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ORIGINAL RESEARCH

Cephalometric Assessment of Effect of Head Rotation toward Focal Spot on Lateral Cephalometric Radiographs

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ABSTRACT

Introduction: The patient's head can be slightly rotated sagittally vertically or transversely with the head holding device. Because of such improper positions due to head rotation, an error can occur in cephalometric measurements. The purpose of this study was to identify the projection errors of lateral cephalometric radiograph due to head rotation in the vertical Z-axis toward the focal spot.

Materials and methods: Ten human dry skulls with permanent dentition were collected. Each dry skull was rotated from 0° to +20° at 5° intervals. A vertical axis, the Z-axis, was used as a rotational axis to have 50 lateral cephalometric radiographs exposed. Four linear (S-N, Go-Me, N-Me, S-Go) and six angular measurements (SNA, SNB, N-S-Ar, S-Ar-Go, Ar-Go-Me, AB-mandibular plane angle) were calculated manually.

Results: The findings were that: (1) Angular measurements have fewer projection errors than linear measurements. (2) The greater the number of landmarks on the midsagittal plane that are included in angular measurements, the fewer the projection errors occurring. (3) Horizontal linear measurements have more projection errors than vertical linear measurements.

Conclusion: The angular measurements of lateral cephalometric radiographs are more useful than linear measurements in minimizing the projection errors associated with head rotation on a vertical axis toward the focal spot.

Keywords: Projection error**,** Head rotation, Lateral cephalometric radiograph**.**

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INTRODUCTION

Lateral cephalometric radiography has been widely used in orthodontics and in orthognathic surgery as an important descriptive, analytic and diagnostic technique. The development of cephalometrics has led to a growing need for exact location of landmarks to improve quantitative studies of craniofacial growth, quantitative evaluation of treatment effects and classification of cases.[1] A head holding device, consisting of an ear rod and nasal positioner, is used for lateral cephalometric radiography, to minimize the projection errors caused by head rotation in the vertical, transverse and anteroposterior axis. However, when the device is used to contact the external auditory meatus and the soft tissue of the patient, the head can be incorrectly positioned sagittally, anteroposteriorly or vertically, because the patient's head can be slightly rotated within the head holding device. Because of such improper positions due to head rotation, an error can occur in cephalometric measurements. Therefore, unless the projection errors are precisely evaluated and understood, cephalometric measurements may have only limited application in orthodontics.[2]

The research question framed for the present study was 'Does head rotation in the vertical Z-axis toward focal spot affects linear and angular measurements of lateral cephalometric radiograph?'

OBJECTIVES

1. To find out variation in cephalometric angular and linear measurement at different rotation of head toward the focal spot on lateral cephalometric radiographs.
2. To understand projection errors of lateral cephalometric radiograph.

MATERIALS AND METHODS

It is a cross-sectional descriptive study that will evaluate effect of head rotation of 10 human dry skulls on lateral cephalometric radiograph toward the focal spot.

Materials

1. 10 human dry skulls were collected from JJMMC Medical College, Davangere, on the basis of following parameters:
   a. Intact human skull and mandible (Fig. 1).
   b. It should have no gross asymmetry
   c. It should have permanent dentition in both upper and lower arches of minimum upto maxillary and mandibular first molars
   d. Sex, occlusion and skeletal pattern were not significantly considered.
2. Artificially prepared stand for seating of skull and adjustments were made with screws for complete stabilization in anteroposterior and transverse axis.
3. Stainless steel wires for attaching mandible to maxilla at glenoid fossa.
4. Cellophane tape for attaching cranial vault to the base of skull.
5. Steel balls of 1.0 mm diameter glued on each of 11 landmarks.
6. Bracket positioner is used to carry steel balls.
7. Glue for attaching steel balls on each of 11 landmarks.
8. Screw driver for fixation of skull to the artificial stand.
9. Custom-made protractor to indicate degree of rotation of head attached to the stand with a metallic indicator (Fig. 2).
10. Lateral cephalometric radiographs.
11. Lateral cephalostat machine.
12. Sharp metal pins were used for joining landmarks.
13. Measuring devices: Scale, protractor and setsquare.

