Comparison of triple image area using panoramic radiography of child and adult dry skull


**ABSTRACT.** Aim** The objective of this study was to compare the zone of simple, double and triple images in a dry infant cranium against an adult completely formed one when panoramic X-ray photography’s were taken. Study design: We took 96 panoramic X-ray photography’s to a dry infant cranium placing a metallic spherical object of 8mm in different anatomical points for later to observe, identify and analyse the image of the object in each of them and determine if the images appeared as simple, double or triple. Results: The 57.15% of images obtained were simple, 16.66% were double and 26.19% triple. The area of triple and double images in the infant cranium did not involve anatomical important structures. Conclusions: The area where triple and double images appear was located in the occipital part in the infantile cranium with respect to the adult skull. On the basis of these results we can suggest that the X-ray photography must not be used as the main radiological support in the making of decisions in patients with craniofacial alterations.

**KEYWORDS:** Panoramic radiography; Skull; Infant; Craniofacial development.

Introduction

The panoramic radiography is an examination that produces an image of the face structures. Since the 60’s it has been registered an increase in the use of the panoramic radiography as popular study. Monsour [2000] considered the panoramic radiography as an invaluable tool for the dentistry of that time, while in the 90’s Mc Donald and Avery [1993], according to the American Association of Pediatric Dentistry and the FDA, recommended its use as a diagnostic means to evaluate the growth and maxillofacial development in children with transitional teething.

The main advantages of the panoramic radiography are the following.

1) The wide image of the anatomical region.
2) The relatively low radiation dose administered.
3) The relative convenience, facility and speed with which the procedure can be executed
4) The fact that it can be used in patients who are not able to open their mouths.

The panoramic radiography is more commonly used when the extension of jaw is desirable, for example, in edentulous patients, subjects who do not tolerate intraoral procedures or with known or suspected diseases.

Experience proved that patients tolerate this study well.

The time to complete the acquisition is short, usually between 3 and 4 minutes, including patient positioning and exposure time. Nevertheless, this study also has some disadvantages [McDavid et al., 1983], determined by a phenomenon commonly observed in the panoramic radiography: the appearance of a structure in more than one position. This happens when the object is intercepted more than once by the X-rays passage during the movement of the scan. This can create different types of images depending on the
location of the object with respect to the movement of the radiation. A real image is formed when the object is located between the center of rotation and the film. An object will be portrayed with a minimum distortion and deformation when it is near the plane in the center of the layer. On the other hand, this will be portrayed with a considerable deformation and distortion when it is remote from the plane. In each case, the image is real as long as it describes an object located between the center of rotation and the film.

A double image is formed when a pair of images of an object is produced by a ray that hits the object twice. The only important advantage of this phenomenon is that a simple image could be used to locate any abnormalities or objects in the anterior region towards the labial or lingual side with no need of another vision in contrast with all the other localisation techniques. This results in a significant decrease in radiation exposure. A ghost image forms when the object is located between the source of X-rays and the center of rotation.

If the portion of the ray intercepts a determined object when it is between the center of rotation and the film, the ghost image will have a real duplicate which might be visible depending upon the distance of the layer plane and the object’s contrast.

The anatomical structures that generally appear as ghost images include the hyoid bone, the cervical thorn, the inferior edge of the jaw and the later edge of the branch, the auditive canal and the mastoid apophysis. Other ghost structures are the rest of the chin and the right and left edges of some apparatuses, as well as earrings, pins, necklaces and hearing prostheses.

The approach corridor is a three-dimensional curved zone, in which the structures are well defined on the panoramic radiography. The objects located at the front or back of the approach corridor appear blurred, magnified or reduced in their size and some distorted to such degree of not being recognized; that is to say, the approach corridor is that region in which the structures will be revealed more accurately. When the mandible is displaced from its optimal position to the posterior side in the corridor of approach near the X-rays source, the ray passes through slower than normal. As consequence, the image becomes horizontally elongated on the film.

On the other hand, when the mandible is displaced to the anterior side, near the film, the ray goes through faster than usual through the anterior structures resulting in the observation of horizontally compressed teeth on the film [Goaz, 1987].

