Orienting Dental Casts to Cephalometric Radiographs

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Dental landmarks common to casts and lateral radiographs are used to orient casts for analysis of three-dimensional dental measurements in relation to skeletal measurements derived from the radiograph. Orientation and measurement of casts is accomplished with a three-axis mounting and measuring device based on the principles of the larger craniostat.

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Two distinct methods of measurement have been commonly employed in the orthodontic study of dentofacial structures. The first involves obtaining direct measurements from the mouth, head and face of the live subject; this was popular with many early clinicians and research workers such as Hellman.[1]

The second is based on indirect measurements taken from radiographs or their tracings. Roentgen rays were first used in the anthropometry of the skull by Pacini[2] in 1922.

The need to standardize the images and make them more consistent and repeatable led Broadbent[3] to introduce the cephalostat to orthodontics. His original technique included a method for orienting dental casts to the radiograph, using a modified bite fork. This very difficult procedure has not survived in practical application. The method that will be described here accomplishes that result by a

much simpler method using dental landmarks common to both the casts and the lateral radiograph.

Broadbent and Brodie[4,5,6] used radiographic cephalometry to demonstrate individual dentofacial development with serial radiographs. Posteroanterior radiographs provided the third dimension in some of these studies, but these films provide limited information on dental dimensions.

Changes in dentofacial structures in the antero-posterior direction, as seen on lateral radiographs, and changes in dental arches as seen on study casts, have been examined separately over the years.

Analysis of vertical mandibular changes was greatly enhanced by Björk's[7,8] method of superimposition on recognized anatomical landmarks in the mandible, based on implant studies. The direction of condylar growth and the type and degree of mandibular rotation are two results of such analysis. However, the examination of many changes in the lateral dimension remained unresolved.

Many of the methods used in the analysis of dentofacial structures have been computerized in order to save time and expand analytical capability. This has been done with the idea of obtaining growth projections and even treatment plans. This is seen in large institutional data banks[9] and in publicly available service agencies.[10] The computerized methods utilize the lateral and/or the posteroanterior radiographic image.[10,11,12] They may involve such sophisticated equipment as semiautomatic or fully automatic scanners which can discriminate between as many as sixty-four shades of grey in the 40,000 segments of the field of view.

It would seem, however, that unless the same measurement is shared by each of the three dimensions, whether computerized or not, an absolute correlation is not possible. The closest approach to a three-dimensional analysis has been achieved in the clinical environment by "eyeballing" the standard lateral skull cephalometric radiograph in occlusion along with the dental study casts.

Orienting Dental Casts

The method to be described in this paper was developed in order to overcome the problems of correlating measurements from standard lateral cephalometric radiographs with dental study casts. It is a relatively simple method not requiring expensive sophisticated equipment.

As this method involves measurements within the dentofacial skeleton in all three dimensions of space, a base occlusal plane common to both standard lateral skull cephalometric radiographs in occlusion and dental study casts is established. Since some of the more commonly used occlusal planes are not capable of repeated accurate identification on both radiograph and cast, a modified plane is used for this purpose.

A point on the distal surface of the first mandibular molar is defined and is referred to as point Q (Fig. 1). This point is relatively easily established on the radiographs, tracings and dental study casts. When a double image is found on radiographs the midpoint is used. The plane selected on this basis is the line joining the mandibular incisor crown tip, point I^{14} to point Q.

On a standard lateral cephalometric radiograph in occlusion, or its tracing, the plane I-Q is established in addition to other required points and planes. Then a conventional orthodontic analysis and coordinate analysis are carried out. For this purpose the established plane I-Q is considered

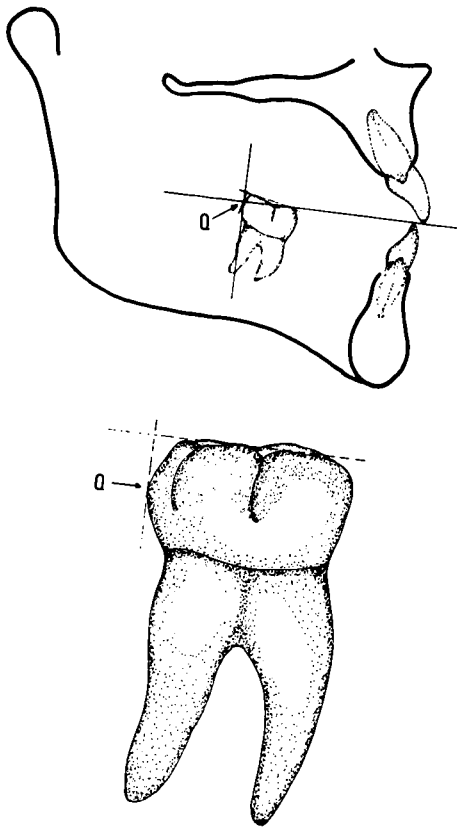

Fig. 1 The distal contact point of the mandibular first molar, defined precisely as the point at which the perpendicular to the occlusal surface of the tooth meets the distal contour, is referred to as point Q[23].

