The Cant of the Occlusal Plane and Distortion in the Panoramic Radiograph

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Laminagraphy is a radiographic technique which permits projection, on X-ray film, of a selected plane of the body while structures outside the focal trough are blurred and not projected on the film. The fundamental principle of laminagraphy is that the X-ray tube and film move during exposure.[1]

Body section radiography had its inception in 1922 when a French patent was issued to Bocage. In the patent he described three methods of laminagraphy or planiography. In the first method, the tube and film moved reciprocally in straight lines along planes that were parallel to each other. In the second method, the tube and film moved reciprocally in circles, squares, crosses and in Archimedean spirals along parallel planes. In the third method, the tube and film moved reciprocally around an axis that was in the plane of the body to be recorded.[2]

Attempts were made at applying this principle to record the dental arches by using one center of rotation. This was not successful because the dental arch is not a true circle but a paraboloid curvature.[3-7] Recognizing this fact, Paatero in 1949 developed a technique to record the paraboloid dental arch using two centers of rotation, one for each side of the face. The left side was projected using an axis near the right molar region. The patient was shifted so that the same axis became positioned in the left molar region for projection of the right side. He originally applied the term pantomography to this technique.[8-11] These principles were later incorporated into the development of the Panorex® by S. S. White.

Several other machines are now available for panoramic laminagraphy. The Siemens Orthopantomograph® uses three centers of rotation and the GE Panelipse® uses continuously moving centers of rotation. This permits the tubehead and film cartridge to rotate around a constantly moving axis in a predetermined semielliptical path closely approximating the patient's dental arch.

Investigators have shown that there are certain distortions inherent in the panoramic laminagraph. Rowse found, in a study using the Siemens Orthopantomograph, that there were several types of distortion which varied in magnitude and type in different regions of the mouth.[13] Brueggeman used wires of known lengths with both a dry skull and a patient and found that the vertical panoramic image distortions remained fairly constant. However, the linear or mesiodistal distortions became increasingly larger as the measurement progressed posteriorly. Image distortions also occurred with improper positioning of the head, asymmetry of the dental arches, and movement of the patient during exposure.[14] Christen and Segreto, using 2.5 cm lengths of wires taped to a human dry skull found, as did Brueggeman, that changes in head position caused great variations in the degrees of panoramic image distortion.[15]

As panoramic laminagraphy has become more widely used, many orthodontists have used it as a means to determine the parallelism between the roots of teeth and the axial relationship of these same teeth to the occlusal plane (Fig. 1). This investigation stud-

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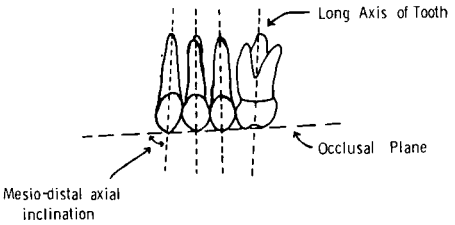

Fig. 1 Tooth relationships investigated in study.

ied the distortion of the panoramic image made by the S. S. White Panorex for these relationships. The variations found were related to changes in the cant of the occlusal plane when the panorex was produced.

Materials and Methods

The panoramic laminagraphic machine used in this study was the S. S. White Panorex unit. In this technique the film and tube rotate on an arc eccentric to the patient's midline and the patient is stationary. Midway through the cycle the axis of rotation is changed by an automatic shift of the chair and this results in the film being blurred in the midline.

The testing device was made of a portion of a protractor stabilized to a plastic base. The protractor was hinged so it could be adjusted to different angular positions. Mounted on the hinged portion were two sets of .018 x .018 rectangular wires. Each set consisted of a horizontal wire (labeled 0P) which had five wires spot welded to it at equal intervals perpendicular to the horizontal wire. The vertical wires were labeled to represent the teeth and extended equal distances below and above the horizontal wire (Fig. 2). The distance between each vertical wire was determined from statistical information taken from a series of fifteen orthodontically treated cases in the Department of Orthodontics at Louisiana State University. The arch widths were determined by measurements recorded by Hume[16] and Moorrees.[17] The angular relationships between the teeth were not reproduced but kept parallel for statistical simplicity.

