Comparison of panoramic radiography and cone beam computed tomography in the detection of mandibular anatomic variations

Mandibular anatomik varyasyonların tespit edilmesinde panoramik radyografi ve konik ışınlı bilgisayarlı tomografinin karşılaştırılması

Assist. Prof. Ömür Dereci
Eskişehir Osmangazi University, Faculty of Dentistry, Department of Oral and Maxillofacial Surgery, Eskişehir

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Corresponding author

Assist. Prof. Ömür Dereci
Eskişehir Osmangazi University, Faculty of Dentistry
Department of Oral and Maxillofacial Surgery,
Odunpazarı 26480 Eskişehir, Turkey
Phone: 905057720950
E-mail: omurdereci@hotmail.com

SUMMARY

Aim: The aim of this study is to compare the efficiency of panoramic radiography (OPG) and cone beam computed tomography (CBCT) in the diagnosis of mandibular anatomical variations of accessory mental foramen (AMF), retromolar foramen (RF), bifid mandibular canal (BMC), mandibular incisive canal (MIC) and lingual foramen (LF).

Materials and Methods: Clinical and radiological data of 189 patients, who were treated between 01/04/2013-01/04/2017, were retrieved from archieves and evaluated retrospectively. The anatomical variations of AMF, RF, BMC, MIC and LF were detected on both OPG and CBCT sections for all included patients by two researchers. The researchers were calibrated with Cohen's Kappa test ($p<0.05$). Statistical significance between OPG and CBCTwas evaluated with McNemar's test. $p<0.05$ was taken statistically significant.

Results: There was no statistically significant difference between radiography techniques in the detection of AMF, RF and BMC ($p>0.05$), whereas, MIC and LF incidences were found to be significantly different between two imaging modalities ($p<0.05$).

Conclusions: CBCT was significantly more efficient than OPG in the diagnosis of MIC and LF. In order to prevent unforeseen complications, advanced imaging techniques should be used in the interforaminal region during pre-surgical planning of oral surgical procedures.

Keywords: Mandibular incisive canal, lingual foramina, retromolar foramen, bifid canal, accessory mental foramen, anatomic variation

ÖZET

Amaç: Bu çalışmanın amacı mandibulada görülen anatomik varyasyonlar olan aksesuar mental foramen (AMF), retromolar foramen (RF), bifid mandibular kanal (BMK), mandibular insiziv kanal (MİK) ve lingual foramenin (LF) teşhisinde panoramik radyografi (OPG) ve konik ışınlı bilgisayarlı tomografinin (KIBT) etkinliklerinin karşılaştırılmasıdır.

Gereç ve Yöntem: Kliniğimizde 01/04/2013-01/04/2017 tarihleri arasında tedavi edilmiş 189 hastanın klinik ve radyografik verileri retrospektif olarak değerlendirildi. Çalışmaya dahil edilen hastaların hem OPG görüntüleri hem de KIBT kesitleri AMF, RF, BMK, MİK ve LF varlığı açısından iki araştırmacı tarafından incelendi. Araştırmacılar Cohen Kappa testi ile kalibre edildi ($p<0.05$). KIBT ve OPG arasındaki istatistiksel fark McNemar testi ile değerlendirildi. $p<0.05$ istatistiksel olarak anlamlı kabul edildi.

Bulgular: İki radyografi tekniği arasında AMF, RF ve BMK'nin tespiti açısından istatistiksel olarak anlamlı bir fark bulunmazken ($p>0.05$), MİK ve LF insidansları açısından istatistiksel olarak anlamlı fark bulundu ($p<0.05$).

Sonuçlar: KIBT, MİK ve LF teşhisinde OPG'den daha başarılıdır. Mandibula interforaminal bölgeye yapılacak cerrahi plan-

lamalarda ileri görüntüleme tekniklerinin kullanılması, öngörülemeyen komplikasyonları önlemek açısından önem taşımaktadır.