as the X axis for the coordinate analysis. A line drawn at right angles to this X-axis at point Q is established as the Y-axis. A typical tracing of a lateral radiograph is shown in Fig. 2.

Cast Measurement

The I-Q plane is established on the dental study cast using the instrument and its accessories to be described. This is based on the same exact points defined and selected on the lateral skull cephalometric radiograph. Unlike the radiograph, the point Q on the casts is not one point but two, on the first permanent molars of the mandible. Thus, when this plane is established on the dental study cast and the arch measurements made between those points, they are at right angles to the mid-sagittal plane. This provides measurements in the lateral dimension exactly correlated to the other two dimensions already available from the lateral skull cephalometric radiograph in occlusion.

Utilizing this technique, any required measurements can be carried out and related to those of the dental study cast. As an example, the vertical and anteroposterior coordinates of the mandibular cuspid crown tips can be related to the lateral dimensions of these same teeth on the dental study cast and to any other arch measurement such as the inter-cuspid distance.

This correlation of the measurements requires the orientation and measurement of dental study casts in the selected plane I-Q. Since commonly available measuring instruments are not sufficiently versatile, it was necessary to design special equipment for localizing the plane I-Q and making the appropriate measurements. The following criteria were considered in this design.

1) Easy accessability for clamping and changing the study casts.

2) Good visibility of the study cast.

3) The ability to change the orientation of the study cast to any required level or tilt.

4) Measurements to be made by moving the firmly clamped cast against a reference pointer adjustable in both the vertical and horizontal planes.

5) Each measurement to be taken as Cartesian coordinates.

6) Measurements to be made by the use of dial calipers, with the potential for future adaptation of more

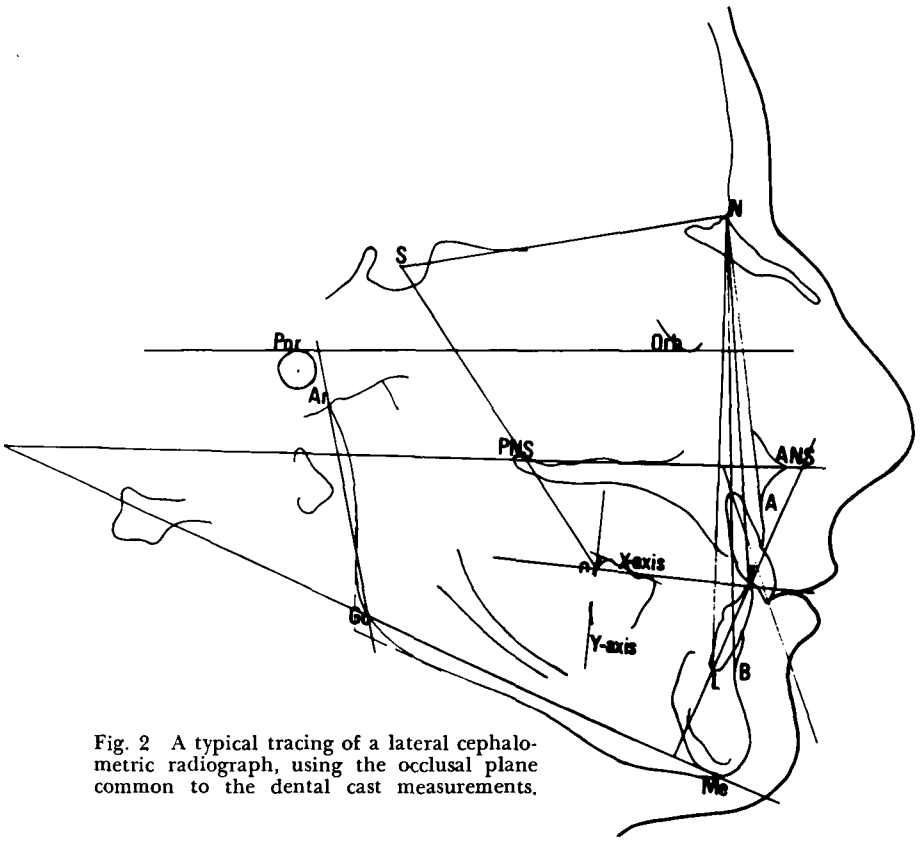

Fig. 2 A typical tracing of a lateral cephalometric radiograph, using the occlusal plane common to the dental cast measurements.

sophisticated equipment like displacement transducers, X-Y plotter, or scanner.

