Ghost Image Mapping of Palatal Bone of Maxilla and Nasal Cavity in Panoramic View Using Cranex D Digital Machine

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Abstract

Introducction:

The mapping of ghost images of the maxilla and the nasal cavity, which are complex structures, is very important. The position of objects that create a ghost image can differ when using various devices. The purpose of this investigation was to study the mapping of ghost images of the maxilla and the nasal cavity using a Cranex D digital panoramic machine.

Materials and methods:

The mapping of ghost images of the maxilla and the nasal cavity, which are complex structures, is very important. The position of objects that create a ghost image can differ when using various devices. The purpose of this investigation was to study the mapping of ghost images of the maxilla and the nasal cavity using a Cranex D digital panoramic machine.

Results:

When the lead ball was located in the posterior third of the septum in the anterior-posterior direction and in the middle third above the base of the septum, a ghost image was detected in panoramic view. If the ball was placed in the posterior nasal spine, the image of the object appeared extremely elongated in a horizontal direction. The same was seen when the ball was located in the posterior third of the septum in the anterior-posterior direction and near the base of the septum.

Conclusion:

 This *in vitro* study examining ghost image mapping of the maxilla and the nasal cavity, using a Cranex D machine, revealed that the ghost envelope was limited. Digital panoramic device manufacturers have attempted to reduce ghost images, and this has now been achieved with this particular digital machine.

Key words:

•Maxilla •Nasal Cavity •Radiography •Panoramic

Introduction

Panoramic radiographs are commonly used by dentists as they have many advantages in terms of imaging of teeth and bone structures. A panoramic radiograph provides an overview of the maxilla, mandible, and adjacent anatomical structures, such as the maxillary sinuses, temporomandibular joint, and hyoid bone, in one single image [1-3]. Presently, several kinds of panoramic machines are available that are capable of producing images with minimal geometric distortion and overlap of anatomic structures from the contralateral side [4]. In the panoramic machine, concurrent rotation of the X-ray source and image receptor around the patient's head is necessary during image acquisition [5]. In this image, the structures located outside of the image layer or the focal trough exhibit reduced sharpness or accuracy. Another disadvantage of panoramic radiographs is the appearance of a distorted image simultaneously with the real image [6-8]. The interpretations of panoramic images is difficult as they may contain images of hard and soft tissues, surrounding air spaces, and ghost and double images [9].

In panoramic radiography images can be real or ghost-like. Furthermore, the real images can be single or double. Langland et al. defined ghost images as distorted images and stated that they are formed "when the object is located between the X-ray source and the center of rotation" or "is behind the rotation center" [1]. Thus, a ghost image can be detected when an object or anatomic structure is out of the zone of focus and has enough density to attenuate radiation [10], even though ghost images are found in all panoramic radiographs. Many attempts have been made to reduce ghost images by various manufacturers of panoramic dental imaging systems [4]. Ghost images may be created from anatomical and non-anatomical structures located in a three-dimensional zone named as the ghost envelope [11]. They are frequently blurry and the vertical component of the images is typically more blurred than their real counterparts [12].

Nowadays, several panoramic radiographic devices have been put on the market by different dental imaging device manufacturers who claim that the ghost images have been minimized and the quality of panoramic images have been improved. The interpretation of the ghost image in several states provides the possibility of accurately identifying objects of interest even without having three-dimensional images. Thus, the detection and mapping of ghost images of structures in the palatal portion of the maxilla and nasal cavity can be considered important. The position of the objects that may create a ghost image can also vary when using various devices. The purpose of this study was to examine the mapping of ghost images, especially in the maxilla and the nasal cavity, using a Cranex D digital machine. This machine is one of the most common radiographic devices used for maxillofacial radiology in clinics in Iran.

Materials and Methods

In this descriptive, *in vitro* study, two adult dry skulls were selected from the Department of Anatomy of the Guilan University of Medical Sciences and prepared. The selected skull was first fixed onto a pre-prepared skull stabilizing device before being positioned into a Cranex D (Soradex, Helsinki, Finland) digital panoramic machine so as to allow image acquisition in a clinical situation. Therefore, the position of the skull was the same and could remain stable throughout the process of capturing images. A lead ball with a 4-mm diameter was put in different locations while taking digital panoramic images. The exposure parameters were set at the lowest level (57 Kvp, 10 mA and 16 sec) to compensate for the lack of soft tissue attenuation. The lead ball was placed and fixed in selected locations with dental wax. For sites that were not easily accessible, the lead ball was fixed onto the tip of a toothpick and placed in a specific location. The different sites of lead ball placement were as follows:
- In the center of the middle third of the palatal bone
- On the right lateral side of the middle third of the palatal bone
- In the center of the posterior third of the palatal bone
- On the right lateral side of the posterior third of the palatal bone
- Between the center and the right lateral side of the middle third of the palatal bone (lateral position)