Methods

Eight anatomic landmarks will be designated on human dry skulls before radiographs are taken. Steel balls of 1.0 mm diameter are glued on each of 11 landmarks including bilateral landmarks.

Fig. 1: The skull

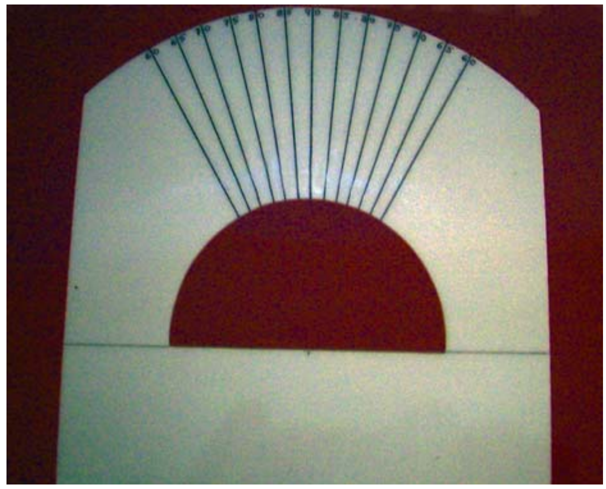


Fig. 2: Custom-made protractor

The land marks include:

a. S (Sella turcica) (Fig. 3)
b. N (Nasion) (Fig. 4)
c. A (Subspinale)
d. B (Supramentale)
e. Me (Menton)
f. Corpus left: The left point of a tangent of the inferior border of corpus.
g. Ramus down: The lower point of a tangent of the posterior border of ramus.
h. Ar (Articulare) (Fig. 5)

The skull is seated over the artificially prepared stand in such a way that FH (Frankfort horizontal) plane of skull will be placed parallel to the floor and is stabilized completely in anteroposterior and transverse axis by adjusting the screws. The mandible is attached to the maxilla at glenoid fossa by ligating with a stainless steel wire. A custom-made protractor is attached to the stand with a metallic indicator that indicates degree of rotation of head in a vertical Z-axis. The skull is placed in a lateral cephalostat machine and is further stabilized with ear rods and nasal positioner.

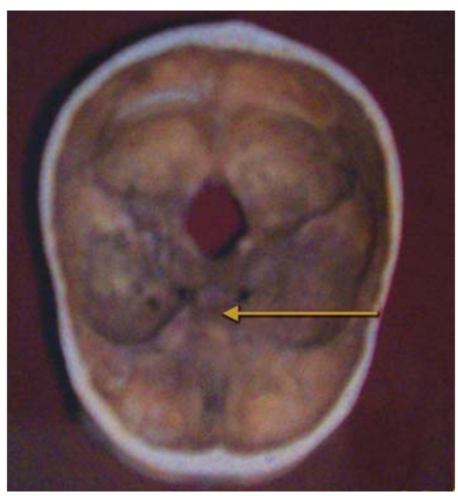


Fig. 3: Sella

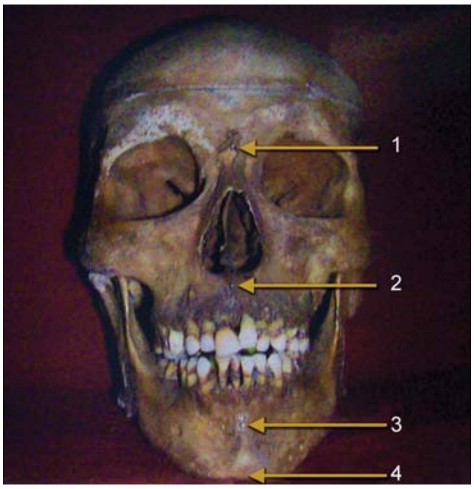
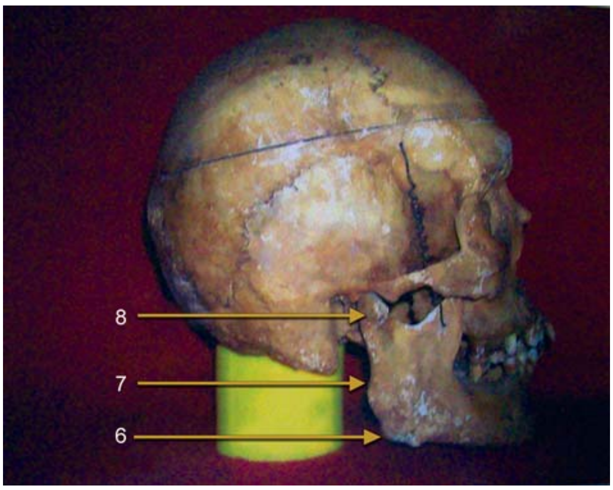


