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Dimensional Changes of radiographic image

Chia-Tze Kao, DDS, MMS*
Tsui-Hsien Huang, DDS**

In diagnosis and treatment planning of orthodontic cases, the radiograph is a useful tool. For many reasons, the image of the radiograph might lose its accuracy. The purpose of this study is to determine in which conditions that the radiogram of the target is acceptable for the evaluation and analysis. The target is a box made of stainsteel wire. It is modified the dimension of the true skull. The target is rotated in 3 dimension (X-axis, Y axis and Z axis) 0 degree, 5 degrees and 10 degrees. The x ray pictures were taken and compared with the true target dimension and analyzed with the statistical method. The result shown that if the angulation of the target and film is withinthe 10 degrees rotation on any axis, the measurements are acceptable.

Introduction

Broadbent is the first one to use the Bolton orientator to correct projection distortion of points both on the middle sagittal plane and away from it.[1] A radiographic image is the two dimensional one of a three dimensional object. There may have dimensional changes when incorrective projection is performed. Tsao points out that measuring radiographic images without proper direction and coordination is in defiance of the first rule of measuring.[2] Adams attampted to standardize the amount of projective distortion at various target-film distances.[3] Ghafari studied the effect of film object distance on posteroanterior cephalometric measurements shows that a film-porionic plane distance of 13 cm could be adopted as a standard for taking posteroanterior cephalographs.[4]

In radiograph analysis, improper steps including technician's errors or patient incooperation will give a poor information to diagnosis. Baumrind and Frantz recognized the problems of reliability due to projective distortion, however still failed to assess the seriousness of logical flaw involved before he fed the radiographic cephalometric data into computer.[5]

Dental Department, Chung Shan Medical and Dental College.
*: Associate Professor. **: Lecturer
Corresponding Author: Dr. Tsui-Hsien Huang.
Dental Department, Chung Shan Medical and Dental College Hospital.
23, Section 1, Taichung Kang Road, Taichung, Taiwan, Republic of China. Phone: 04-2015111 exr. 2506
Fax:886-4-2367348.

The shape of head is a three dimensional object and seldem symmetric. In posteroanterior radiographic there may exist many diagnostic errors on radiograph. It may be caused by head rotation about the X, Y and Z áxes. The purposes of this study are to find out if the target is changed by its standardized projection position about the axes, would be accepted for clinical diagnosis.

Material and Method

In this study, the projected object is used the box as the head substitute. The box is made by 0.040 inches satinless wire in figure 1. To measure the different horizontal and vertical dimensional changes, the box was subdivided into several parts. The anterior horizontal compoments of box are A-B, B-C, D-E, E-F and G-I margins. The posterior horizontal compoments of box are J-K and L-M margins. The anterior vertical compoment of box are A-G, B-E, E-H and C-I margins. The posterior vertical compoments of box are J-L and K-M margins.

The object and film distance is as following: the distance (d2) between the mesial margin (J) of the box and film is 113 mm, the distance (d1) between the distal margin (AB) of the box and the film is 275 mm. The radiogram were taken with machine was set at 70kVp, 100 mA and 1/20 second.[2] The radiogram were taken by the same technician.

The projection were taken at the 0 degree, 5 degrees and 10 degrees rotation individually along the X axis, Y axis and Z axis. The film was placed on the viewbox and the image length of the margin was measured directly from cephalometric films. The image dimensions of 0 degree and 5 degrees, 0 degree and 10 degrees were calculated respectively and compared to the standard. The object/image ratio was calculated by using the true length of the line guage divided by image length. The simple regressional analysis was used to find the correlation of various factors.

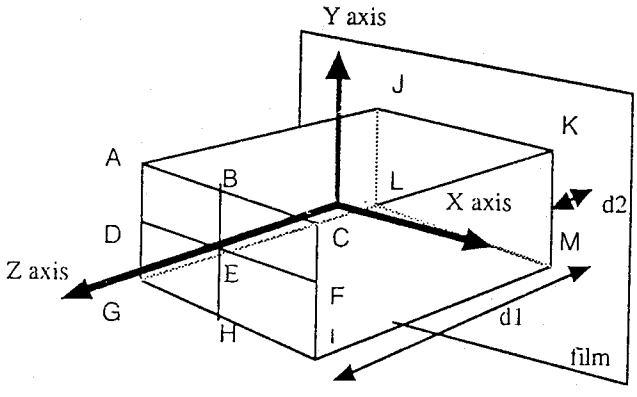

Figure 1. The landmarks of the object and the relation with the three axes. d1: the distance between the mesial margin of object and film. d2: the distance between the distal margin of the object and film.

