Evaluation of the risk of inferior alveolar nerve injury during an implant procedure: A comparative study between OPG and CBCT

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Background and objectives: Dental implants are considered as one of the major options for replacement of missing teeth and this surgical procedure may be accompanied by trauma to the adjacent vital structure when there is inadequate information of the implant site. The use of OPG as a preliminary diagnostic instead of CBCT may expose the patient to a high risk of trauma to an inferior alveolar canal. To evaluate the possibility of the risk of endangering inferior alveolar nerve during implant placement using OPG or CBCT as a preoperative assessment tool.

Patients and methods: This study is a prospective cross-sectional study carried out in outpatient clinic of the college of dentistry and Denta Plus private center in Erbil city during the period from 1st of January to 31st of August, 2018. A sample of 49 patients was selected according to special criteria: Group I consists of 33 patients who had implant in molar and premolar regions, in this group pre-implant assessment done by Orthopantomogram (OPG). Group II; consists of 16 patients who had implant in molar and premolar regions, in this group pre-implant assessment done by Cone beam computed tomography (CBCT). The measurement of the distance between a dental implant and inferior alveolar canal were analyzed by CBCT which classified into four levels of parameters (distances) a-Safety zone ≥2 mm, b-Risky zone 1-2 mm, c-Error and high risk >0-1 mm, d-Traumatized ≤0 mm.

Results: the distance between implant and inferior alveolar canal (IAC) for group I (OPG) patients were as following: - in the safety zone for 30.3%, in the risky zone for 15.2%, in error & high risk for 21.2% and traumatized for 33.3%, while this distance for group II (CBCT) patients was in the safety zone for 75%, in the risky zone for 6.3%, in error & high risk for 12.5% and traumatized for 6.3%.

Conclusion: Cone beam computed tomography is the best choice compared to OPG in the pre-implant evaluation and planning for placement as it showed a lower risk of injury to an inferior alveolar canal.

Keywords: Dental implant, cone beam computed tomography, orthopantomogram.

Introduction

The dental implants now a day represented the common way in replacing missed teeth. The success of a dental implant is depending on restoring both the function and aesthetic of missing teeth that demands thorough pre-implant planning. Evaluating the morphology of bone considered one of the main tasks to determine the quality, quantity, topography and adjacent anatomical structures at the implant site.¹ Assessment of dental implant includes history, physical
examination, and imaging. The orthopantomogram (OPG) can be considered as the most popular imaging technique used for pre-implant radiographic evaluation.

The cone beam computed tomography (CBCT) is an advanced imaging modality replaced high cost, heavy and radiation exposure risk related to conventional computerized tomography (CT) scans. Indeed, the dental implant images of CBCT were more precise than CT scan images. Dental implant evaluation requires multiple cross-sectional images of CBCT, which are currently accessible, easily handled, and low radiation risk, compared to CT. The American Association of oral and maxillofacial radiology supported the use of CBCT in planning for a dental implant.

The shortcoming of OPG comes from its two-dimensional property that gives less information. It is unable to display buccolingual sides of objects in relations to the inferior alveolar canal. The other point is improper sharpness of displaying structures outside the center of rotation of radiology source.

The main advantage of applying CBCT in the dental implant is to provide three-dimensional views that help the examiner to have a better inspection of surrounding hard tissues. It is facilitating the accuracy of views and clarifying the anatomical conflicts.

For the dental implant field, the CBCT is very useful for the preoperative surgical plan, postoperative assessment and for long-term follow up assessment. Preoperatively, it helps in detecting the morphology and relevant directions, local anatomic and pathological configurations of the residual alveolar ridge. Post-operatively it assists in the better evaluation of complications resulting from the dental implant. One of the serious complications of improper dental implant placement is the injury to anatomical structures like inferior alveolar nerve and adjacent teeth or perforation of the maxillary sinus.

Proper placing of a dental implant in the jaw bone is achieved by appropriate pre-implant planning including assessment of anatomical structures. In Kurdistan region, most of the implantologists are depending only on (OPG) as an assessment tool which may increase the risk of improper placement and different injuries. The aim of the study was to evaluate the possibility of the risk of endangering inferior alveolar nerve during implant placement using OPG or CBCT as a preoperative assessment tool.

Patients and Methods
This study is a prospective cross-sectional study carried out in the outpatient clinic of the college of dentistry and Denta Plus private center in Erbil city during the period from 1st of January to 31st of August, 2018. A sample of 49 patients was selected and divided into two groups: Group I: consists of 33 patients who had implant in molar and premolar regions, in this group pre-implant assessment done by Orthopantomogram (OPG). Group II: consists of 16 patients who had implant in molar and premolar regions, in this group pre-implant assessment done by Cone beam computed tomography (CBCT).