Anahtar kelimeler: Mandibular insiziv kanal, lingual foramina, retromolar foramen, bifid kanal, aksesuar mental foramen, anatomik varyasyon

INTRODUCTION

Anatomic variations in the mandible are abnormal appearances of normal anatomical structures and originate from normal anatomic neurovascular bundles that are harboured in intrabony corticated canals and foraminas. Mandible has a main canal which carries inferior alveolar neurovasculature and supplies nutrition to mandibular teeth, periodontal tissues and neighbouring structures. Variation in normal mandibular anatomy becomes an important matter in oral surgical procedures, especially in dental implant placement and autogenous graft harvesting due to the probability of occurrence of intra or post-operative surgical complications.[1-3] Recently, many studies have been reported to clarify the incidence and to establish working classifications for anatomic variations.[1,4-8]

Panoramic radiographs (OPGs) are one of the preferred imaging methods in dentistry for many years thanks to their wide use in practice, easy accessibility and wide viewing area.[9] In the past years, traditional OPG was thought to be sufficient to evaluate the anatomic structures before surgery. However, artifacts and magnification in the OPGs may cause significant anatomic variations to be overlooked in surgical operations.[7] There is no sufficient data that all anatomic variations can be safely diagnosed with the usage of OPG in routine clinical setting. Cone beam computed tomography (CBCT) imaging method have become more popular to remove aferomentioned disadvantages of OPGs. The fact that OPGs cannot provide quantitative values and detail in the bone structure makes CBCT more advantageous and reliable in observing variations in the normal anatomy.[10] Although there are many studies explaining the incidence and types of mandibular anatomic variations, no detailed comparison of OPG and CBCT techniques has been made in terms of the exact diagnosis of anatomic variations.

The aim of this study is to compare the diagnostic abilities of OPG and CBCT in the detection of mandibular anatomic variations of accessory mental foramen (AMF), retromolar foramen (RF), bifid mandibular canal (BMC), mandibular incisive canal (MIC) and lingual foramina (LF).

MATERIALS AND METHOD

The study protocol was approved by the local Clinical Research Ethics Commitee with approval number 17/05/2017-8 and performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

The clinical and radiographic data of patients referred to Oral and Maxillofacial Surgery Clinic for dental surgical treatment between 01/04/2013-01/04/2017 were retrived from archieves and evaluated retrospectively. The inclusion criteria of the study were as follows;

1- Patients older than 13 years old with complete eruption of permanent teeth.

2- Undamaged or non-missing radiographic and clinical data

3- Simultaneous presence of mandible on OPG and CBCT images

4- Patients with clear OPG without any artifacts

A total of 189 patients were selected for the study according to inclusion criteria. OPGs and CBCT images were obtained with Planmeca ProMax 2D (66kV, 7mA, 16s, Helsinki, Finland) X-ray Unit and Planmeca ProMax 3D MID (90kVp, 8mA, 13.5s, Helsinki, Finland) X-ray unit, respectively. All radiographic images were acquired with same patient positioning and technique. Images were evaluated with a software program (Romexis Viewer 4.3.1R) on a high-resolution grey scale monitor. The presence of anatomical variations of AMF, RF, BMC, MIC and LF were evaluated on both OPGs and CBCT axial, sagittal and frontal images for each patient by two researchers, seperately.

All statistical analysis was performed with SPSS version 20.0 (IBM, Chicago, IL) statistics software package. The calibration of observers were performed with Cohen's Kappa test. The change in the incidence of anatomic variations between OPG and CBCT was compared with McNemar's test. The significance level was set at $p<0.05$.

RESULTS

The Kappa values for AMF, RF, BMC, MIC and LF presence were 0.79, 0.72, 0.85, 0.97, 0.74, respectively in OPG and0.91, 0.86, 0.96, 0.89, 0.82, respectively in CBCT ($p<0.05$). Mean age was 30.7±11.4 with an age range of 16-65. The mean ages of female and male patients were 31.1±11.8 and 30.4±11.1, respectively. Age and gender distribution of all cases was shown in Table 1.