Result

The object/image magnifying ratio is 86.21% for the anterior compoment and 96.15% for the posterior compoments.

The body/0 degree magnification of Y axis rotation, X axis rotation and Z axis rotation are 1.16 at anterior horizontal and anterior vertical compoments, 1.04 at posterior horizontal and posterior vertical compoments.

In Y axis rotation, the image change of 5 degrees is less than image of 10 degrees. When the rotational angle is increased, compoments distorted more on the far side from the film. (table 1)

In X axis rotation, the image change of 5 degrees is less than the that of 10 degrees. In 5 degree group, only anterior vertical components variate significantly. (table 2)

Table 1. The comparison of radiograph image along the Y axis rotation.

							Y axis			Y axis	
		Body	df(B-0)	0 degree	Magnification	df(B-5)	5 degree	df(0-5)	df(B-10)	10 degree	df(0-10)
Ant. Horizontal	A-B	75.5	12	87.5	1.16	−12	87.5	0	−11.5	87	0.5
	B-C	74	12	86	1.16	−12	86	0	−8	82	4
	D-E	75	12	87	1.16	−12	87	0	−11	86	1
	E-F	74	12	86	1.16	−10	84	2	−8	82	4
	G-I	149	24	173	1.16	−23	172	1	−20	169	4
Ant. Vertical	A-G	162	25	187	1.16	−26	188	−1	−27	189	−2
	C-I	162	25	187	1.16	−23	185	2	−27	186	1
	B-E	83	13	96	1.16	−13	96	0	−13	96	0
	E-H	80	11	91	1.16	−11	91	0	−11	91	0
Post. Horizon-	J-K	148.5	5.5	154	1.04	−4.5	153	1	−7.5	156	−2
tal	L-M	148.5	5.5	154	1.04	−5.5	154	0	−8.5	157	−3
	J-L	162	6	168	1.04	−6	168	0	−8	170	−2
Post. Vertical	K-M	162	6	168	1.04	−6	168	0	−5	169	−1

df(B-0): difference between body and 0 degree.

df(0-5): difference between 0 degree and 5 degrees.

df(0-10): difference between 0 degree and 10 degrees.

Table 2. The comparison of radiograph image along the X axis rotation.

						X axis				X axis	
		Body	df(B-0)	0 degree	Magnification	df(B-5)	5 degree	df(0-5)	df(B-10)	10 degree	df(0-10)
Ant. Horizontal	A-B	75.5	12	87.5	1.16	−12	87.5	0	−12	87.5	0
	B-C	74	12	86	1.16	−12	86	0	−9	85	1
	D-E	75	12	87	1.16	−12	87	0	−12.5	87.5	−0.5
	E-F	74	12	86	1.16	−12	86	0	−12.5	86.5	−0.5
	G-I	149	24	173	1.16	−25	174	−1	25	174	−1
Ant. Vertical	A-G	162	25	187	1.16	−26	188	−1	−24	186	1
	C-I	162	25	187	1.16	−26	188	−1	−24	186	1
	B-E	83	13	96	1.16	−12	95	−1	−11	94	2
	E-H	80	11	91	1.16	−12	92	−1	−12	92	−1
Post. Horizon-	J-K	148.5	5.5	154	1.04	−4.5	153	1	−4.5	153	1
tal	L-M	148.5	5.5	154	1.04	−5.5	154	0	−4.5	154	0
	J-L	162	6	168	1.04	−6	168	0	−6	168	0
Post. Vertical	K-M	162	6	168	1.04	−6	168	0	−6	168	0

df(B-0): difference between body and 0 degree.

df(0-5): difference between 0 degree and 5 degrees.

df(0-10): difference between 0 degree and 10 degrees.

Table 3. The comparison of radiograph image along the Z axis rotation.

						Z axis				Z axis	
		Body	df(B-0)	0 degree	Magnification	df(B-5)	5 degree	df(0-5)	df(B-10)	10 degree	df(0-10)
Ant. Horizontal	A-B	75.5	12	87.5	1.16	−11.5	87	0.5	−10.5	−10.5	1.5
	B-C	74	12	86	1.16	−11.5	85.5	0.5	−10.5	−10.5	1.5
	D-E	75	12	87	1.16	−12	87	0	−12	−12	0
	E-F	74	12	86	1.16	−12	86	0	−12	−12	0
	G-I	149	24	173	1.16	−23	172	1	−22	−22	2
Ant. Vertical	A-G	162	25	187	1.16	−25	187	0	−26	−26	−1
	C-I	162	25	187	1.16	−25	187	0	−26	−26	−1
	B-E	83	13	96	1.16	−13	96	0	−13	−13	0
	E-H	80	11	91	1.16	−11	91	0	−11	−11	0
Post. Horizon-	J-K	148.5	5.5	154	1.04	−5.5	154	0	−5.5	−5.5	0
tal	L-M	148.5	5.5	154	1.04	−5.5	154	0	−5.5	−5.5	0
	J-L	162	6	168	1.04	−6	168	0	−6	−6	0
Post. Vertical	K-M	162	6	168	1.04	−6	168	0	−6	−6	0

df(B-0): difference between body and 0 degree.

df(0-5): difference between 0 degree and 5 degrees.

df(0-10): difference between 0 degree and 10 degrees.

