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Review

Limitation of 2dimension (2D) Vs 3dimension (3D) imaging application in dental treatment

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Panoramic radiography is a 2 dimension radiograph (2D) and the most widely used technique. Because of the limitations of 2D radiographic techniques, due to overlapping lack of sharpness, technique sensitive and high radiation exposure to the patient, the need for more advanced techniques that could show anatomical relationships three dimensionally increased. Due to the introduction of CBCT, 3D images are becoming more easily available for use in dentistry. However, transfer of treatment plane into successful treatment is more achievable with 3D images. Thus, it takes into consideration less complication, no time wasting for dentist and patient and no financial loss for both patient and the dentist.

Key words: Panoramic radiography, 2 dimension, 3D images.

INTRODUCTION

Presurgical planning is mostly made with radiographs such as panoramic, lateral cephalometric, periapical radiographs, and computed tomography. However, none of these types of radiography represents a perfect modality. Each type of radiographic has its own advantages and disadvantages. Therefore, the radiation dose, magnification rate, and specific indications need to be considered when selecting the type of radiographic images to be used in presurgical planning (Hu and Kim, 2012).

Periapical radiographs have been used for many years to assess the jaws pre-implant and post-implant placement. The long cone paralleling technique for taking periapical x-ray is the technique of choice for the following reasons (Gintaraas and Hom-Lay, 2010):

a) Reduction of radiation dose;
b) Less magnification;
c) True relationship between the bone height and adjacent teeth.

For long cone paralleling technique, it should be taken with a film-focal distance of approximately 30 cm. The film is highly flexible, literally and figuratively, it's processing is often suboptimal, with deleterious consequences to the image quality. The angulation can cause distortion and in cases of mental foramen is located in low position; periapical film cannot properly locate its position (Gintaraas and Hom-Lay, 2010).

When a specific region is too large to be seen on a periapical view, panoramic radiograph can be the method of choice (Gintaraas and Hom-Lay, 2010).

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Panoramic imaging is a technique for producing a single tomographic of the facial structures that includes both the maxilla and mandible and their supporting structures (Stuart and Michael, 2009). A panoramic radiograph provides an overview of dental arches and a close view of large number of maxillary sinuses, the tempromandibular joint (TMJ) and hyoid bone (Benjamin et al., 2012), and thusthe OPG is used with magnification factors of 1.2(Siemen Orthophos) and 1.25(Plameca) (Stuart and Michael, 2009).

DISCUSSION

The following technical points are important when a panoramic radiograph is taken (Benjamin et al., 2012):

a) The patient should be seated or should stand fully upright, with the head immobilized, utilizing a chin rest and a radiolucent bite block.
b) Spectacles, neck chains, earrings, and dentures or dental appliances must be removed before exposure.
c) The patient should place the tongue against the palate during the exposure in order to prevent a radiolucent stripe above the maxillary teeth.
d) The machine movement should be explained to the patients because of the relatively long exposure especially relevant with the children.

Panoramic radiographs are commonly used for screening, diagnosis, and selecting the best possible surgical approach (Hu and Kim, 2012).Finding an appropriate location and measuring the available bone based on panoramic radiograph is one of the most frequently used modalities for presurgical planning (Hu and Kim, 2012).

The principal advantages of panoramic images

1. Coverage of facial bones and teeth or hard tissues (Gintaraas and Hom-Lay, 2010; Stuart and Michael, 2009; Gungor et al., 2006).
2. It allows more accurate localization of mental foramen in both the horizontal and vertical dimension, and periapical radiographs do not reveal the position of mental foramen if fall below edge of film (Stuart and Michael, 2009; Gungor et al., 2006).
3. Convenience of the examination for the patient (Stuart and Michael, 2009).
4. It is suitably used in patients that are unable to open their mouth and visual aid in patient education (Stuart and Michael, 2009).

