An Instrument for the Analysis of Facial Growth*

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In order to provide proper anatomical fit between the individual bones of the skull during composite craniofacial growth, the progressive enlargement of any one bone must be accompanied by corresponding, proportionate growth and remodeling changes of the others.[1] The instrument described in the present report was designed to (1) identify, (2) measure, and (3) to visually demonstrate the nature of these complex morphological *interrelationships and growth interactions* that exist among the separate bones during their respective remodeling processes.

Instrument Design

Ordinary cephalometric planes and lines are not used in the design of the instrument since they do not represent the effective dimensions of individual bones. Rather, the separate anatomical planes of the actual bones themselves (or the key parts of these bones) are utilized so that direct growth relationships between them may be studied.[2] These planes and dimensions correspond to the linear segments of the instrument as illustrated in Figure 1. They serve to identify (1) the horizontal plane of the mandibular corpus, (2) the horizontal plane of the ramus, (3) the vertical plane of the ramus, (4) the horizontal plane of the superior part of the nasomaxillary complex, (5) the horizontal plane of the inferior part of the maxilla, (6) the vertical plane of the anterior part of the maxilla, (7) the vertical plane of the posterior portion of the nasomaxilla, (8) the vertical plane of the cranial base, (9) the horizontal plane of the cranial base, and (10) the horizontal and vertical planes of the zygoma. Note that the vertical dimension of the nasomaxillary complex includes the separate nasal and maxillary arch portions.

The instrument was constructed so that its adjustable dimensions will fit most extremes in facial size within the six to fifteen year range. The segments were machined from stock aluminum bars and plates of appropriate size. These segments slide on one another so that they may be either expanded or shortened in length as needed. A "slide rule," tongue-in-groove dovetail assembly was used, as illustrated in Figure 2, and lock screws were provided for the sliding segments so that they can be firmly secured after individual adjustments. Beveled washers, machined to fit the tongue, were placed on the offset lock screws and serve to hold the segments by friction contact when the screw is tightened. A movable joint is located at all horizontal-to-vertical intersections. By releasing or tightening the screw that forms a pivot for each joint, its angle may be adjusted as desired. A hole was drilled in the center of these pivot screws and long, tight-fitting, pointed pins were placed through the holes. The pins are used as points for measuring the overall length of the adjustable segments. Five support legs are provided and are adjustable for height.

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* From the Department of Anatomy and the Center for Human Growth and Development, the University of Michigan. Supported in part by USPHS Grant DE-02272.