In the testing sequence the device was placed on the chin rest of the Panorex machine (Fig. 3). A series of exposures were made at 5 Ma and 10 Kvp with the X-ray head in a vertically fixed position. The angular settings on the testing device were varied from —4° to +20° perpendicular to a line parallel to the floor. Kodak DK-75 film was used with Cronex Hi Plus

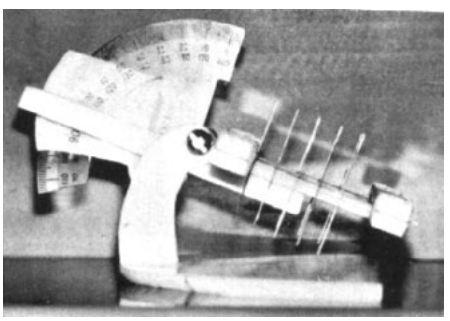

Fig. 2 Testing device. Protractor and soldered wires.

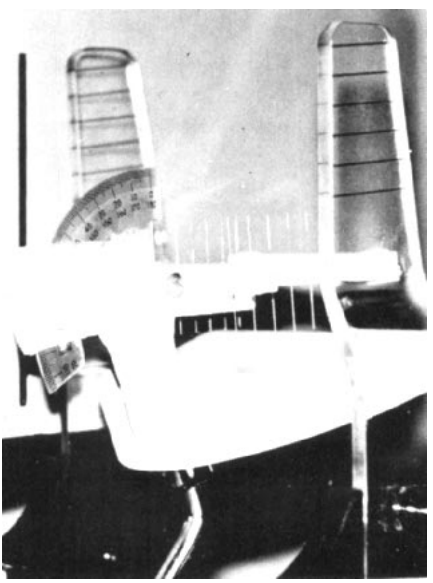

Fig. 3 Testing device in chin rest.

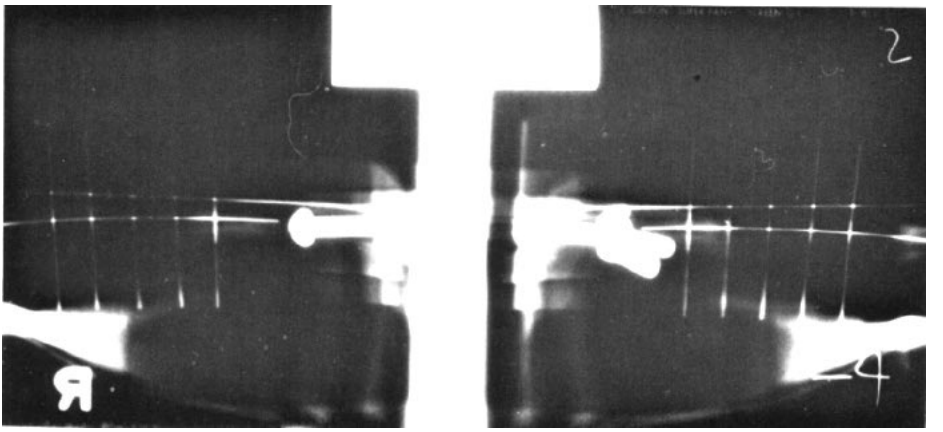

Fig. 4 Developed panorex of wires in testing instrument. Occlusal plane (OP) reading —4°.

screens. The film was developed in a Kodak RP-Xomat automatic processor with Kodak RP solutions (Fig. 4).