Disadvantages of panoramic images

1. Inadequate for fine anatomical details available on intraoral periapical radiographs (Stuart and Michael, 2009; Gintaraas and Hom-Lay, 2010).
2. Structures are not sharp and are distorted.
--For a panoramic radiograph position of the structure of interest, structures that are outside the center of rotation of the radiologic source and detector are not displayed sharply and are distorted over proportionally (Stuart and Michael, 2009; Neugebauer et al., 2008).
3. Overlapping images.
--Presence of overlapping structures can hide odontogenic lesions (Stuart and Michael, 2009; Benjamin et al., 2012; Ngeow and Yusof, 2003). Mesial or distal angulation of X-ray beam may be associated with growth and development of the patient (Stuart and Michael, 2009).
-- The anterior area where more distortion exists than posterior area, the reliability of panoramic radiographs for presurgical planning of an implant is questionable (Wafa'a and Ahmed, 2005).
4. Not accurate in the identification of mental foramen.
--Maybe due to intrinsic characteristics of the examiner, such as emotional, visual and neurological factors (Arzouman et al., 1993; Bolin et al., 1996).

Table 1 shows four studies that evaluated radiographic signs associated with nerve damage. Diversion of canal was the radiographic sign associated with nerve damage in majority of published studies, while Narrowing of root was the least associated sign (Palma-Carrió et al., 2010). According to Valmaseda-Castellón et al. (2001), diversionof the canal was the only radiographic sign statistically associated with nerve damage. For Blaeser et al. (2003), darkening of the root, interruption in the whiteline of the canal and the diversion of the canal were allstatistically related with nerve damage.

According to Sedaghatfar et al. (2005), a retrospective study showed that the following four panoramic features were significantly associated with inferior alveolar nerve exposure following third molar removal: Darkening of the root, interruption of the white line of mandibular canal wall, diversion of mandibular canal, narrowing of the root.

Gomes et al. (2008) did not observe any statistically significantrelationship with any radiographic sign; for theseauthors, the OPG does not provide any definitive data topredict nerve damage during surgery of lower third molar.

The presence or absence of cortical bone around the mandibular canal, the buccolingual relationship between the mandibular canal and the lower third molar, and the detailed shape of the root might not be clearly evident on a panoramic radiography (Feras and Steen, 2012). Advance imaging modalities is required for correct identification of mental foramen (Gintaraas and Hom-Lay, 2010). Cone Beam Computed Tomography (CBCT) is a relatively new diagnostic tool for presurgical localization of inferior alveolar nerve (Flygare and Ohman, 2008). Three-dimensional CBCT are becoming more readily available for use in maxillofacial applications. CBCT provides better image quality of teeth and their

Table 1. Radiographical signs associated with inferior alveolar nerve damage.

Author	Radiographic sign related to inferior alveolar nerve damage			
	Darkening	Narrowing	Interruption	Diversion
Valmaseda-Castellon et al., 2001	-	-	-	+
Blaeser et al., 2003	+	-	+	+
Sedaghatfar et al., 2005	+	+	+	+
Gomes et al., 2008	-	-	-	-

surrounding structures, compared with conventional CT. It reduces the radiation dose as compared with conventional CT (Gintaraas and Hom-Lay, 2010; Stuart and Michael, 2009; Zahra et al., 2011). CBCT images are known to have higher quality than CT images with 1/400 radiation dose of conventional CT (Hu and Kim, 2012). It offers high spatial resolution (Zahra et al., 2011).

CBCT was significantly superior to panoramic images in predicting neurovascular bundle exposure during extraction of impacted third molar (Tantanapornkul et al., 2007; Eduardo et al., 2012). Although CBCT allows such evaluation, panoramic radiography is still often the first imaging method in the investigations of third molars (Eduardo et al., 2012). Panoramic radiography is the most widely used technique. Because of the limitations of conventional radiographic techniques, the need for more advanced techniques that could show anatomical relationships three dimensionally increased. Due to the introduction of CBCT, 3D images are becoming more easily available for use in dentistry (Zahra et al., 2011). According to Hu and Kim (2012), the errors found while using panoramic radiograph were greater compared with CBCT. CBCT should be used for presurgical planning and postoperative evaluation especially when dentists with limited experiences place implants. But this study shows that there will be fewer errors when presurgical plans are made using panoramic radiograph in mandible than in maxilla. Mandibular canal is easy to identify in most cases, except those with thick cortical bone or a high proportion of trabecular bone. Presurgical planning in mandible can be performed safely using panoramic radiograph by dentists with sufficient experience and skill, whereas, presurgical planning using CBCT is strongly recommended when a buccolingual location of mandibular canal needs to be evaluated (Stuart and Michael, 2009).

In the study published by Tantanapornkul et al. (2007), the authors concluded that CBCT was superior to PAN in predicting surgical exposure of the IAN vascular bundle as it has significant higher sensitivity and specificity than PAN (Table 2).