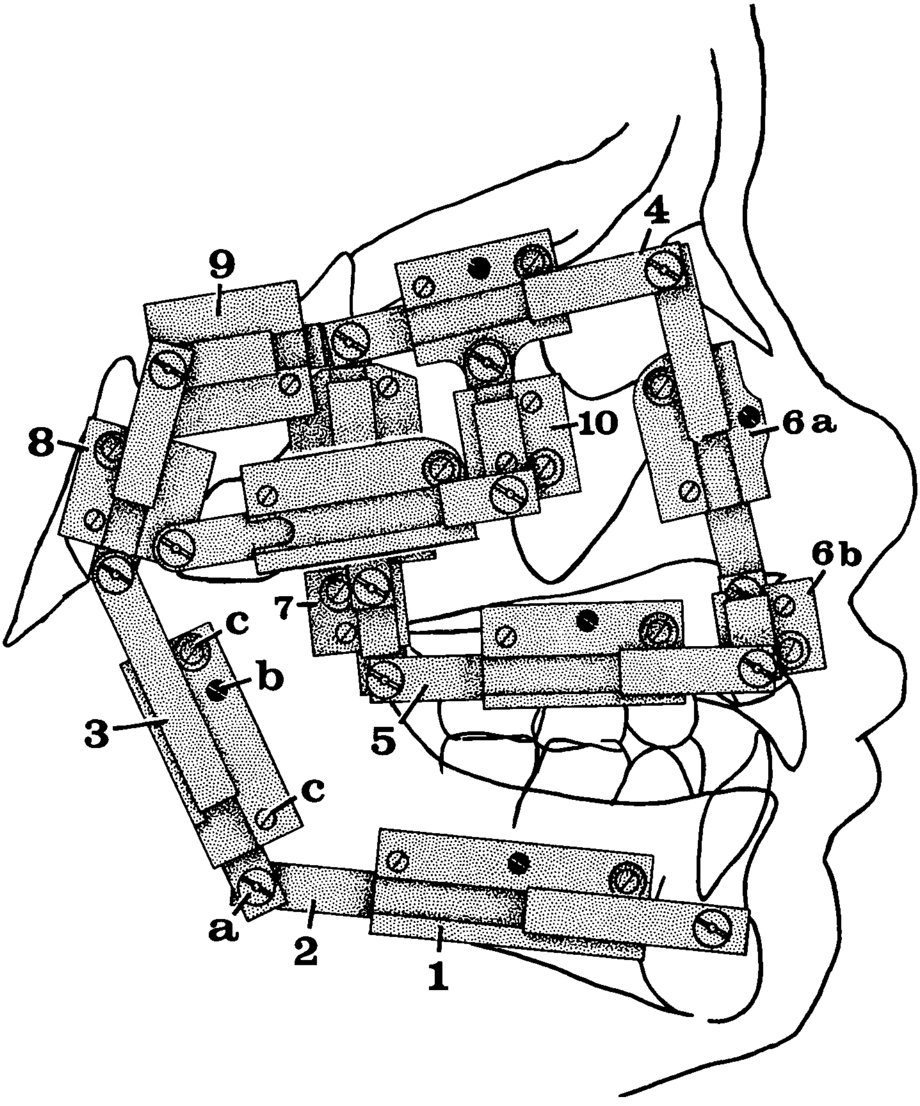

Fig. 1 The instrument has been superimposed over a headfilm tracing. No specific alignment with particular landmarks is intended in this illustration, since the instrument may be adjusted for any combination of anatomical points as desired. Each vertical-to-horizontal joint (*a*) has a marker pin in its center so that selected landmarks such as sella, nasion, gonion, or other similar anatomical structures can be precisely registered. Five adjustable support legs are provided (*b*), and the telescoping segments are secured by lockscrews (*c*). The following anatomical segments are included: the horizontal span of the corpus (1); the horizontal dimension of the ramus (2); the vertical dimension of the ramus (3); the superior horizontal part of the nasomaxilla (4); the inferior horizontal portion of the maxilla (5); the vertical nasal part of the anterior maxilla (6*a*); the vertical alveolar part of the anterior maxilla (6*b*); the corresponding vertical nasal and alveolar portions of the posterior maxilla (7); the vertical dimension of the cranial base (8); the horizontal part of the spheno-occipital complex (9); and the vertical and horizontal segments of the zygomatic arch (10).