Some authors have reported the appearance of ghost images within the panoramic radiography when the structure of interest lies in definite positions within the mandible [Mounsour 1990], while others mention the influence of the position of the true object with respect to the center of rotation [Sewerin, 1990]. It has been demonstrated that the dimensions of the ghost image show the distance between the center and the real object. When the height is uniform, the real object is the base of the center of the rotation. A ghost image can appear narrower or wider than the true structure, when the dimensions are different in several angles of vision.

According to Reuter and collaborators, triple images are formed when the object is located in ana rea where it is intercepted three times by the ray. According to their investigation, this area has a diamond-like shape [Reuter et al., 1999].

In the investigation performed by [Márquez et al., 2001] 18 panoramic X-rays were taken to an adult human dry skull; one of them served as control when comparing it to the other 17 in which a special device was placed so that identification of the X-rays was possible. The device was placed in strategic anatomical points on the dry skull to observe the projected images of the object in the X-ray and to assess if the image that appeared was a real, a double or a triple image. The diamond area, where the triple images form, turned out to be smaller in comparison to the one described by Reuter. Thus, it was inferred that the panoramic radiography is a reliable tool to elaborate a diagnosis for adults. However, because of the appearance of unreal images (double and triple images) they concluded that the panoramic radiography has a limited use, and the diagnosis had to be corroborated by another type of examination [Márquez et al., 2001].

The skull of the infants is different from the adult skull; as the child develops the skull modifies its dimensions accordingly to the patterns of growth and development, displaying a great complexity. The anterior cranial fossa around the age of 10 reaches complete growth unlike the medium cranial fossa, which keeps growing until adulthood, increasing its cross-sectional distance to the posterior cranial fossa. The sphenooctipital synchondrosis is one of the main centers of cartilaginous growth of the base of the skull, where ossification continues until the age of twenty.

The main objective of this study was to determine if the area of triple images in the panoramic radiography of the infantile dry skull are similar to those observed in the adult dry skull. In addition, it is a purpose of the investigation to identify if this zone involves important anatomical structures.
Materials and methods

This research was performed using an X ray panoramic PANEX-EC (J. Morita Corporation) model X100EC-9405 of 1980 of 110 kilovolts (kV) and 20 milliamperes/second (mAs). The radiographic technique consisted of 4mAs with 80 kV with a exposure time of 15-17 seconds using soft chasis universal Kodak film sensitive to the green, with manual revealing using the time-temperature method (24º C and 1.5 minutes of revealing). In total, 96 panoramic X-rays were taken, using right-left and left-right trajectories, to an infantile dry skull (approximately 10 years of age) selected by the evaluation of the dental eruption. Ten X-rays were used for the calibration of the radiographic technique, two X-rays served as control; the remaining panoramic X-rays were taken placing a spherical metallic object of 8mm of diameter in different anatomical strategic points later to observe, to identify and to analyse the image of the object in each one of them.

The dry human skull was placed following manufacturer instructions. The Frankfort plane of the cranium must be parallel to the floor while the sagittal plane should be perpendicular to the floor. We prevented occlusion placing cotton rolls between the upper and lower central incisors, and the cranium was immobilised with a support placed on the forehead with a block of clay 5 mm thick and two lateral supports were used to prevent skull’s movement, helping the ray to reach it with a -10º angle.

The sequence of exposure begins at the mastoid apophysis, continues towards ahead, following an elliptical trajectory similar to those of the mandibular arches and ends at the opposite side of the mastoid apophysis. The beam crosses the ascending branch and condyle in an oblique form, exposing the dental arches perpendicularly to diminish the superposition of teeth. In order to obtain a suitable panoramic X-ray the skull was placed appropriately and on guard with the head carefully aligning with the focal corridor.

The X-rays taken with the metallic object were analysed and compared visually with the control X-rays to establish the number of images present. Using a digital camera, HP photosmart 945 of 5, 3 MP, photographs were taken from the metallic object in each of the infantile dry skull’s poistions, and of the 88 obtained X-rays.