The instrument shown in Fig. 3 has an adjustable stage to support the cast and a freely movable vertical chuck supported on horizontal and vertical arms. Accessory T-bars and a straight pointer are attachable to this chuck for cast orientation and measurement.

A T-bar is a three-dimensional structure made of 0.5 mm stainless steel tubing in varying sizes so that one may be fitted to each cast with the stem of the T oriented to point I and the tips of the cross-bar to points Q. This establishes the occlusal plane on the basis of those three points. Two T-bars are shown stowed upside-down in holes at the left front of the instrument in Fig. 3. The T-bar fits into the spring-loaded vertical chuck of the measuring instrument, so that it is freely movable in the vertical plane.

During the measurement procedure, a T-bar of appropriate size for the cast is chosen and fitted to the chuck. The dental study cast is fixed firmly to the tilt-top table of the measuring instrument with the cast clamp screw and orientated on its universal joint to the selected occlusal plane of the T-bar. This establishes the selected plane on the dental study cast.

The T-bar is then removed from the vertical chuck and replaced by the

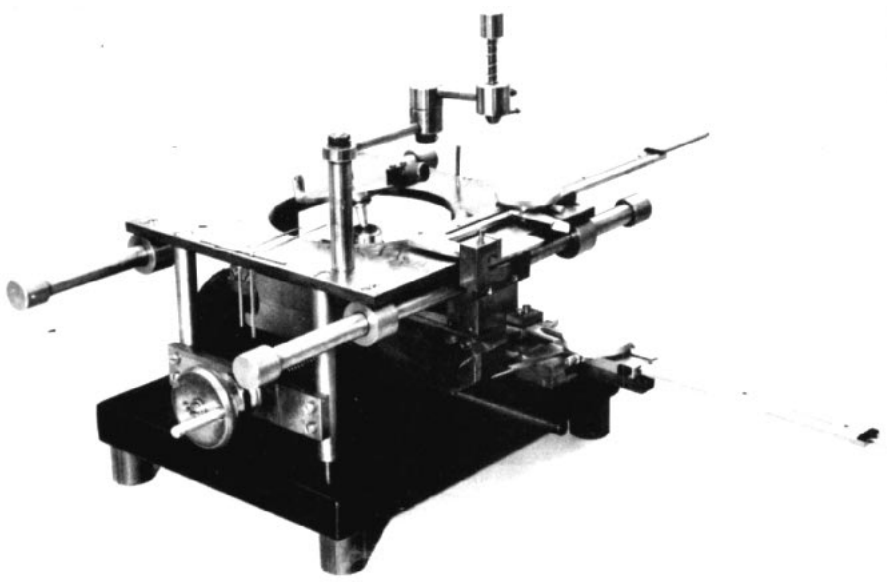

Fig. 3 The cast-measuring instrument.

pointer. By moving the dental study cast with reference to this pointer, the required measurements are read off the dial calipers fixed to the measuring instrument.

The movement on the two horizontal coordinates of the instrument is achieved by the attachment of drive mechanisms based on the rigid part of the structure. Dial calipers register movements to an accuracy of 0.02 mm.

Since the measurements are made on Cartesian coordinates, the distance between any two points 1 and 2 is given by the formula:

$$D = \sqrt{(x_1-x_2)^2 + (y_1-y_2)^2}$$

By this method, the measurements obtained from the analysis of lateral cephalometric radiographs or their tracings, corrected for enlargement, can be exactly correlated to the measurements of the dental study casts in the same individual.

Summary

A technique is described for relating dental structures to standardized lateral head radiographs in occlusion, through the use of oriented dental study casts. This is based on an occlusal plane which is common to both the radiograph and the dental study casts. An instrument has been described which enables the establishment of this defined plane and provides a means for obtaining arch measurements in that plane, supplying the third or lateral dimension to the two dimensions already available from the radiograph.

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