower margin of the orbit to the porion. The lower line is drawn tangent to the lower border of the body of the mandible. When these two lines are extended posteriorly, they meet to form the required angle. A measure of this angle is made with a protractor.

In order to obtain the Frankfort-mandibular angle on a profile photograph, two lines are inscribed. The upper line is drawn on the photo through the orbitale and the tragion points. These cranial landmarks should be placed on the patient's face with a skin marking pencil, prior to photographing. The lower line is drawn on the photo, to pass through the gonion and the gnathion points. The resulting angle formed is the Frankfort-mandibular angle.

TABLE II. THE RELATION OF THE FRANKFORT-MANDIBULAR PLANE ANGLE MEASURE TO THE RECOMMENDED AXIAL INCLINATION OF THE MANDIBULAR INCISORS IN ORTHODONTIC TREATMENT.

FRANKFORT-MANDIBULAR ANGLE	INCISOR MANDIBULAR ANGLE	
	According to ±5°	*Total*
20°	90° + 5°	95°
21°	90° + 4°	94°
22°	90° + 3°	93°
23°	90° + 2°	92°
24°	90° + 1°	91°
25°	90° + 0°	90°
26°	90° — 1°	89°
27°	90° — 2°	88°
28°	90° — 3°	87°
29°	90° — 4°	86°
30°	90° — 5°	85°
31° and above	90° — (—5° to —10°)	85° to 80°

(Based on lectures in course in orthodontics given by Dr. Samuel J. Lewis)

Table II indicates the recommended angulations the orthodontist should attempt to position the mandibulars incisors with orthodontic appliances, if a favorable result and a reduction of the dentofacial prognathism are to be obtained. It is important to note that in any case where the Frankfort-mandibular angle measures 31° or above, the 90° ± 5° formula no longer applies. The mandibular incisors should then be inclined lingually so as to form an 80° to 85° angle with the mandibular plane.

The final method in use is the direct facial measurement. Tweed[7], Salzmann[8], and Savitz[9] have described techniques for obtaining the Frankfort-mandibular angle measurement directly on the face of the patient.

In this article a new instrument, the *facial goniometer,* is introduced and described by the author, which facilitates the measuring of pertinent facial angles and can be done directly on the face of the patient. An instrument which serves to measure angles is called a goniometer (Gr. *angle+measure*). Since this instrument has been designed to measure facial angles exclusively, it is conveniently referred to as the *facial goniometer.*

FEATURES OF THE FACIAL GONIOMETER

The facial goniometer makes it possible for the orthodontist to measure the Frankfort-mandibular angle, -- unassisted and in a few seconds.

The facial goniometer is simple to fabricate, can be made entirely of stainless steel, and will serve indefinitely.

While the instrument is in place for the measurement of the Frankfort-mandibular angle, it is possible to read on the instrument scale the distance in inches from the tragion point to the point of intersection posteriorly of the two lines forming this angle without any additional adjustment. The instrument has a convenient locking thumb-screw, which makes it possible to lock the arms in the angular relationship measured on the face of the patient.

In addition to measuring the Frankfort-mandibular angle, it is possible to make a direct facial measurement of the gonion angle with the facial goniometer. The gonion angle is another valuable angle used in the diagnostic appraisal of an orthodontic case. If the gonion angle should measure 125° or less, this would signify a favorable factor in orthodontic diagnosis and treatment[10]. The measurement of the gonion angle taken from a photo or by the direct facial method will always register a few degrees larger than

when it is determined on profile radiograms. This difference is explained by the fact that the most distal point of the condyle of the mandible, which is used in the craniometric measurement,

Fig. 1. Orbital Skin-Marking Guide. A piece of .020" soft brass wire is folded on itself and locked in a broach holder. The end of the wire is formed into a loop about 3 mm. in diameter, and is in turn bent to conform to the lower margin of the orbit.

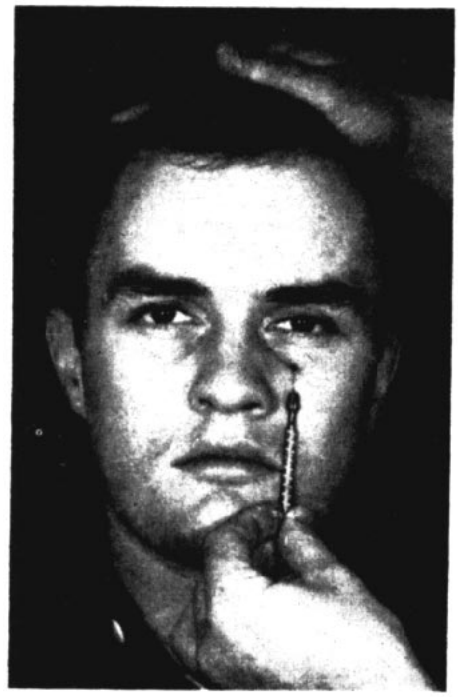

Fig. 2. The orbital guide in position for skin marking.

is slightly anterior to the skin marking point, the tragion[11].