For the design of the scheme, the skull in caudal-cranial direction was photographed to obtain a general vision of the base. The camera was stabilised with a support with leveling of position. The skull was stabilised on a circular support and leveled with a bubble level to leave the plane of Frankfurt parallel to the floor.

The images were considered as simple when the study object was projected a single time on the panoramic X-ray. The images were considered double when the study object was projected twice on the panoramic X-ray. Finally, triple images were considered those in which the study object was projected three times on the panoramic X-ray.

The dimensions of the area of triple images on the infantile dry skull were defined by means of the anatomical points used during the investigation when three images appeared when the object was placed in these points. The images’ clarity was defined as the geometric characteristic that refers to the ability of the X-ray film to produce the contour of the object of study. Isomorphism was defined as the same repeated form of an object without distortion.

The 42 anatomical points used were the following. 1. Upper maxillary (the anterior portion between the central incisors at cervical level). 2. Incisive fosse. 3. 1 cm in front of the posterior nasal spine. 4. Posterior nasal spine. 5. Spix spine of the right side. 6. Spix spine of the left side. 7. Right maxillary tuberosity. 8. Left maxillary tuberosity. 9. Angle of the right branch of the mandible. 10. Angle of the left branch of the mandible. 11. Upper portion of the external face of the right internal pterygoid lamina. 12. Upper portion of the external face of the left internal pterygoid lamina. 13. Bottom of the pterygoid fossa of the right side. 14. Bottom of the pterygoid fossa of the left side. 15. Internal pole of the right condyle. 16. Internal pole of the left condyle. 17. Posterior side of the left mandibular condyle. 18. Posterior side of the right mandibular condyle. 19. Right oval foramen. 20. Left oval foramen. 21. Right side of the mandible at cervical level of the first permanent molar. 22. Left side of the mandible at cervical level of the first permanent molar. 23. Left sinus maxillary junction. 24. Carotid canal of the right side. 25. Junction of vomer bone with the inferior face of the body of the sphenoid. 26. 0.5 cm behind the junction of vomer with the inferior face of the sphenoid body. 27. Vertex of the mastoid apophysis of the right side. 28. Vertex of the mastoid apophysis of the left side.
29. Outer hearing duct of the right side.
30. Outer hearing duct of the left side.
31. Anterior left spine hole.
32. Basion point.
33. 1 cm in front of the basion point.
34. 1 cm at the back of the basion point.
35. Internal and anterior rim of the condyle on the right side of the occipital bone.
36. Internal and posterior rim of the condyle on the left side of the occipital bone.
37. External rim of the condyle on the right side of the occipital bone.
38. External rim of the condyle on the left side of the occipital bone.
40. Condylar fossa of the left side.
41. Carotid duct of left side.
42. Rasgado anterior hole of the left side.

**Results**

When the X-rays of the different anatomical points captured with right to left and left to right movements were observed, it was determined that no variation was produced due to the scanning movement. In all the X-rays a similar image was obtained from the bone structure of the objects placed on it.

The panoramic control X-rays were compared with the samples and the type of image that appeared in each of them was defined. The results, according to the type of image obtained for each of the anatomical points evaluated, are: for 24 anatomical points (57%) were obtained simple images, for 7 (17%) double images, while 11 (26%) appeared as triples images (Table 1). Figure 1 shows a double image with its respective control, while figure 2 is a triple image. The areas of simple, double and triple images could be clearly delimited and they are shown in figure 3. The only anatomical points that produced a simple, clear and isomorphic image were in the oval foramen of the left side.

The objects placed on flat sagittal mid surface in the panoramic X-ray appeared misplaced, specifically towards the right side (Fig. 4), when the object was placed in the middle of the upper maxilla between the central incisors at the cervical level in the incisive fossa.

In this investigation an area similar to the one described by Márquez [Márquez et al., 2001] was found, in which the skull of a young adult was used to determine that the central rhombus is the area of the

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**Anatomic points**

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<td>Maxillar tuberosity on the right side</td>
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<td>7.</td>
<td>Angle branch of the right mandible</td>
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<td>9.</td>
<td>Top of the external surface of the right inner pterygoid plate</td>
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<td>Oval hole on the right side</td>
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<td>19.</td>
<td>Inner mandibular body at the cervical level of the first permanent molar on the right side</td>
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<td>20.</td>
<td>Union of vestibular and posterior wall of the maxillary sinus on the left side</td>
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**TABLE 3 -** The images of the anatomic points listed can be simple, crisp and isomorphic.