Inclusion criteria include patients aged 18 years or older with mandibular premolar and molar implant who were assessed preoperatively by CBCT and OPG. Exclusion criteria include patients with a history of surgical intervention (trauma, fracture, cystic lesion, lateralization of inferior alveolar nerve, mental nerve). Ethical approval was obtained from the Ethical Committee of the College of Dentistry and written informed consent was taken from selected patients.

The data was collected by the researcher from recorded preoperative CBCT and OPG. The measurement of distances between the dental implant and inferior alveolar canal were analyzed by CBCT by measuring the closest points between the implant and inferior alveolar canal. The NNT software for linear measurements was used to evaluate the distance between the implant and inferior alveolar canal in both sagittal and coronal views and by measuring the closest points between the implant and inferior alveolar canal.
distance of implant to inferior alveolar canal classified into four levels of parameters depending on anatomic limitation to implant placement\(^3\): a-Safety zones ≥2 mm, b-Risky zone 1-2 mm, c-Error and high risk >0-1 mm, d-Traumatized ≤0 mm (either with contact, inside or cross the canal) (Figures 1 and 2).

The measurement of the distance between the implant and the inferior alveolar canal was done according to the following views: **Coronal view:** the measurement done by measuring the shortest distance of implants to the inferior alveolar canal (IAC) in the cross-sectional coronal view (CSCV) in mm and this measurement was done by finding the shortest distance between the implant and IAC from different measurements from different points (buccal, center, lingual) and choosing the shortest distance (Figure 3A). This reading illustrates the position and relation of the dental implants (DI) to the vital tissues in the vertical and buccolingual dimensions and any possibilities of injury. **Sagittal view:** the measurement done by measuring the shortest distance of implants to the inferior alveolar canal (IAC) in the cross-sectional sagittal view (CSSV) in mm and this measurement was done by finding the shortest distance between the implant and IAC from different measurements from different points (mesial, center, distal) and choosing the shortest distance (Figure 3B). This reading illustrates the position and relation of the dental implants (DI) to the vital tissues in the vertical dimension and any possibilities of injury.
CBCT device: Cone Beam CT Newtom, model: Giano FOV: 8 * 11 cm Made in Italy (Software NNT 9.0 version). Workstation (DELL: core I 7, ram 16, hard 2 Terabyte Made in the USA. Dicom Printer: Codex and Car stream Made in USA and X-ray viewer also Made in the USA in addition to anti-noise program and Voxel size 0.3.

Statistical analysis was carried out with SPSS software version 22. On analysis, the Chi-square test and Fischer’s exact test were used for categorical variables and independent sample t-test was used for continuous variables. \( p \leq 0.05 \) was considered statistically significant.

Results

Mean age of group I patients was 59.6 years and mean age of group II patients was 58.1 years old. Males represented 54.5% of patients in group I while males represented 37.5% of group II. No significant differences were observed between patients of study groups regarding their age and gender (Table 1).

Implant in the right side was present in

Table 1: Distribution of demographic characteristics according to study groups

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre-OPG (group I)</th>
<th>Pre-CBCT (group II)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>%</td>
<td>No.</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;40 years</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>40-49 years</td>
<td>5</td>
<td>15.2</td>
<td>4</td>
</tr>
<tr>
<td>50-59 years</td>
<td>9</td>
<td>27.3</td>
<td>4</td>
</tr>
<tr>
<td>( \geq 60 ) years</td>
<td>19</td>
<td>57.6</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>33</td>
<td>100.0</td>
<td>16</td>
</tr>
<tr>
<td>Mean±SD (years)</td>
<td>59.6±8.4</td>
<td>58.1±6.5</td>
<td>( 0.5^{**} \ NS )</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>18</td>
<td>54.5</td>
<td>6</td>
</tr>
<tr>
<td>Female</td>
<td>15</td>
<td>45.5</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>33</td>
<td>100.0</td>
<td>16</td>
</tr>
</tbody>
</table>
54.5% of group I patients, while the right side implant represented 43.8% of group II patients. In both groups the first molar site for implant placement showed higher percentage in comparison to other sites of implant placement of study groups, it is shown in group I as 45.5% while in group II as 50%. No significant differences were observed between patients of study groups regarding sides and sites of implants (Table 2).