Fig. 4: Nasion (1), point A (2), point B (3) and menton (4)



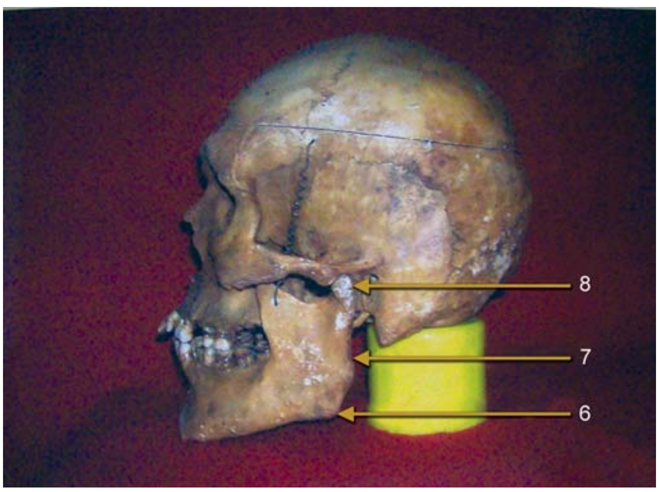


Fig. 5: Left and right sides of skull gonion (6), ramus down (7) and articulare (8)

The standard focus median plane distance of 60 inches was used respectively. Each skull is rotated from 0° (Figs 6 to 8) to +20° at 5° intervals. A vertical axis, the Z-axis, is designated as a rotational axis connecting the center of both ear rods in the direction of submentovertex and 50 radiographs will be taken based on this axis. The code + means rotation toward the focal spot.

Fig. 6: 0 degree

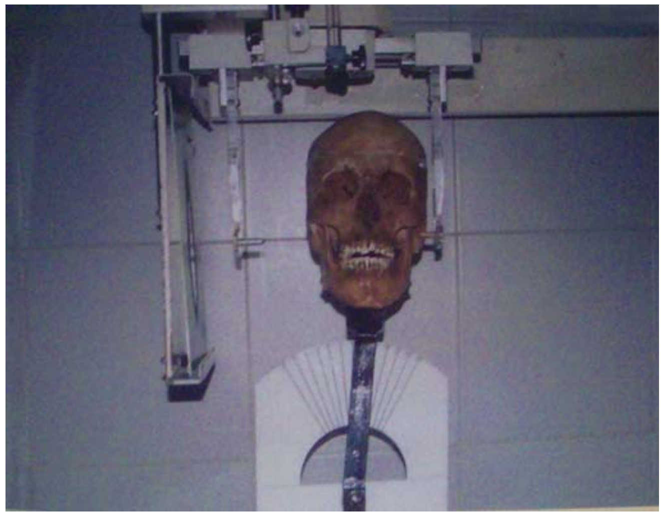


Fig. 7: +5 degree

Fig. 8: +20 degree

The point at which the steel balls on the landmarks including corpus left ramus down and articulare meet the bone surface is marked on the film with a sharp metal pin. Detailed measurements with length units in millimeter and angular units in degrees will be made manually.