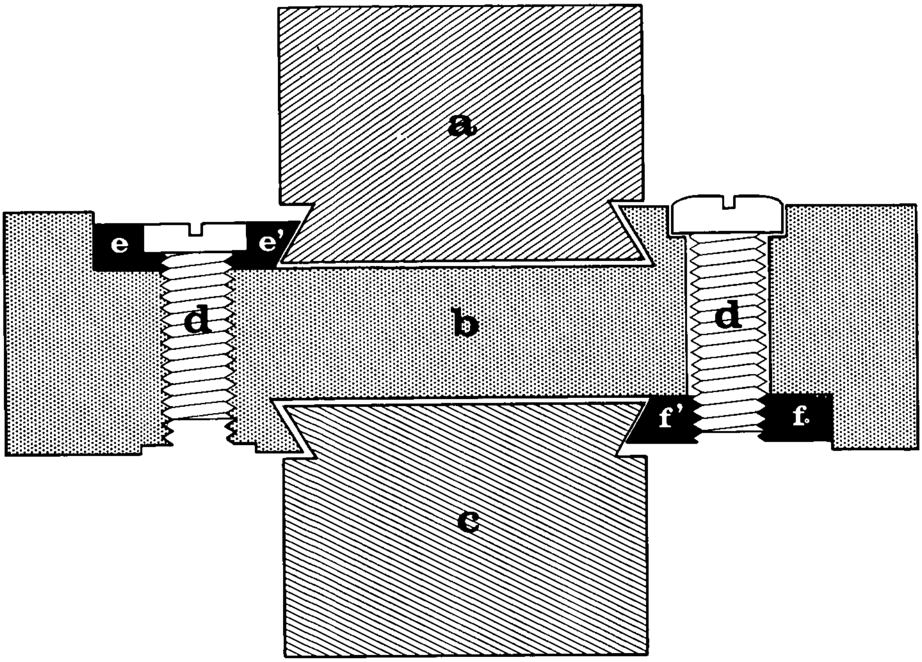

Fig. 2 The construction of the dovetail assembly is schematized in this sectional view of three adjustable, interlocking segments (*a, b, c*), such as those that comprise the corpus of the mandible (see Figure 1). By tightening or releasing the lockscrews (*d*) with their beveled washers (e, f), the assembly may be lengthened or shortened as needed.

The instrument may be placed directly over a headfilm or a tracing, and the various segments and angles can then be adjusted so that the points of the marker pins exactly touch corresponding anatomical landmarks on the headfilm.

Instrument Uses

1. A primary purpose is the identification and study of specific bones or parts of bones which are involved in interdependent "action and reaction" growth changes. For example, if the spheno-occipital portion of the cranial floor lengthens in its horizontal plane, what direct changes necessarily take place in the facial bones in order to balance this growth effect with regard to overall facial configuration? By manipulation of the instrument, dependent growth changes may be precisely *located* and *measured* for any given amount of cranial-base elongation. It will be found that the nasomaxillary complex is displaced (carried) anteriorly in conjunction with this particular growth change, but that the actual enlargement of the maxilla itself is not directly dependent upon it. However, in order to displace the mandibular corpus anteriorly to a corresponding position, it is shown by the instrument that the *ramus* of the mandible must necessarily lengthen horizontally to an extent that matches the elongation of that part of the cranial floor (the spheno-occipital portion) which parallels the ramus. The many other possible combinations of growth changes that take place throughout the different areas of the craniofacial skeleton may similarly be identified, demonstrated, and individually analyzed. The complex interrelationships between all of them can be visualized and studied in the same manner. It is pointed out that all three major regions of the face

and anterior cranium (the maxilla, mandible, and the cranial floor) must be included in such analyses in order to meaningfully interpret the overall process of composite growth.

2. This instrument is useful in testing ideas and hypotheses developed during the course of growth studies. For example, an investigator may wish to determine the possible effect of upward or downward occlusal plane rotation as a contributing factor to maxillary or mandibular protrusion. By simulating disproportionate vertical changes using this instrument, any desired degree of maxillary-mandibular arch rotation can readily be produced in conjunction with various other combinations of imbalanced growth. The results may be visualized directly, the basis and the extent of the consequent malocclusion may be determined and measured, and the nature of the relationships between the specific bones involved may be analyzed.

3. The dimensions in a headfilm or its tracing can be accurately duplicated by the instrument. Subsequent growth changes as observed in serial films may then be made, and the growth history of that individual can thus be reconstructed and evaluated for normal interrelationships between the bones and parts of bones. Also, the predicted extent of growth in a given segment or plane can be estimated by first providing any desired amount of growth in other selected segments and then adjusting the instrument for balance and "fit" between all the dimensions.

4. The instrument may be utilized in the analysis and clinical diagnosis of craniofacial imbalance. All of the various possible combinations that predispose a facial skeletal problem can be initially worked out and classified by trial and error with the instrument. The particular combination that underlies a given problem in an individual face may then be identified and evaluated. For example, it may be necessary to determine if the combined vertical dimension of a subject's ramus and contiguous cranial floor is associated in a direct way with a Class III situation. By duplication of the entire dimensional pattern of that individual with the instrument, or by reproducing his growth history if serial headfilms are available, the relationships of this particular dimension to the remainder of the craniofacial composite may then be studied and analyzed.

5. The anatomical planes represented by the linear segments of this instrument from a two-dimensional pattern may thus be recorded directly on a Grafacon tablet in the form of line designs.

6. The instrument is effective in teaching. It is helpful to the instructor and student alike in understanding or explaining the basic concepts of facial growth and, particularly, the complex interactions among the many separate parts as they continue to enlarge in relation to one another.

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2. Enlow, D.H., Moyers, R. E., Hunter, W. S., and McNamara, J. A., Jr.: A Procedure for the Analysis of Intrinsic Facial Form and Growth. *Am. J. Orthod.,* 56:6, July, 1969.