Measurement

The parallel wires were identified on the radiographs and labeled for measurement (Fig. 5). Each wire corresponded to a specific region of the mouth. Measurements of the angular relationships between the simulated teeth and occlusal plane were done directly from the radiographs with the use of a cephalometric protractor to the nearest 0.5 degree. Linear lengths were measured with a vernier caliper to the nearest 0.1 mm. All measurements were done in a completely dark room. These readings were transferred to a computer data recording sheet for analysis. Angular measurements of the wires to the occlusal plane, parallelism between adjacent wires, and the length of each wire were recorded (Fig. 6).

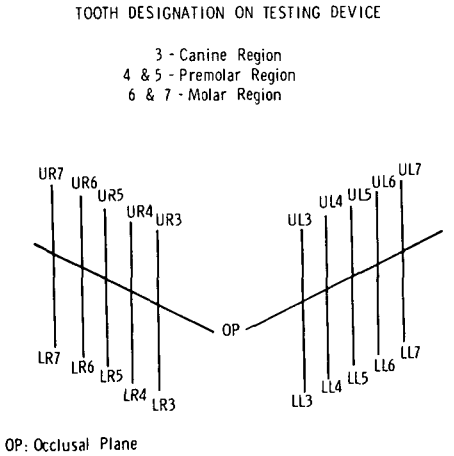

Fig. 5

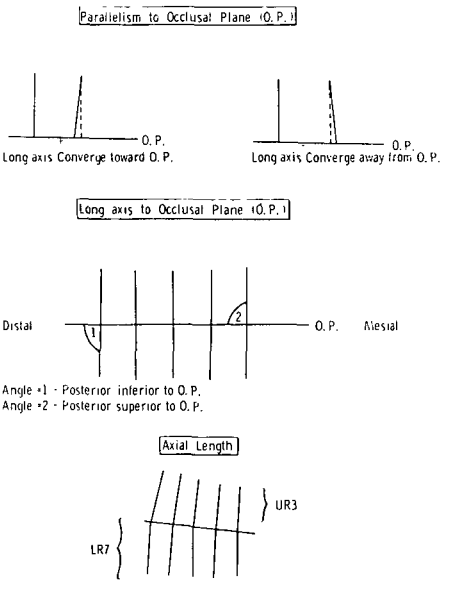

Fig. 6 Measurements of panorex image. Axial length, parallelism between wires and angular relationship to the occlusal plane.

Results

Parallelism between adjacent wires (Figs. 7 and 8)

In the maxillary arch the wires converged away from the occlusal plane as the testing device was adjusted from —4° to +20° to the occlusal plane. The canine region showed the largest range of variation (3.5°) from parallel. This region also had a high negative correlation coefficient of —0.90°. The premolar-molar region showed the smallest range (1.5°) and the lowest correlation coefficient was in the molar region. In the mandibular arch the wires diverged away from the occlusal plane as the OP changed from —4° to +20°. The canine-premolar area showed the greatest range (3.5°) and the highest positive correlation coefficient of +0.83. The smallest range of variation was in the molar region and the trend in the correlation coefficient was to decrease as you moved toward the molar region.

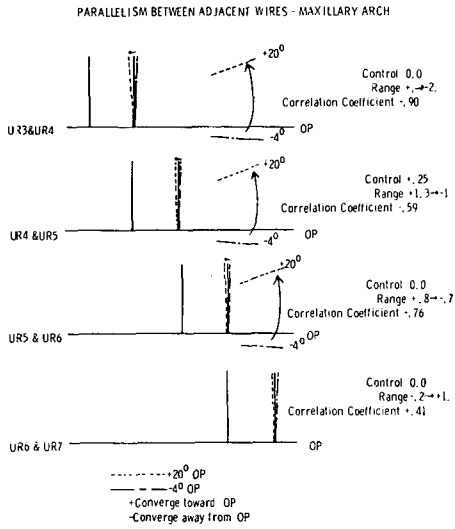

Fig. 7 The wires on the testing device were moved from —4° to +20° to a line parallel with the floor. The dotted lines indicate the movement of the wires on the panorex image of the maxillary arch.