Preparation of the Patient

The accuracy of the direct facial measurement of the Frankfort-mandibular angle will largely depend upon the care with which the cranial landmarks are placed on the face. An excellent skin marking pencil is the black, water-soluble, indelible Mongol pencil. Fill a dappen dish with water to which a few drops of liquid soap have been added. The liquid soap, when added to the water, was found to be of value in producing a well-defined skin mark, especially on patients with oily skins.

The orbitale point is palpated by using a shaped piece of .020" soft brass wire locked in a broach holder to form an orbital marking guide (Fig. 1). The free end of the brass wire is formed into a loop and is in turn bent at an angle so as to conform to the contour of the lower margin of the orbit. While adjusting the wire loop to the rim of the orbit, be sure the pupil of the eye is directed straight ahead. Dip the marking pencil into the water solution prepared above and mark the skin at the bend of the wire loop at the margin of the orbit (Fig. 2).

The tragion point is marked at the depression or notch above the tragus of the ear, at the level of the upper margin of the external auditory meatus.

The gonion point is then marked on the skin, if the orthodontist wishes to measure the gonion angle of the mandible. The gonion is the prominence at the point of the angle of the jaw at the junction of the lower border of the body of the mandible with the posterior border of the ascending ramus. It was found that as an aid to

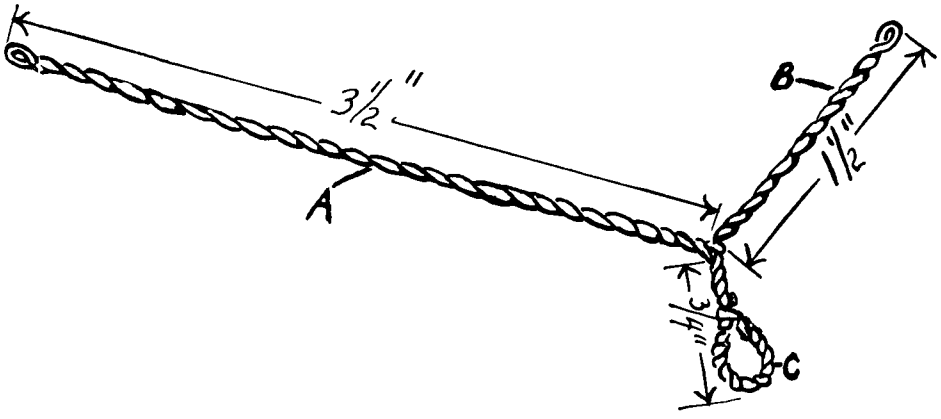

Fig. 3. Gonion Skin-Marking Guide. A 15" length of .028" soft brass wire is folded and twisted into a modified Y form.
A. Conforms to the lower border of the body of the mandible.
B. Conforms to the border of the ascending ramus of mandible.
C. Handle.

locating and palpating the gonion a 15" length of .028 soft brass wire can be twisted and fashioned into a modified Y form (Fig. 3). This gonion marking guide can be molded to the angle of the jaw and aids greatly in defining the gonion point for skin marking (Fig. 4).

Fig. 4. The gonion guide in position for locating and defining the gonion point.

Direct Facial Measurement with the Facial Goniometer

After the face has been properly prepared with the required skin markings, the patient *stands* before you with his profile side to you. Instruct the patient to keep his teeth together in centric occlusion. The thumb screw on the protractor head is loosened slightly so that the arms of the instrument can be moved if pressure is applied. The upper ruled arm is placed so that the lower edge of it is in line with the orbitale and tragion points, while the lower arm is cupped under the lower border of the mandible (Fig. 5). It can be adjusted in a simple manner. By moving the instrument back and forth, while opening and closing the arms, you will arrive at the proper angulation in a few seconds. When the

angle is correct, tighten the thumb screw. The instrument is now locked in position for the reading. The pointer arm of the protractor indicates the angle on the scale.

Before removing the instrument from the face, note the distance in inches on the upper ruled arm where it touches the tragion point. By reading the scale at this point, one may determine the distance from tragion to the intersection of the lines which form the Frankfort-mandibular angle.