Following linear and angular measurements were calculated from lateral cephalometric radiographs:

1. Linear measurements
   a. Horizontal measurements
      - Anterior cranial base length (S-N)
      - Mandibular body length (Go-Me)
   b. Vertical linear measurements
      - Anterior facial height (N-Me)
      - Posterior facial height (S-Go)
2. Angular measurements
   - SNA
   - SNB
   - Saddle angle (N-S-Ar)
   - Articular angle (S-Ar-Go)
   - Gonial angle (Ar. Go-Me)
   - AB to mandibular plane angle

RESULTS

The changes in the cephalometric linear and angular measurements occurring with 0° to +20° rotational angles are presented in Tables from 1 to 10.

1. Linear measurements
   a. Horizontal linear measurements
      - *Anterior cranial base length:* The anterior cranial base length was 67.9 mm at 0°. Its length increased and then decreased as the rotational angle toward the focal spot is increased.
      - *Mandibular body length:* The mandibular body length was 69.65 mm at 0°. Its length increased and then decreased as the rotational angle toward focal spot is increased. The degree of these changes was not significant.
   b. Vertical linear measurement
      - *Anterior facial height:* The anterior face height was 123.25 mm at 0°. Its length increased as the rotational angle toward focal spot increased. There was statistical difference in the measurement from 0° to each rotational angle toward focal spot ($p < 0.001$) and the maximum magnification was 2.3% at +20° rotational angle.
      - *Posterior facial height:* The posterior facial height was 80.15 mm at 0°. These was statistical difference in the measurement from 0° to each rotational angle toward focal spot ($p < 0.01$) and the maximum magnification was 1.6% at +20° rotational angle.
2. Angular measurements
   - *SNA:* SNA was 79.95° at 0°. There was no statistical difference existed in the measurements from 0° to each rotational angle toward the focal spot ($p > 0.8$).
   - *SNB:* SNB was 74.9° at 0°. There was no statistical difference in the measurements from 0° to each rotational angle toward the focal spot.
   - *Saddle angle:* The saddle angle was 131.6° at 0°. There was no statistical difference in the measurement from 0° to each rotational angle toward focal spot ($p > 0.5$).
   - *Articular angle:* The articular angle was 138.20° at 0°. There was a statistical difference in the measurement at +15°, +20° ($p < 0.01$) rotation toward focal spot.
   - *Gonial angle:* The gonial angle was 126.85° at 0°. There was a statistical difference in the measurement at +5°, rotation angle ($p < 0.01$) toward focal spot.
   - *AB to mandibular plane angle:* AB to mandibular plane angle was 73.9° at 0°. There was statistical difference existed in the measurement from 0° to +20° along with rotational angular toward the focal spot ($p < 0.001$).

Linear Measurement (mm)

Table 1: Nasion-sella

Skull no. 1-10	Rotation toward focal spot (degree)				
	20	15	10	5	0
Mean	65.2	65.8	66.1	68.2	67.9
SD	5.4	5.50	5.50	5.30	5.52
Error (%)	–4.1	–3.1	–2.7	0.4	0.0
*p-value	<0.05	<0.05	0.07	<0.05	–

Table 2: Gonion-menton

Skull no. 1-10	Rotation toward focal spot (degree)				
	20	15	10	5	0
Mean	68.25	68.9	69.85	69.8	69.65
SD	5.4	5.5	5.3	5.6	5.4
Error (%)	–2.0	–1.1	0.3	0.2	0.0
*p-value	<0.001	<0.01	0.17	0.28	–

Table 3: Nasion-menton

Skull no. 1-10	Rotation toward focal spot (degree)				
	20	15	10	5	0
Mean	126.1	125.35	124.7	123.95	123.25
SD	4.4	4.4	4.3	4.4	4.1
Error (%)	2.3	1.7	1.2	0.6	0.0
*p-value	<0.001	<0.001	<0.00	<0.01	–