The distribution of distance of implant to IAC according to study groups are shown in table 4 and figure 2 which shows that the distance between implant and IAC for group I patients were as following: in a safety zone for 30.3%, b- risky zone for 15.2%, c- error & high risk for 21.2%, d- traumatized for 33.3%, while this distance for group II patients were as following a- safety zone for 75%, b- risky zone for 6.3%, c- error & high risk for 12.5%, d- traumatized for only one patient. There was a significant difference between group I patients and group II patients in all zones for the distance between the implant and IAC (P=0.02) as shown in table 3.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre-OPG (group I)</th>
<th>Pre-CBCT (group II)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>%</td>
<td>No.</td>
</tr>
<tr>
<td>Side of implant</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>18</td>
<td>54.5</td>
<td>7</td>
</tr>
<tr>
<td>Left</td>
<td>15</td>
<td>45.5</td>
<td>9</td>
</tr>
<tr>
<td>Total</td>
<td>33</td>
<td>100.0</td>
<td>16</td>
</tr>
<tr>
<td>Site of implant</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Second premolar</td>
<td>9</td>
<td>27.3</td>
<td>2</td>
</tr>
<tr>
<td>First molar</td>
<td>15</td>
<td>45.5</td>
<td>8</td>
</tr>
<tr>
<td>Second molar</td>
<td>9</td>
<td>27.3</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>33</td>
<td>100.0</td>
<td>16</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Distance groups</th>
<th>Pre-OPG (group I)</th>
<th>Pre-CBCT (group II)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>%</td>
<td>No.</td>
</tr>
<tr>
<td>Safety zone</td>
<td>10</td>
<td>30.3</td>
<td>12</td>
</tr>
<tr>
<td>Risky zone</td>
<td>5</td>
<td>15.2</td>
<td>1</td>
</tr>
<tr>
<td>Error and high risk</td>
<td>7</td>
<td>21.2</td>
<td>2</td>
</tr>
<tr>
<td>Traumatized</td>
<td>11</td>
<td>33.3</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>33</td>
<td>100.0</td>
<td>16</td>
</tr>
</tbody>
</table>

* Fishers exact test, S=Significant.
Discussion

The results of this study indicated that the placement of dental implant in lower premolar and molar region showed high risk of trauma to IAC which was about 33.3% of patients evaluated with OPG while in CBCT group patient showed less risk to trauma which was about 6.3% and this result especially for OPG group were higher than that result which reported by Sahota et al\textsuperscript{14} they showed in this study 22% risk of trauma in OPG group and 5% in CBCT group patient. Our study agrees with the results of de Mello et al\textsuperscript{15} study which proved that CBCT is more accurate in the placement of dental implant than other imaging modalities. This study showed that the postoperative IAC trauma percentage in patients evaluated preoperatively with CBCT was 6.3% which was higher than trauma proportion of 3% detected by Angelopoulos et al\textsuperscript{16} and Sahota et al\textsuperscript{14} as 5%, this higher percentage of trauma by CBCT in our study was attributed to surgical procedure error in an attempt to bypass IAC cause trauma to the canal.

During oral surgery, the inferior alveolar nerve is the most common nerve exposed to injuries (64.4%), followed by the lingual nerve (28.8%).\textsuperscript{17} Hillerup et al reported that the main risk factors for inferior alveolar nerve injury were 3\textsuperscript{rd} molar surgery, injection of local anesthesia, endodontic treatment and dental implant surgery.\textsuperscript{18} The result of this study disagree with what conducted recently by Shahidi et al\textsuperscript{19} as they revealed that OPG can be used safely in the pre-surgical phase of dental implant placement in posterior alveolus of the mandible, especially in routine and simple cases and this is due to limitation of OPG in providing the required for placement of dental implant and its correct relation to the inferior alveolar canal which can be more clarified by using CBCT as shown by Mirbeigi et al\textsuperscript{20} in this study observed that CBCT was a most accurate diagnostic tool for assessment of inferior alveolar canal. Kamrun et al\textsuperscript{21} study revealed that OPG is still the most widely used radiographs for evaluation of dental implant surgery as these techniques are accompanied by low cost, easily obtainable and with low radiation exposure compared to CT scan. Vazquez et al\textsuperscript{22} study suggested that panoramic radiographs in conjunction with periapical radiographs are satisfactorily for the bone volume assessment in anatomical important regions such as the molar region, where the presence of inferior alveolar nerve makes implant placement challenges, and all of these studies are inconsistent with our study findings.

Dental implant becoming the treatment of choice for edentulous patients, especially with an appropriate preoperative CBCT planning which provided high-resolution images, enhancing the ability to recognize
the anatomical structures and accurate implant placement in comparison to other radiographic diagnostic techniques. From the result of this study indicated that the use of CBCT in pre-implant planning and evaluating the anatomical structure can provide the require information for a surgeon for proper assessment and evaluating the risk of trauma to any adjacent vital structure in comparing to other modality of imaging which available nowadays.

Conclusion
Cone beam computed tomography (CBCT) using for pre-implant evaluation provide more accurate information and decrease the risk of trauma to an adjacent vital structure. Orthopantomogram (OPG) showed less accurate information than CBCT and showed a high risk of trauma if used as a preliminary diagnostic tool for implant placement.

Conflict of Interest
The authors reported no conflict of interest.

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