Table 1. Age and gender distribution of all patients included in the study.

GENDER	AGE GROUPS					TOTAL
	13-25 n(%)	26-35 n(%)	36-45 n(%)	46-55 n(%)	56-65 n (%)	
Male	43 (22.7%)	31 (16.3 %)	20(10.5%)	2 (1%)	5 (2.6%)	101(53.4%)
Female	39 (20.5%)	23 (12.1%)	18 (9.5%)	3 (1.6%)	5 (2.6%)	88 (46.6%)
TOTAL	82 (43.2 %)	54 (28.4%)	38 (20%)	5 (2.6%)	10 (5.2%)	189(100%)

All observed incidences of AMF, RF, BMC, MIC and LF anatomic variations were demonstrated in Table 2.

Table 2. Observed incidences of all anatomic variations in OPGs and CBCT sections.

	OPG n(%)	CBCT n(%)	*p*
Accessory Mental Foramen	25 (13.2%)	33 (17.5%)	0.096
Retromolar Foramen	10 (5.3%)	16 (8.5%)	0.109
Bifid Mandibular Canal	27 (14.3%)	37 (19.6%)	0.076
Mandibular Incisive Canal	24 (12.7%)	62 (32.8%)	0.0001*
Lingual Foramen	19 (10.1%)	112 (59.3%)	0.0001*

McNemar's test *$p<0.05$

CBCT: Cone beam computed tomography

OPG: Panoramic radiography

There was no statistically significant difference between radiography techniques in the detection of AMF, RF and BMC ($p>0.05$). The incidences of MIC and LF were significantly different between two imaging modalities ($p<0.05$). CBCT was significantly more efficient than OPG in the diagnosis of these two variations (Table 1, $p<0.05$).

DISCUSSION

The most important anatomic landmarks in the planning of mandibular surgery are mandibular canal and mental foramen.The pre-surgical planning of various surgical procedures such as mandibular third molar extraction, orthognathic surgery, fracture fixation or dental implant placementmay changedue to the variations of neurovascular structures in the mandibular canal.[11-13] The variations of the mandibular canal may lead to the difficulty of providing anesthesia, extensive hemorrhage in the surgical field and post-operative sensory loss. The correct pre-surgical monitoring of these variations should be made in order to prevent surgical complications.

AMF is the presence of another foraminal structure apart from the main mental foramen. Mental foramen is the continuation of the mandibular canal and the exit point of the mental nerve and provides the innervation of the the lower incisor teeth, mucosa and lower lip.It is important that the mental foramen is properly detected during surgery and remains intact during the procedure.The incidence of AMF was reported between 5%-30% in studies that used CBCT for the detection of the variation.[14-17] In our study, AMF was detected in 33 patients (17.5%) and it is consistent with literature findings. The detectability of AMF in OPG was reported low in the literature, as found similar in the current study.[1,14] However, there was no statistical significant difference between CBCT and OPG in the detection of AMF ($p>0.05$).

RF is defined as an accessory canal in the retromolar region.[7,18] RF is often continuated with a canalicular structure and associated with inferior alveolar canal or its branches in several cases.[8] It is suggested that retromolar surgeries such as impacted third molar extraction or ramus graft harvesting may disrupt this accessory foramen and cause severe hemorrhage due to its arterial content.[18] The incidence of RF reported between 12%-75%.[8,18-21] Bilecenoğlu and Tuncer[18] reported the incidence of RF as 25% in a Turkish population. In the current series, the incidence of RF (8.5%) was relatively lower than that of the literature.

BMCs are alveolar inferior canals particulated into two parts manifesting different shapes and courses along the mandibular body.[7] The incidence of BMC in the current study was 19.6%. An incidence between 25%-66.5% was reported in the literature, thus the incidence was slightly reduced in the current study.[1,7,18] OPG has been found ineffective in the detection of BMC and the usage of CBCT images are suggested and promoted for several advantages such as low radiation density and high quality image rendition.[1,22-24] However, in the current study, there was no statistically significant difference between OPG and CBCT evaluation in the detection of BMCs.