Table 4: Sella-gonion

Skull no. 1-10	Rotation toward focal spot (degree)				
	20	15	10	5	0
Mean	81.75	81.3	81.15	81	80.5
SD	5.07	5.10	5.17	5.22	5.18
Error (%)	1.6	1.0	0.8	0.6	0.0
*p-value	<0.001	<0.01	<0.01	<0.01	–

Table 5: SNA

Skull no. 1-10	Rotation toward focal spot (degree)				
	20	15	10	5	0
Mean	80.00	80.1	80.4	80.1	79.95
SD	4.4	4.7	4.6	4.4	4.1
Error (%)	0.1	0.2	0.5	0.2	0.0
*p-value	0.82	0.54	0.15	0.39	–

Table 6: SNB

Skull no. 1-10	Rotation toward focal spot (degree)				
	20	15	10	5	0
Mean	74.3	74.6	74.65	75	74.9
SD	4.73	4.49	4.30	4.35	4.10
Error (%)	–0.8	–0.4	–0.3	0.1	0.0
*p-value	0.1	0.19	0.27	0.64	–

Table 7: Nasion-sella-articulare (N-S-AR)

Skull no. 1-10	Rotation toward focal spot (degree)				
	20	15	10	5	0
Mean	131.5	131.6	131.7	131.6	131.6
SD	4.64	4.66	4.69	4.68	4.45
Error (%)	–0.1	0.0	0.1	0.0	0.0
*p-value	0.54	0.86	0.66	1	–

Table 8: Sella-articulare-gonion (S-Ar-Go)

Skull no. 1-10	Rotation toward focal spot (degree)				
	20	15	10	5	0
Mean	140.0	139.5	139.1	138.6	138.2
SD	1.7	2.2	2.0	1.9	2.2
Error (%)	1.3	0.9	0.7	0.3	0.0
*p-value	<0.01	<0.05	0.54	0.11	–

Table 9: Articulare-gonion-menton (Ar-Go-Me)

Skull no. 1-10	Rotation toward focal spot (degree)				
	20	15	10	5	0
Mean	128.8	128.1	127.9	127.4	126.85
SD	8.5	8.5	8.3	8.5	8.4
Error (%)	1.5	1.0	0.8	0.4	0.0
*p-value	<0.01	<0.01	<0.001	<0.01	–

Table 10: AB/Go-Me

Skull no. 1-10	Rotation toward focal spot (degree)				
	20	15	10	5	0
Mean	75.6	75.0	74.6	74.3	73.9
SD	5.7	5.6	5.7	5.4	5.5
Error (%)	2.2	1.4	0.9	0.5	0.0
*p-value	<0.01	<0.001	<0.001	<0.05	–

For tables 1 to 10, *paired t-test: $p < 0.05$ = S; $p < 0.01$ = S; $p < 0.001$ = HS

DISCUSSION

Head rotation can occur in the anteroposterior axis, vertical axis and transverse axis. However, standardization on the anteroposterior and transverse axes is actually hard to achieve. Rotation on the transverse axis causes no distortion of images. Although the head rotates on the transverse axis, the location of head is parallel to the central ray, only the location of images on the film changes, but this does not cause a change of relationship between land marks.[3] However, rotation in the anteroposterior axis affects landmarks vertically, not horizontally.[5]

A major source of random errors in cephalometric investigations is usually the identification of landmarks.[6] This source of error was markedly reduced in the present study, due to the availability of placed sets of metallic markers (steel balls of 1.0 mm diameter) at the defined anthropometric points.

In the present study, the measurement values are different according to the direction of rotation because different planes have different magnification with different ratios.

Concerning projection errors of linear measurement, Ahlqvist et al[4] supposed that the effects of rotations on the anteroposterior and vertical axis may be identical. In their study using a computer model similar to the real dry skull, they found that rotation of ±5° from the ideal position resulted in errors of less than 1%, a margin that is usually insignificant and difficult to distinguish from other errors. However, the errors became significant at even a few degrees of rotation more than ±5°.