- Beneath the inferior turbinate and at the level of the middle third in an anterior-posterior direction
- Beneath the inferior turbinate and at the level of the posterior third in an anterior-posterior direction
- Beneath the middle turbinate and in the middle third in an anterior-posterior direction
- Beneath the middle turbinate and in the posterior third in an anterior-posterior direction
- On the middle third of the nasal septum above its base and in an anterior-posterior direction
- On the middle third of the nasal septum above its base and in the posterior third of the septum in an anterior-posterior direction
- On the base of the nasal septum and in the middle third of the septum in an anterior-posterior direction
- On the base of the nasal septum and in the posterior third of the septum in an anterior-posterior direction
- On the posterior, lateral and medial walls of the maxillary sinuses
- On the posterior nasal spine
-On the posterior border of the palatal bone, along the posterior nasal spine on the right side
After changing the location of the lead ball on the palatal bone and in the nasal cavity, photographic images were taken to document the different locations of the ball. The above -mentioned steps were repeated with a second dry skull, which was smaller in size compared to the first skull.
Herein, we have detailed the radiographic findings of lead balls that were placed in various locations and produced ghost images when panoramic radiographs were taken using a Cranex D machine.

Results

1) On the middle third of the nasal septum above its base, and in the posterior third of the septum in an anterior-posterior direction:
In panoramic views, the radiopaque images of the lead balls were horizontally elongated, which appeared similar to the ghost images of the lead balls overlapping their real images (Figures 1B &1C).
2) On the base of the nasal septum and in the posterior third of the septum in an anterior-posterior direction:
The image of the lead ball in Figure 2A was elongated more drastically while in Figure 2B, it appeared to be slightly stretched and had an irregular margin.
3) The lead ball located on the posterior nasal spine:
Figure 3 shows extreme stretching of the lead ball images bilaterally along the horizontal dimension of the nasal cavity. When the lead balls were positioned in the center of the middle third of the palate or on the right or left sides of the posterior third of the palate, the images became round and had regular margins. However, the images of the lead balls that were located in the center of the posterior third of the palate were slightly stretched horizontally and were oval in shape. The lead balls beneath the inferior and middle turbinate in the middle and posterior thirds and also on the medial, lateral and posterior walls of the maxillary sinuses did not create ghost images. Table 1 shows the panoramic views of the different locations of the lead balls that had been placed in both skulls.

Figure 1. (A): Location of the lead ball in the posterior third of the nasal septum in an anterior-posterior direction and on the middle third of the septum above its base. (B) & (C) Radiographic results of first and second dry skull images.

Figure 2. (A & B) Horizontally elongated images of the lead balls placed in the midline of panoramic views.

Figure 3. (A): Location of the lead balls in the posterior nasal spine. (B & C) Radiopaque bands are shown extending bilaterally in the nasal cavity.

Table 1. Different locations of bullet and resultant panoramic views without ghost images

Location	Skull 1	Skull 2
In the center of the middle third of the palatal bone		
On the right lateral side of the middle third of the palatal bone		
In the center of the posterior third of the palatal bone		
On the right lateral side of the posterior third of the palatal bone		
Between the center and the right lateral side of the middle third of the palatal bone (lateral position)		
Beneath the inferior turbinate and at the level of the middle third in an anterior-posterior direction		

Location	Skull 1	Skull 2
Beneath the inferior turbinate and at the level of the posterior third in an anterior-posterior direction		
Beneath the middle turbinate and in the middle third in an anterior-posterior direction		
Beneath the middle turbinate and in the posterior third in an anterior-posterior direction		
On the middle third of the septum from its base and in an anterior-posterior direction		
On the base of the nasal septum and in the middle third of the septum in an anterior-posterior direction		
On the posterior wall of the maxillary sinus		
On the lateral wall of the maxillary sinus		
On the medial wall of the maxillary sinus		
On the posterior border of the palatal bone along the posterior nasal spine on the right side		

Discussion

In addition to considering the use of different panoramic devices and parameters, such as the efficiency of the x-ray generator, image sensor, and image processing software, it is crucial to take into account factors such as reducing unwanted images like ghost images.

One of the most commonly used panoramic devices in dento-maxillofacial imaging centers is the Cranex D. In this study, the lead balls that were located on the middle third of the nasal septum above its base and in the posterior third of the septum in an anterior-posterior direction, on the base of the septum in the posterior third of the septum in an anterior-posterior direction and on the posterior nasal spine produced ghost images combined with an elongated image of the lead balls. The changes in the positions of the balls along the midline, from the middle to the posterior portion of the palate and also from the sides to the midline were responsible for varying degrees of horizontal magnification and distortion of their images.

