The Effects of the Slit in Orthopantomography

Report 2. Comparison Between Orthopantomography and Ordinary Tomography

by

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Abstract

Orthopantomography for dental X-ray examinations is a kind of tomography which has a special characteristic different from any other tomographic methods. A comparative study of radiographic images formed by ordinary tomographic equipment with the attachment of slits devised by the authors and images produced by orthopantomography is presented.

As a result of comparing image-formation in orthopantomography with that of ordinary tomography using the same objects, (1) hardly any blur was observed inside the contours of the orthopantomographic image, (2) a very slight blurring effect of orthopantomography was observed on the slit side, (3) the slit played an important role in limiting the tomographic effect, and (4) consequently, orthopantomography may be considered as a very special type of tomography in the presence of slits.

Introduction

Orthopantomography is an improved version of pantomography developed in 1953 by PAATERO et al. [1–5], and it is now widely used in dental clinics as a radiographic method of investigating the dental arch. The method, therefore, has been studied widely and a number of studies have been published [6–17].

However, there are still divergent opinions about the process of forming the image, and no standardization has yet been achieved [18–24]. Because of this, the authors investigated the effect of the slit, an indispensable factor in image formation in orthopantomography, and are promoting research on this subject [23,24]. As part of this research, a comparative study of radiographic images formed by ordinary tomographic equipment with the attachment of slits devised by the authors and images produced by orthopantomography is presented.

Experimental Equipment and Methods

1. Radiographic Equipment

For the experiments, the orthopantomographic equipment, “Orthopantomo

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R-100" made by the Hida Electric Co. and the Polytome type U tomographic equipment made by Philips of Holland were used.

2. Objects

- 1) Philips test chart (down-scaled by half, angle of incline 30 degrees).
- 2) Aluminum cylinders (5, 10, 20 mm in height, 6, 15, 25 mm in diameter).

Using these two types of objects, settings were made so that the tomographic plane (To.P.) or the tomographic layer (T.L.) was in the center of the object (Fig. 1).

3. Exposure Conditions and Methods of Film Processing

1) Orthopantomography

Both types of objects were radiographed using the primary and secondary slits attached to the orthopantomographic equipment, and also after they had been removed.

'A' is the result with the primary and secondary slits attached, and 'B' is the result with the primary slit attached, but the secondary slit removed. 'C' is the result with both the primary and secondary slits removed. Before taking the radiographs, the tomographic layer of the equipment was obtained as a reference from the orthopantomograph test-chart made by Hida Electric Co. Then, setting each object on the anterior teeth, as shown in Fig. 1 (a), the radiographs were taken.

2) Tomographic Method

With respect to the presence or absence of the slits attached by the authors to the tomographic equipment, the conditions for taking pictures of the same objects as above were:

Fig. 1 Using these two types of objects, settings were made so that the tomographic plane (To.P) or the tomographic layer (T.L.) was in the center of the object.
a) Vertically placed on tomographic layer (or plane) in orthopantomography or tomography..
b) Parallely placed on tomographic layer (or plane) in orthopantomography.

Table 1 Exposure conditions

Radiographic method	Orthopantomography			Tomography				
	1, 2 slit +	1 slit + 2 slit -	1, 2 slit -	ZONO 10°	LINEAR 50°	LINEAR 50° with slit	CIRCULAR 36°	HYP0
Tube voltage (kVp)	71	58	55	52	50	48	52	52
Tube current (mA)	1.8	1.8	2.8	70	20	70	70	70
Filtration (mm)			Cu 0.48				Cu 0.43	Cu 0.43

+ : slit present

- : slit absent

A. Linear Tomography

- a. Linear Zonography 10 degrees (hereinafter abbreviated as ZONO 10 degrees)
- b. Linear tomography 50 degrees (hereinafter abbreviated as LINEAR 50 degrees)

B. Slit added to LINEAR 50 degrees, with its width fixed at 40 mm (hereinafter abbreviated as LINEAR 50 degrees with slit).

C. Other Tomographic Movement

- a. Circular movement tomographic angle 36 degrees (hereinafter abbreviated as CIRCULAR 36 degrees)
- b. Hypocycloidal movement (hereinafter abbreviated as HYP0).

Details of radiographic conditions, such as tube voltage, tube current, etc. are given in Table 1. For photosensitive material, Sakura A type film and Dupont Hi-plus intensifying screens were used for the orthopantomography, and Sakura A type film and Kyokko LT-II intensifying screens were used for the tomography.

For processing the exposed films, the Sakura QX-1200 automatic processor was used with standard conditions (processing time of 3 minutes and 30 seconds).

Results

1. Examination with "Orthopantom0 R-100"

A. Primary and secondary slits present

As shown in Fig. 2(a), when both the primary and secondary slits were used, almost no blur was found on the wire on the buccal side (film side) centered on the center wire of the test chart, so it was clearly observable, but on the lingual side (tube side), distortion to the right and left and a blur were observed. When both the primary and secondary slits were used, as shown in Fig. 3(a) and (b), the contours of the object were clear, but a slight blur was formed at the outer edges of the contours in the tube shifting direction.