However, more recent study published by Ghaeminia et al. (2011), found no significant difference between PAN and CBCT (Table 2). Both investigations found high sensitivities for CBCT(0.93 vs 0.96), however the main reason for the lack of significance in the later study is due to a much lower specificity(0.77 vs 0.23).

Localization of the mental foramenradiographically is difficult due to lack of consistent anatomical landmarks for reference and the foramen cannot be clinically visualized or palpated (Wafa'a and Ahmed, 2005).

The supraorbital and infraorbital notches are located by palpation. An imaginary line is drawn through supraorbital notch, pupil of the eye, infraorbital notch which continues down to pass through mental foramen. A point which is midway between the lower border of the mandible and gingival margin is estimated and marked on the imaginary line to locate the mental foramen (Balaji, 2007).

What is the limitation of OPG or 2D radiograph in implant dentistry?

Using the 2D or OPG radiograph in the treatment plane of implant placement is with great limitation in defining the exact location of the anatomical structure. This will make the operator toexperience:

1-The worse situation, this occur when it is difficult to determine the exact location of inferior dental nerve, the operator will choose the nearest to the alveolar ridge and consider it as the location of the nerve, to avoid inferior dental complex damages;

2-Short diameter implant to avoid jeopardizing the vital structure;

3-Narrow diameter implant, difficult to estimate the width of the alveolar ridge or edentulousarea apically and coronaly, thereby making the operator to choose narrow implant in order to be in the safe side;

4-Open and see technique, whether the ridge needs bone augmentation, expansion or implant angulations;

5-Under or over estimation of the bone density, operator will totally depend on the hand sensation during osteotmy procedure to determine the bone density or quality;

6-Unaware about any anatomical variation, like mandibular incisive canal, anterior loop of inferior dental canal and mental foramen location;

7-In upper anterior immediate implantation, buccal bone width is crucial in determining the treatment plane, whether immediate implant can be proceed after tooth extraction or socket augmentation and delay implant placement is better? All these informations are difficult to

Table 2. The comparisons between CBCT and panoramic radiograph (PAN) and the appraisal of evidence.

Author	Tantanapornkul et al., 2007	Ghaeminia et al., 2011
Location	Tokyo/ Japan	Nijmegen/The Netherlands
Population	142 impacted mandibular third molars	53 impacted mandibular third molars from 42 patients with increased risk of inferior alveolar nerve injury
Test	CBCT, PAN	CBCT, Digital PAN
Golden standard	Inferior alveolar nerve exposure	Inferior alveolar nerve exposure
Outcome	**CBCT:**Specificity (77%), Sensitivity (93%), PPV(49%) NPV(98%) Accuracy(80%) Inter-observer agreement: Excellent **PAN :**Specificity (63%), Sensitivity (70%), PPV(31%) NPV(90%) Accuracy(64%) Inter-observer agreement: Fair to Excellent Interruption of the mandibular canal wall (k-value=69%) Darkening of the root (k-value=87%) Diversion of the mandibular canal (k-value=78%) Narrowing of the root (k-value=56%)	**CBCT:** Specificity(23%) Sensitivity(93%) PPV(49%) NPV(88%) Accuracy(55%) **PAN :**Specificity (3%), Sensitivity (100%), PPV(44%) NPV(100%) Accuracy(45%) Inter-observer agreement: Poor Darkening of the root (k-value=87%) Interruption of white line (k-value= 52%)
Critical Appraisal	Checklist Score: 8/9 Strength: Prospective study Blinded and highly qualified Evaluators, large sample size Weakness: Bias Strength of evidence: A	Checklist Score : 6/9 Strength: Blinded Experienced Qualified evaluators, randomised Weakness: Selection Bias Strength of evidence : C
Conclusion	CBCT is superior to PAN in predicting neurovascular bundle exposure during third molar extraction	CBCT and PAN in predicting inferior alveolar nerve exposure: no significance difference CBCT shows 3D, important in surgery planning

extract from 2D images.

Conclusion

There is no doubt that 3D images give big advantages for dental implantologiest and patients with superiority compare to 2D images. Transfer of treatment plane into successful treatment is more achievable with 3D images. It takesinto consideration less complication, no time wasting for dentist and patient, no financial loss for both

patient and the dentist. However, it also builds up the confident between the dentist and the patient, and more trust in dental implant as one of treatment option for the patient.

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