MICs are accessory corticated canals that extend anterior to the mental foramen and provide nerve and blood supplies to the incisive teeth. Until recently there were doubts regarding the presence of MIC, however, the existence of this variation was proved in recent anatomical studies.[3,6] The innervation of the lower anterior teeth, lower canine teeth, and premolar teeth is provided by the mental nerve that emerges from mental foramen.The path followed by the nerve after mental foramen separation is usually in the trabecular bone without cortical borders.MIC tract can easily be misdiagnosed on conventional radiographs due to thick cortical bone plate and magnification artifacts of the mandible.[5] MIC is in the danger zone for the surgical interventions in the interforaminal region, especially for dental implant placement and autogenous symphyseal graft operations. Such surgeries may disrupt the MIC and cause instant hemorrhage and parasthesia on peri-operative or post-operative processes.[2,25,26] The incidence of MIC varies between 83% to 100% in CBCT images.[3,5,6,27,28] Several studies reported that the incidence of detection of MIC is between 2.7-15 % in OPG.[24,26,28] The incidences of MIC for OPG and CBCT in the current study are 12.7% and 32.8%, respectively. CBCT was significantly better in the diagnosis of MIC compared to OPG ($p<0.05$).

Interforaminal region is often subjected to a range of surgical interventions such as dental implant placement, pre-prosthetic surgeries, biopsy, autogenous graft harvesting, genioplasty or miniplate fixation for trauma in routine clinical setting. LF are small bony holes which are located on the anterior lingual surface of the interforaminal region. They are categorized in two types as lateral lingual foramen (LLF) and medial lingual foramen (MLF).[4] MLF is located on the median plane of the mandible, mostly as an isolated bony hole, whereas LLF is observed laterally to the median plane, mainly around lateral and canine region. Both foramina and associated canals con-

tain nerve and artery bundles that may be derived from various main branches such aslingual artery, sublingual artery, submental artery, mylohyoid nerve, lingual nerve and alveolar inferior nerve.[29-33] It is crucial to monitorize the exact positions of LF to prevent neurosensory and hemorrhagic complications on the floor of the mouth during or after the surgical interventions in this region.[4,34-36] Mraiwa[6] suggested that immediate implant placement deeper than extraction sockets may cause perforation of LF. Hemorrhage was reported after surgical intervention on the anterior region of the mandible between right and left mental foramens, although this region was reported as a safe zone for dental implant placement.[12,37,38] Gahleitner[39] reported a frequency of MLC and LLC as 98% and 72%, respectively. Another study revealed a percentage of 85.07% for the incidence of MLC.[4] A hundred and twelve patients had median and lateral lingual foramina in the present study. Patients included in the current study were relatively young (mean age: 30.7±11.4) and had dentate jaws and CBCT sections of the superior aspect of the mylohyoid muscle was taken into account due to the lack of alveolar bony resorption. This situation might have led to the misdiagnosis of LF that are located inferior to the mylohyoid muscle, thus, decreasing the incidence.
Anatomic variations of the mandible may become important variables in pre-surgical planning. Insufficient evaluation of surgical site before surgery may lead to bothersome complications during surgery. CBCT imaging is a gold standard radiographic method to visualize variative structures that cannot be completely diagnosed in OPG. Interforaminal region is especially important in oral surgery, because it may contain medial-lateral LF, MIC and their many variative branches.

CONCLUSIONS

OPG seems to be useful to monitorize anatomic variations of AMF, RF, BMC in routine pre-surgical evaluation. However, it was found to be less efficient for the identification of the MIC and LF compared to CBCT. An elaborate analysis with CBCT imaging should be made before oral surgical procedures that will be performed in the mandibular anterior region, especially in interforaminal region to reduce intra and post-operative complications.

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