B. No secondary slit

When only the secondary slit was absent, almost identical images were formed, as shown in Fig. 2(a) and Fig. 3(a) and (b), and the blur on the contours was slightly

(a)

(b)

Fig. 2 Orthopantomographs of the Philips Test Chart
a) Primary and secondary slits present.
b) Primary and secondary slits absent.

(a)

(b)

Fig. 3 Orthopantomographs of the aluminum cylinder. Primary and secondary slits present
a) Parallely placed on tomographic layer.
b) Vertically placed on tomographic layer.

greater than when both the primary and secondary slits were present. However, no great difference was observed between the results for the test chart and those for the aluminum cylinders.

C. Both primary and secondary slits absent

As shown in Fig. 2(b), only the center wire and the wires in front of and behind the center wire were clearly visible, while the wires ahead and behind them were recognized only as multiple blurred images.

The metal balls attached to the wires were recognized as blurred images following the direction of the tube shift.

When both the primary and secondary slits were removed, as in Fig. 4(a) and (b), the contours of the X-ray image formed by the aluminum cylinders, unlike those in Fig. 3(a) and (b), were accompanied by a blurred belt-like image countering the tube shifting direction.

2. *Tomographic Method*

A. Linear tomography

a. ZONO 10 degrees

As shown in Fig. 5(a), the number of wires observable on the test chart was large, showing the considerable thickness of the tomographic plane.

As shown in Fig. 6(a) and (b), the contours of the aluminum cylinders were also formed very clearly. However, a very slight blur was seen along the inner and outer sides of the tube shifting direction, producing a slight increase in width and diameter.

b. LINEAR 50 degrees

As shown in Fig. 5(b), only the center wire in the tomographic plane was observable on the test chart; all other wires were blurred.

As shown in Fig. 7(a) and (b), the contours of the aluminum cylinders showed contour-formation accompanied by a uniform and wide blurred image on the inner and outer sides, matching the tube shifting direction.

B. LINEAR 50 degrees with slit (slit width of 40 mm)

As shown in Fig. 8(a), the observable wires on the test chart image were more clearly visible than in ZONO 10 degrees, showing an increased thickness of the tomographic layer.

As shown in Fig. 8(a) and (b), the contours of the aluminum cylinders were clear. While a slight increase in width and diameter towards the tube shifting direction was noted, blur was hardly noticeable at the contours. The image obtained was similar to that in ZONO 10 degrees.

C. Tomography with other tomographic movement

a. Circular movement

As shown in Fig. 9(a), aluminum cylinder contour formation and circular blurred shadow around the contours along the tube focus shifting direction were found. But as shown in Fig. 9(b), the contours of the aluminum cylinders parallel to the tomographic plane were indistinct, because of the blur above and below.

(a)

(b)

Fig. 4 Orthopantomographs of the aluminum cylinder. Primary and secondary slits absent
a) Parallelly placed on tomographic layer.
b) Vertically placed on tomographic layer.

(a)

(b)

(c)

Fig. 5 Linear tomograms of the Philips Test Chart
a) Image obtained by linear zonography 10 degrees.
b) Image obtained by linear tomography 50 degrees.
c) Image obtained by linear tomography 50 degrees with slit.

(a)

(b)

Fig. 6 Linear 10 degrees zonograms of the aluminum cylinder
a) Vertically placed on tomographic plane.
b) Parallelly placed on tomographic plane.

(a)

(b)

Fig. 7 Linear 50 degrees tomograms of the aluminum cylinder
a) Vertically placed on tomographic plane.
b) Parallelly placed on tomographic plane.

(a)

(b)

Fig. 8 Linear 50 degrees tomograms with slit of the aluminum cylinder (slit width 40 mm)
a) Vertically placed on tomographic plane.
b) Parallely placed on tomographic plane.

(a)

(b)

Fig. 9 Circular 36 degrees tomograms of the aluminum cylinder
a) Vertically placed on tomographic plane.
b) Parallelly placed on tomographic plane.

(a)

(b)

Fig. 10 Hypocycloid tomograms of the aluminum cylinder
a) Vertically placed on tomographic plane.
b) Parallelly placed on tomographic plane,

b. Hypocycloidal movement

As shown in Fig. 10(a), contour formation was accompanied by a clover-like blur in the tube focus shifting direction on the inner and outer sides of the aluminum cylinders. Meanwhile, as shown in Fig. 10(b), the contours were indistinct as in Fig. 9(b).

Discussion

No special difference was found between the object contour depictions produced by orthopantomography with the primary and secondary slits. When only the primary slit or only the secondary slit was used, no difference was found between the X-ray images, which were almost the same as those produced using both the primary and secondary slits. This shows that the presence either of the primary or the secondary slit is enough to produce the desired effect. However, the primary slit serves to control the X-ray beam before it reaches the film, that is, the X-ray beam not containing data on the object, thus having a connection with the reduction of the quantity of the object's exposure to radiation.