Relationship of the long axes of the wires to the occlusal plane (Figs. 9 and 10)

All wires showed angulations toward the mesial in the maxillary arch. The canine region showed the smallest variation from the perpendicular (0.2°) to OP when the testing device was varied from —4° to +20°. The variation increased and the correlation coefficient increased in a positive direction mesially in the arch. The mandibular arch showed the wires to angulate toward the distal as the OP was increased. The canine region showed the least change and molar region the greatest change.

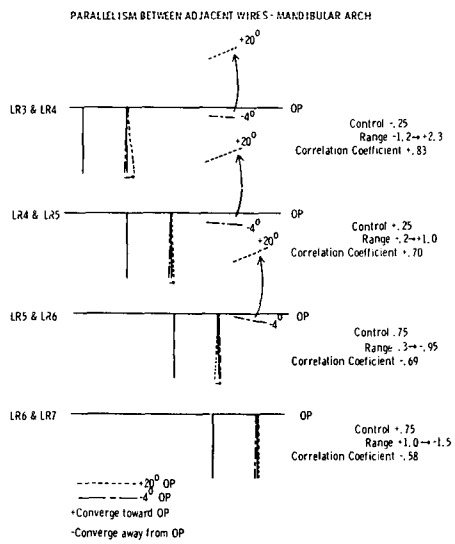

Fig. 8 The wires on the testing device were moved from —4° to +20° to a line parallel with the floor. The dotted lines indicate the movements of the wires in the panorex image of the mandibular arch.

Axial length of the wires (Table I)

In the maxillary arch the canine region showed the least elongation and a high negative correlation coefficient of —0.90. This represented a 25% magnification. Moving distally, the magnification became larger and the correlation coefficient dropped significantly.

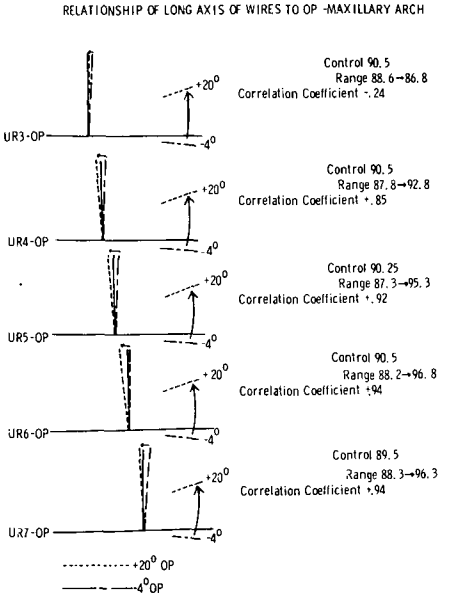

Fig. 9 The wires on the testing device were moved from —4° to +20° and the images on the panorex film were measured for their relationship to the occlusal plane in the maxillary arch.

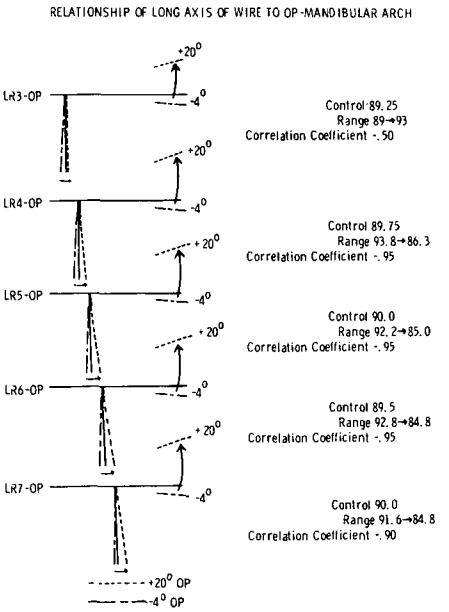

Fig. 10 The wires on the testing device were moved from —4° to +20° and the images on the panorex film were measured for their relationship to the occlusal plane in the mandibular arch.