Also, by moving the lead ball from the middle third toward the posterior, beneath the inferior and middle turbinates, elongation of the images occurred, but they retained their sharp and regular edges. We also found that after making changes in the location of the lead balls in the posterior nasal spine towards the posterior border of the palatal bone, the ball images varied from round to oval in shape and had regular margins. The anterior-posterior dimension of skull A was bigger than skull B. Therefore, the posterior portion of the palate and the septum in skull A that was located within the ghost zone was larger than that in skull B. Thus, the elongation of the ghost image in skull A was more pronounced than that in skull B when taking a panoramic view. The vertical component of the ghost image has been reported to be "more blurred than the horizontal component" [1], whereas in our study, the horizontal component of the ghost image was more blurred.

Higashi et al. [13] reported three images of a bullet that was located along the midline of the nasal cavity; however, in our study, the lead balls located in the midline of the nasal cavity did not create three images. Unfortunately, the type of mic machine that was used in their report was not clear.

In the Dalili et al. case report [14], the ghost image of a foreign body that was located on the floor of the nasal cavity and below the right inferior turbinate was found to be superimposed on the left sinus. However, in the current study, no ghost image was detected when placing the lead ball beneath the inferior turbinate. These differences in findings may be related to the shape and size of the foreign body or maybe due to selection of a different imaging mode (child versus adult) in the Dalili et al. case [14].

Kaugars and Collett [10] have described three-dimensional zones of mandibular ghost images, produced by three panoramic machines (Orthopantomograph 5, Panelipse and Panorex). They proposed that this area should be called the ghost envelope.

It is clear that the form of the ghost area is dependent on the device and its incidence occurs when using various panoramic machines. In their study [10], the object that was located in the midline could produce a double image in all three panoramic machines. In the Orthopantomograph 5 and the Panelipse, the object that was located in the midline produced a third image as a ghost image, due to an overlap of the ghost envelope and the double-image zone. When using the Panorex machine, ghost images were not formed from objects located in the midline. Moreover, three images of a midline object were also not formed using this machine.

Monsour and Mendoza [11] have demonstrated the mapping of the ghost envelope using the Ortho Oralix DC-Ceph. They showed that the ghost images of the objects that were located below or in the level of mandibular body were slightly higher than the primary image, but for a superiorly-located object the resultant ghost image was located more superiorly than in the primary image. Thus, the presence or absence of ghost images of soft tissue calcifications on panoramic radiographs help in locating them.

Langland and Langlais have explained the characteristics of ghost and double images and have shown anatomical areas that produce these images.

For example, the posterior portion of the hard palate can create ghost and double images in panoramic view, as it is located in a diamond-shaped zone that may produce such images simultane-

ously [1]. However, in our study, there were no double images, but the bullet located in the midline and the posterior part of the palate and nasal cavity created a horizontally stretched image that indicated a tendency to create a ghost image. Figure 4 reveals the confines of the ghost envelope in the Cranex D machine used in our study.

Conclusion

It appears that the Cranex D digital panoramic machine produces a small ghost image zone that includes the posterior part of the palate and the nasal cavity at the midline (i.e., the septum and the central region of the hard palate).
The images of the lead balls that were located in the middle of the posterior portion or beneath the inferior or the middle turbinates extended from the nasal cavity toward the maxillary sinuses.

Conflict of interest

In addition, there was no financial support given or conflict of interest associated with this investigation.
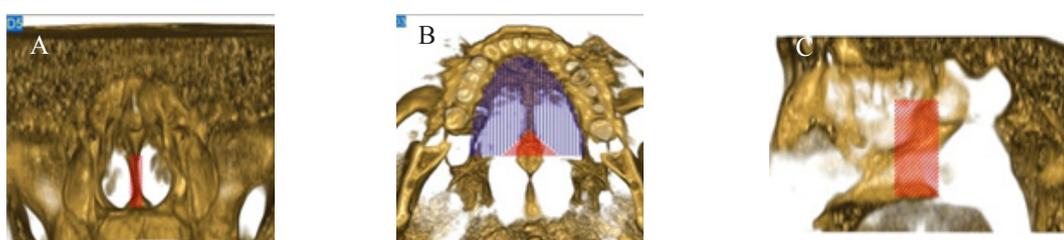

Figure 4. The map of the ghost envelope in the Cranex D machine from posterior, bottom and lateral views. The red patch shows the zone of the ghost image.

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