The secondary slit, on the other hand, controls the X-ray beam containing data of the object and of scattered rays. This is a fundamental difference. However, as the X-ray image produced by using only the secondary slit shows less blur than that produced by using only the primary slit, the secondary slit may well play an important role in image-formation. This was already discussed in the studies [25] undertaken by TAKAHASHI et al., but no analysis has been undertaken.

When both the primary and secondary slits are removed, blur may be observed countering the tube shifting direction, thus forming part of the object contours (Fig. 4(a), (b)). This image formation is similar to that in a tomograph; it can be regarded as an over-blurred tomograph, or as a tomograph with an extremely thin layer.

2. Tomography

ZONO 10 degrees and LINEAR 50 degrees radiographs were taken of the same objects as for orthopantomography. The layer thickness is notable for ZONO 10 degrees, and contour-formation with little blurring was obtained, since the wires of the Philips test chart outside the tomographic plane and the aluminum cylinders were not adequately blurred. Meanwhile, the LINEAR 50 degrees layer proved to be not as thick as for ZONO 10 degrees, and only the center wire of the Philips test chart could be observed, all the other wires being blurred. With the aluminum cylinders, blur was formed in the direction of the tube, shifting inside and outside the contours. But in the case of orthopantomography without the primary and secondary slits, the Philips test chart image was accompanied by blur on the buccal wires around the center wire in the tube shifting direction, while all the wires on the lingual side were blurred. In the image of the aluminum cylinder, blur in the tube shifting direction around the contour was formed (Fig. 4(a), (b)). But when the primary and secondary slits were present, practically no blur shadow was observable inside the contour (Fig. 3(a), (b)). This is thought to have been caused by the limiting of the blur inside the slit, and this is how it differs from ordinary tomography.

When the slits prepared by the authors were added to LINEAR 50 degrees, the

Philips test chart formed a thick layer and an image similar to that produced by ZONO 10 degrees (Fig. 5(c)). In the case of orthopantomography, however, hardly any blur was observed on the buccal side of the center wire, but with the lingual side wires, blurring increased the closer the wire was to the lingual side (Fig. 2(a)). The formation of blur under the influence of the slits, even when the relative position of the focus, objects and slits is taken into account, is the way in which orthopantomography is thought to differ from ordinary tomography. In orthopantomography, in short, the existence of the slits is thought to minimize the blurring effect on the part of the object closest to the slit (buccal side) and to increase it considerably on the focus side. Meanwhile, with the aluminum cylinder image, an X-ray image similar to an orthopantomograph was obtained. However, the blur on the inside and outside of the contours that was observed with LINEAR 10 degrees was hardly observed because of the use of the slits (Fig. 8(a)), and an X-ray image similar to an orthopantomograph (Fig. 3(a)) was formed. The blur on the outside contour, however, was less than in an orthopantomograph. This appears to show that the blur around the contour diminishes as the slit is made narrower, and that the slit controls the blur.

In tomography, the contour outside the tomographic plane is extended and the image is formed as a multiple image of the contour on the tomographic plane and the blurring shadow that has been extended. But the blur on the tube side of the object and that on the outside of the tomographic plane of the film side differ geometrically and exert an effect on the object contour image on the tomographic plane. This means that in tomography, contour formation is accompanied by blur peculiar to the movement selected. For example, clover-like blur appears with Hypocycloidal movement (Fig. 10). Tomography is thus a method of obtaining an X-ray image by clarifying the image in the target area and blurring the contours above and below the target area. Materialization of a blur, however, takes place on the geometric background, and it varies with different factors, such as the speed of the tube, the film and the tube shifting direction.

Orthopantomography is a tomographic method, and the contours are clear with this method because of the presence of the slits, which limit the tomograph depiction to a certain area. The contours are thought to be clear because of the limiting of the tomographic effect. In a series of research reports [26–28] on rotatory cross-section radiography, TAKAHASHI et al. claim that the principle effect of the slits is the reduction of scattered rays, and while there are still many obscure points in the effect of the slits, there is no doubt that they play an important role in the formation of images.

The slit gives rise to an appropriate blurring effect, and this effect, unlike the blur natural to tomography, is slight near the slit and well-marked on the tube focusing side, as was shown in the experiment. The alteration of the slit width in orthopantomography is effective for obtaining either a simple radiographic or a tomographic image. In other words, it is conceivable that a radiograph obtained in the presence of slits can be a simple radiograph or a tomograph.

Conclusions

As a result of comparing image-formation in orthopantomography with that of ordinary tomography using the same objects, the following conclusions were drawn:

1. Hardly any blur was observed inside the contours of the orthopantomographic image.
2. The very slight blurring effect of orthopantomography was observed on the slit side.
3. The slit plays an important role in limiting the tomographic effect.
4. Consequently, orthopantomography may be considered as a very special type of tomography in the presence of slits.

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