For the measurement of the gonion angle adjust the facial goniometer as is shown in (Fig. 6).

Fabrication of the Facial Goniometer

The facial goniometer is a very simple instrument to make. The basic requirement is a protractor, similar to the General protractor No. 17 or No. 18 with an attached, adjustable pointer arm. This type of protractor has a thumb screw which makes it possible to lock the pointer arm at any angle from 0° to 180°. It can be obtained in a well stocked hardware store. One company makes this protractor in stainless steel, which is always a desirable feature.

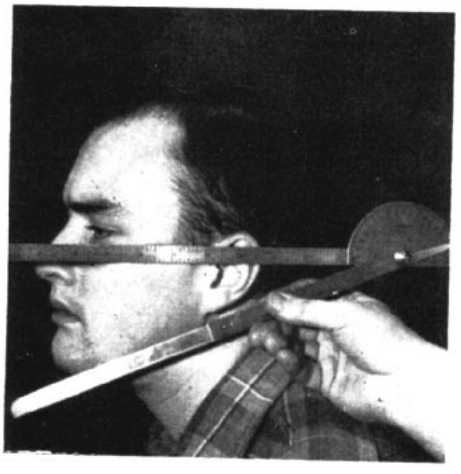

Fig. 5. The facial goniometer in position for measuring the Frankfort-mandibular plane angle. The upper arm is placed so that its lower edge is in line with the orbitale and the tragion points; the lower arm is cupped under the lower border of mandible.

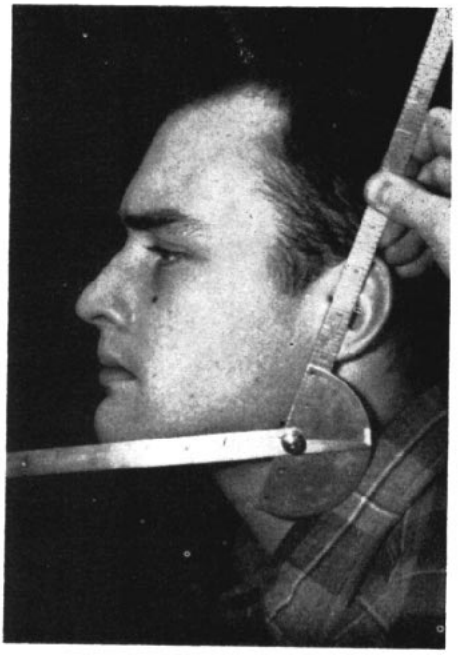

Fig. 6. The facial goniometer adjusted for the measurement of the gonion angle. The upper arm is placed so that it is aligned on its inner edge with the tragion and the gonion points; the lower arm conforms to the lower border of the mandible.

After obtaining the required type of protractor, it is advisable to visit a sheet metal shop where spotwelding is done. This type of shop is best equipped to provide and to attach the strips of stainless steel material on the protractor.

To make the upper arm of the facial goniometer, a strip of .049″ thick stainless steel material is cut to 14½″ x ½″. This piece is spotwelded to the under, unruled surface of the protractor head at its lower edge.

The lower arm is made of a strip of .037″ thick stainless steel 11″ x 1½″. This piece is bent on its 1½″ side to form a right angle with a 1″ side and a ½″ side. The ½″ side is spotwelded to the under side of the protractor

pointer arm 1¾″ away from the center of the thumb screw post. (If the lower strip were attached more closely than 1¾″ from the center of the thumb screw post, it would not be possible to close completely the arms of the instrument).

Care should be taken so that there are no sharp edges on the instrument. All corners should be rounded off and polished smoothly.

To complete the facial goniometer after the necessary sheet metal work has been done, an engraver should be requested to inscribe a 12″ rule, scaled in eighths of an inch, starting at the thumb screw post of the protractor and continuing along the upper arm. This scale should read from right to left, with the 1″ mark engraved close to the thumb screw post.

SUMMARY

Craniofacial measurements serve as a valuable adjunct in the everyday practice of orthodontics. Information gained from certain of these measurements should be known to the orthodontist as early as is possible in the examination of the patient — especially if he is required to render a preliminary or provisional diagnosis.

The measurement of the Frankfort-mandibular plane angle and the gonion angle is stressed because of its clinical importance in indicating the existence of abnormalities in growth and in determining prognosis. It will also signify the probable need for extracting teeth and the proper positioning of the mandibular incisors in treatment.

A new instrument, the facial goniometer, is introduced by the author. It is simple to make and is designed to give the orthodontist a quick yet accurate method for measuring the Frankfort-mandibular angle and the gonion angle directly on the face of the patient.

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