**FIG. 1 -** The second photograph shows a doble image, and the radiographic control is in the first image.
triple images. These consist of two lateral anterior areas of simple images and two posterior lateral areas of double images. The difference found in the infantile skull is that the images are located more towards the occipital bone (Fig. 3).

**Discussion**

This investigation was designed to identify the appearance of double and triple images in panoramic X-rays in children in order to compare them with the area of triple images described for the dry skull of an adult. In addition, it was performed because of the importance of the appearance of the images at the time of diagnosis in this particular kind of radiographies.

We defined simple images those that in previous studies were referred to as real images, with the purpose of having a straightforward interpretation, since simple images appearing in X-rays are not always real. As a result images were projected with different clarity.

As Goaz and White [1987] mentioned, it was difficult to find a greater amplitude and depth than the one usually obtained on the field of vision. The authors refer a number of alterations that can be seen on a panoramic X-ray as a result of its curved tomographic cut, mainly consisting of lack of clearness and alteration in the form of the structures that have moved away from the approach corridor.

Swerin [1990] in his work refers to the influence of the true object’s position on the alteration in the formation of images. The present investigation had similar results in terms of identifying and clearly limiting the projection areas of simple, double and triple images, according to the position of the object.

An area similar to the one described by Márquez [Márquez et al., 2001] in a study where a skull of young adult was used was found. In addition, during the investigation the central rhombus representing the area of triple images formed by two anterior areas of simple images and two later posterior areas of double images, was identified. The difference found during this investigation was the location over the skull due to the smaller dimensions of the infantile dry skull. The diamond area of triple images, as well as those of double images on both sides, was observed more towards the occipital part in the infantile skull, because the anteroposterior diameter of the latter is shorter compared to an adult skull due to lack of development which will has not taken place. However, the appearance of these double and triple images does

**Fig. 2** - The formation of a triple image occurs when a panoramic radiography is taken with a metallic object placed in the anterior and internal part of the occipital bone.

**Fig. 3** - The areas of simple (I), double (II) and triple (III) image respectively.

**Fig. 4** - Deviation of the image to the right in one object placed in the middle line over the posterior nasal spine.
not involve important anatomical structures. The importance relays on just acknowledging its presence. Sarac and Dilberovic [2004] mention that most of the people, infants or adults, might display cranial asymmetry. Observations of this characteristics were made. However, as Kaugars and Mollet [Monsour 2000] mentioned, there is a need to understand the advantages and disadvantages of using the panoramic X-ray. Knowing the phenomena that may occur while taking the radiography is important because they might cause double or triple images. The study object might appear in a different position within the X-ray which might not be the correct one. In addition, there is a lack of suitable isometry and isomorphism between the object of study and the projected image or a superposition of anatomical structures, magnification and distortion.

Knowing the alterations and accurately determining the areas of formation of these images, it will be possible, in some cases, to find among the obtained radiography the original position of the object of study. We can in some cases locate within our radiography with certain approach the original position of the object to be analysed.

Therefore the idea that the panoramic X-ray is a procedure that produces a simple image will have to be rejected, and we considered that its use does not have to be overvalued as a diagnostic tool to identify craniofacial injuries in paediatric patients.

Conclusion

In the panoramic projections, the image of a structure can appear in more than a position, as well as distorted and/or deformed. Like in the dry skull of the adult simple, double and triple images form. The diamond zones where triple images appear, as well as the zone of double images on both sides, were crossed more towards the occipital part in the infantile skull because this one has a shorter antero-posterior length than the adult skull. Nevertheless, this zone does not involve important anatomical structures. Cranial asymmetry was found on the infantile dry skull used for this study. On the basis of these results we can suggest that panoramic X-ray does not have to be used as unique radiological support in the decision making in patients with craniofacial alterations.

Aknowledgement

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