AXIAL LENGTH

Wire *	Control (mm)	Panorex® Range (mm)	Correlation Coefficient of Panorex®
UL3 & UR3	20.40	25.50 - 23.63	-.90
UL4 & UR4	20.45	25.65 - 24.40	-.87
UL5 & UR5	20.40	25.70 - 25.18	-.92
UL6 & UR6	20.45	25.60 - 25.80	-.20
UL7 & UR7	20.50	28.00 - 24.80	-.05
LL3 & LR3	20.40	25.50 - 25.00	-.49
LL4 & LR4	20.30	25.66 - 25.30	-.48
LL5 & LR5	20.45	26.10 - 25.45	+.46
LL6 & LR6	20.40	26.25 - 25.55	+.25
LL7 & LR7	20.45	26.20 - 25.34	+.30

TABLE I

Measurement of the wire lengths when the testing device was at —4° and +20° to the occlusal plane and the active control measurement. Wires were used to represent the teeth.

The mandibular arch did not show such a large range of values between the different regions and there was also a low correlation coefficient for each of the areas. The magnification factor varied from 22.5% in the canine region to 28% in the second molar region.

Discussion

Since the Panorex laminagraph is in popular use among orthodontists as a means of determining root parallelism, it is necessary to understand what distortion is present and in what position the patient would have to be oriented to minimize this distortion. The type of distortion falls into three categories: (1) parallelism between teeth, (2) long axis to OP, and (3) elongation. All three types of distortion had a fairly high degree of correlation with the cant of the occlusal plane.

Parallelism in the canine and premolar regions showed a higher range of variability than the other regions and varied from 1.2° to 3.5°. Distortion of the long axes of the wires to the OP had almost an opposite relationship to parallelism with the canine and premolar regions showing the least amount of distortion and the molar region the greatest. The amount of elongation had a somewhat different pattern; all regions

of the mandibular arch showed about the same magnification (approximately 25%). In the maxillary arch the canine region showed the least elongation and the elongation increased in the molar area.

Using a statistical test (squares of differences) which shows the set of measurements that had the least variation from the control, it was found that the radiograph taken with the occlusal plane equal to +6° showed the least distortion.

All these data must be interpreted by the clinician who is using the Panorex to determine approximate relationships of the long axes of the teeth with one another. These differences of 2°, 3° or even 5° may not carry any clinical significance. However, he should understand that there is a certain amount of distortion with the Panorex laminagraph and that it varies in a positive or negative direction as the occlusal plane becomes steeper.

Summary

A study was undertaken to evaluate the type, amount, and place of distortion in the Panorex laminagraph from canine to molar. The effect of varying the cant of the occlusal plane on this distortion was also determined. The need for this study is the result of the orthodontists' popular use of the Panorex for determining root parallelism and obtaining diagnostic information without knowing the degree of distortion in such a laminagraph. On the basis of this study the following conclusions were reached:

1. As the occlusal plane is tipped from —4° to +20° in relation to a parallel line with the floor, the maxillary tooth roots converge away from the occlusal plane and the mandibular tooth roots diverge away from the occlusal plane.

2. The largest amount of distortion of parallelism is in the canine-premolar region of both arches.

3. The largest amount of distortion of the tooth long axis to the occlusal plane is in the molar region with maxillary teeth angulated to the mesial and the mandibular teeth angulated to the distal.

4. Head positioning in the chin rest is important and when the occlusal plane is located at +6°, there is the least amount of distortion.

5. Elongation was more pronounced in the maxilla and increased in the molar region. Magnification ranged from 22.5% to 28%.

6. The clinical significance of the distortion with the Panorex laminagraph is not important as long as the clinician understands that there is a small amount of distortion and that it varies with the cant of the occlusal plane.

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