The projection error of the present study was different depending on the direction of rotation, contrary to the results of Ahlqvist et al.[4]

The anterior cranial base length and mandibular body length increased and then decreased as the rotational angle toward focal spot increased. This is thought to be due to an offset, because the farther from the film the head rotates, the more the image is magnified, and the rotation itself causes the shortening of the images. That is, if the image magnification caused by the greater rotation from the film is larger than the image reduction caused by the rotation itself, the length may be increased but in the reverse case, it will be decreased.

In the anterior facial height there was a statistical difference in the measurement from 0° to each rotational angle toward the focal spot ($p < 0.001$).

In posterior facial height, the difference was less than 1.6% at all rotational angles. The variation due to head rotation was the least among all the linear measurements.

The amount of rotational axis error was greater in the horizontal linear measurement than in the vertical linear measurements, especially in the mandibular body length. This may be because the landmarks of the mandibular body length are located farther vertically from the central ray and contains bilateral structures. When heads were rotated 5° toward the focus, each distortion value was not above ±1°. Moreover, most of the distortion values were less than ±0.5°. When 10° rotation was made toward the focus, the distortion increased, and the values were just within ±2°.

In summary, for the lateral cephalometric radiograph, 10° of head rotation to the focus produced the largest value possible. In reality, even 5° of head rotation is hard to find in a clinical procedure. In the present study SNA, SNB and saddle angle showed less than 1.6% differences at all rotational angle. Even the more distorted articular angle, gonial angle and AB to mandibular plane angle showed less than 2.2% difference. The projection errors of angular measurement did not exceed 2.2% difference at all rotational angles regardless of direction of angle and it was far less than that of linear measurement.

It should be borne in mind that the conclusions of this study are based on measurements from films taken of one particular human skull and it may be considered that skull morphology plays a part in the nature of any distortions produced by rotation and whether the same angular/linear distortions would take place if the measurements were obtained from a series skull exhibiting variations in skeletal pattern.

In conclusion, angular measurements of lateral cephalometric radiography are more useful than linear measurements to minimize the projection errors associated with head rotation on the vertical axis. For example, a combination of saddle angle, articular angle and gonial angle has greater diagnostic merit than facial height ratio in the Jarabak analysis.

Furthermore, considering the projection error caused by head rotation on the anteroposterior and transverse axes as well as the vertical axis, the lateral cephalometric radiograph may lead to an interpretation that is very different from the real condition of the patient. Therefore, in exposing films, the projection errors should be reduced as much as possible. The location of the patient's head should be represented consistently. In order to predict and analyze the change caused by orthodontic treatment and the growth, the film should be exactly processed and should be accompanied by further development of head positioning devices.

SUMMARY AND CONCLUSION

Angular measurements have fewer projection errors than linear measurements. The greater number of landmarks on the midsagittal plane that are included in angular measurements, the fewer the projection errors occurring.

Horizontal linear measurement increase and then decrease as the rotational angle toward the focal spot is increased. Horizontal linear measurements have more projection errors than vertical linear measurements according to head rotation.

In summary, angular measurements of lateral cephalometric radiograph are more useful than linear measurements in minimizing projection errors associated with head rotation on a vertical axis.

REFERENCES

1. McWilliam J, Welander U. The effect of image quality on the identification of cephalometric landmarks. Am J Orthod 1978;48(1):49-56.
2. Yoom YJ, Kim KS, Hwang MS, Kim HJ, Choi EH, Kim KW. Effect of head rotation on lateral cephalometric radiography. Angle Orthod 2001;71:396-403.
3. Ahlqvist J, Eliasson S, Welandes U. The cephalometric projection II: Principles of image distortion in cephalography. Dentomaxillofac Radiol 1983;12:101-08.
4. Baumrind S, Frantz RC. The reliability of head film measurements 2 conventional angular and linear measurements. Am J Orthod 1971;60(5):505-17.
5. Baumrind S, Frantz RC. The reliability of head film measurements 1. Landmark identification. Am J Orthod 1971;60(2):111-27.
6. Anlqvist J, Eliasson S, Wealander U. Effect of projection errors in cephalometric length measurements. Eur J Orthod 1986;10:353-61.

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