Table 4. The simple regression of all measurements.

		Intercept	Slop	t value	r	df
	B-0 Ant. H.	−0.03	1.16	638.64	1	3
	B-0 Ant. V.	−1.2	1.16	123.51	1	2
Y axis	0-5(H)	−0.02	0.99	76.65	1	3
	0-10(H)	−0.82	0.98	39.9	0.999	3
	B-5(H)	−0.06	1.15	81.7	1	3
	B-10(H)	−0.86	1.14	42.53	0.999	3
	0-5(V)	−0.5	0.99	62.04	1	2
	0-10(V)	−0.5	1.01	62.71	1	2
	B-5(V)	−1.3	1.16	78.24	1	2
	B-10(V)	−1.71	1.17	56.14	1	2
X axis	0-5(H)	−1	1.01	9002.85	1	3
	0-10(H)	−1.01	1.01	110.97	1	3
	B-5(H)	−1.04	1.17	596.34	1	3
	B-10(H)	−1.05	1.17	115.389	1	3
	0-5(V)	−0.92	1.01	92.17	1	2
	0-10(V)	0.12	0.99	62.59	1	2
	B-5(V)	−2.16	1.17	362.46	1	2
	B-10(V)	−1.11	1.15	126.94	1	2
Z axis	0-5(H)	0.5	0.99	88.13	1	3
	0-10(H)	0.51	0.99	264.44	1	3
	B-5(H)	0.47	1.15	232.21	1	3
	B-10(H)	0.48	1.14	85.26	1	3
	0-5(V)	0	1	999	1	2
	0-10(V)	−1	1.01	3539	1	2
	B-5(V)	−1.2	1.16	123.51	1	2
	B-10(V)	−2.22	1.17	127.98	1	2

All test are statistically significant at p=0.0001.
H: Horizontal; V; Vertical.
B: body of experiment.
0: 0 degree.
5: 5 degree.
10: 10 degree.

In the Z axis rotation, the image change of 5 degrees is less than that of 10 degrees. The posterior compoments do not change on 5 or 10 degrees rotation. (table 3)

In regressional analysis of all parameters show that all factor are high decision value(r). There are exist equation on each different measurement. (p=0.0001). (table 4)

Discussion

It is necessary to alwayse bear in mind that the concept of three dimenion of the head on analyzing the cephalogram. There are often existed errors on the analyzed results. Proper techniques can reduce the error between the object and image.

In Y axis analysis, as the rotation angle increased, the horizontal compoment magnificant is decreased while the vertical compoment magnificant is increased. In X axis analysis, as the rotation angle increased, the horizontal compoment magnificant has little change and the vertical compoment magnificant is decreased. In Z axis analysis, as the rotation angle is increased, the horizontal compoment magnificant is little change and the vertical compoment magnificant is increased. All results show that improper position of object will result false image.

When the facial asymmetry patient needs to take the posteroanterior cephalogram. It is difficult to decide the coorect projection position of the head. From this study, when proceeding the normal shooting technique, if the deviation of the facial midline is less than the 10 degrees, the result will still be acceptable. Also, if the projection and object is less than 10 degrees deviation on any axises, the results of the film analysis can be applied for diagnosis.

Conclusion

No matter when in taking the lateral or posteroanterior cephalogram, if the deviation of the object and film is less than the 10 degrees rotation on any axis, it is believed that the film can be given an acceptable informations.

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放射線影像變形之探討

高嘉澤*　黃翠賢**

臨床上，X光用於牙科臨床診斷中佔有重要的角色，尤其在矯正治療之診斷與治療計畫之決定。由於許多因素會造成影像失眞，間接會影響診斷之正確性。本研究目的乃欲了解於何種情況下會造成X光影像的誤差。作者以不銹鋼線製作與眞實顱骨大小相近之立方體。依照後前牖攝影之方式，將物體於三度空間下作0度、5度和10度之旋轉，再分別給於攝影。由X光影像大小與實物大小作一比較其統計學上的差異性。結果發現物體於10度內之旋轉，影像與實物之大小差異不具差異性。

中山醫學院　口腔醫學研究所*牙醫系**