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CT Study of the Medial Depression of the Human Mandibular Ramus

Estudio TC de la Depresión Medial de la Rama Mandibular Humana

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SUMMARY: The aim of this study was to describe the radiographic features of the medial depression of the human mandibular ramus (MDMR) on CT images. The radiographic features of the depression were assessed on multiplanar reformatting (MPR) section of CT scans of eighteen mandibles with 36 MDMRs. The MDMR was observed to be a smooth bone concavity with intact medial and lateral cortical plate located on the medial aspect and anterior to the greatest depth of the sigmoid notch. The average mediolateral depth of the depression was 1.64 mm (Std Dev 0.63 mm), while the average thickness of the thinnest area of the mandibular ramus at the site of the depression was 1.08 mm (Std Dev 0.33 mm). The average anterioposterior width of the depression was 10.39 mm (Std Dev. 3.36 mm). The soft tissue window images showed that the temporalis tendon inserts at the depression in all cases. MDMRs have CT features that help in its identification.

KEY WORDS: Mandible; Abnormalities; Anatomy & histology; Diagnostic imaging.

INTRODUCTION

The medial depression of the human mandibular ramus (MDMR), also called medial sigmoid depression, is a variation of normal anatomy seen on the medial aspect of the ramus of the mandible just below and anterior to the greatest depth of the sigmoid notch. This depression has been described in the literature on anatomical studies on human mandibles and on panoramic radiographs (Langlais *et al*., 1983; Clark & McAnear, 1984; Langland *et al*., 1989; Kang, 1991; Carvalho *et al*., 2001; Dalili & Mohtavipour, 2003; Sudhakar, 2014). On panoramic radiographs, it appears as a radiolucency resembling a foramen (pseudoforamen) and may even be misinterpreted as a pathological condition or pseudocyst (Langlais *et al*.; Clark & McAnear) (Fig. 1). It was first reported by Langlais *et al*. in a study on dry human skulls. They described MDMR on panoramic radiographs made of the skulls as a unilateral or bilateral, small, round, ovoid or triangular well-defined radiolucency that generally lacks a cortical margin. Salivary gland-related cortical defects involving the ascending ramus (Stafne bone defect) have been reported (Prapanpoch & Langlais, 1994; Campos *et al*., 2004; Hisatomi *et al*., 2019; Lee *et al*., 2019). Unlike the medial depression of the mandibular ramus (MDMR), these defects were reported to occur at a more posterior and / or inferior location in the medial or lateral aspect of the mandibular ramus and were all unilateral and appeared as well-defined radiolucencies that are unilocular, multilocular or irregular in shape. The medial depression of the mandibular ramus (MDMR) is an anatomical variation that can be readily recognized on panoramic radiographs and, if no surgical procedures are planned at this site (such as sagittal split osteotomy orthognathic surgery), needs no further radiographic investigation or intervention.

Although MDMR was long recognized as an anatomical variation, when it is encountered on panoramic radiographs, it might be misinterpreted as an anomalous coronoid foramen. Since cone beam computed tomography (CBCT) is now widely utilized in dental clinics, unnecessary radiographic exposures might be made to investigate it even in patients of young age (Subhan, 2018; Nyer Firdoose, 2020). Even after CBCT examination is made, MDMR can still be misinterpreted as a foramen due to inappropriate thresholding setting in transparent volume-rendered images or misinterpreted in CT sections as interruption in bone surface due metal artifact in CT sections resulting from metallic objects in the oral cavity such as filling materials or dental prosthetic components. Young patients can be further exposed to unnecessary multidetector CT (MDCT) examination which

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required higher radiation exposure or costly magnetic resonance imaging (MRI) for further investigation (Subhan). This misinterpretation could be due to the fact that there is currently no accurate description of MDMR on MDCT or CBCT images and all previous studies on it provided radiographic description based on panoramic radiographs only. Thus, the purpose of this study is to describe the radiographic features of MDMR on MDCT and CBCT images.

MATERIAL AND METHOD

After the research project was reviewed and approved by the institutional review board (IRB), permission was granted to conduct this study. The study protocol was in compliance with the Helsinki Declaration. MDCT and CBCT scans of the mandible made for adult patients referred to the oral and maxillofacial radiology clinic at the Dental University Hospital at King Saud University in Riyadh were reviewed. The CT examinations were made using GE Lightspeed VCT 64-raw helical CT scanner (GE Healthcare, Milwaukee, Wisconsin, USA) with a tube voltage of 120 kV; auto mA tube current; section thickness and separation between sections was 0.6 mm, and pitch was 0.98. The matrix size was 512 × 512 with a minimum 16 cm field of view. CBCT examinations were made using Planmeca ProMax 3D CBCT unit (Planmeca Oy, Helsinki, Finland) with a voxel size not more than 0.4 mm. The reconstructed images were then transferred to workstation for reformatting and image analysis as DICOM format (Digital Imaging and Communications in Medicine) with Romexis software version 5.2.0.R (Planmeca Oy, Helsinki, Finland). These examinations were originally requested to assess lower third molars or dental implant sites. Selection criteria for the chosen examinations were scans that included at least a field of view that included both mandibular rami and full sigmoid notches and coronoid processes. Selection criteria for the chosen examinations were scans that included at least a field of view that included mandibular ramus and no intrabony pathology or history of previous surgery in the mandible. Cases were selected when a well-defined depression on the medial aspect of the ramus of the mandible just below and anterior to the greatest depth of the sigmoid notch was noted on MDCT or CBCT examinations. These inclusion criteria were comparable to previous anatomical studies made on this depression on dry mandibles or radiographic studies on panoramic radiographs. The study variables collected for each case were: the presence of foramina at the area of the MDMR, the thickness and integrity of the mandibular ramus at the MDMR and the radiodensity of content of MDMR on MDCT - soft tissue windows. For linear measurements on axial sections, a standardized multiplanar reformatting (MPR) section was made along the anteroposterior, mediolateral and inferiosuperior axes of the mandibular ramus for all the cases by an oral and maxillofacial radiologist with over 20 years of experience and saved (Fig. 2a). The same operator viewed all the MDCT and CBCT examinations on a 22-inch Dell E228WFP flat panel monitor (Round Rock, TX, USA) with a display resolution of 1680 × 1050 pixels. The images were viewed with the same software used for MPR. The observer could only adjust the brightness and contrast to evaluate the MPR images to assess MDMRs and perform linear measurements. The mediolateral depth of the MDMR was measured as the greatest length of a line drawn perpendicular to a line along the medial surface of the mandibular ramus in the area of the depression. The thickness of the mandibular ramus was measured along the shortest line drawn between the lateral and medial cortical plates of the ramus in the widest area of the depression (Fig. 2b). The width of depression was measured at the widest anterioposterior dimension at a line perpendicular to the line representing the mediolateral depth.

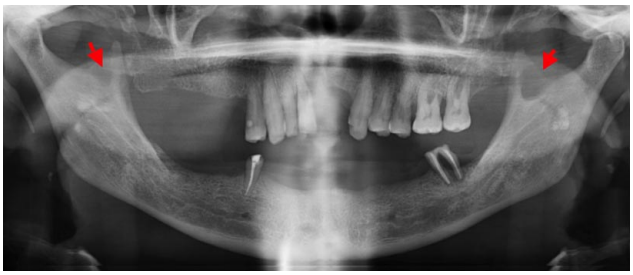

Fig. 1. Panoramic radiograph showing a bilateral symmetrical semilunar shaped radiolucency (arrows) that lacks cortication in the anterior most upper mandibular ramus region near the sigmoid notch.

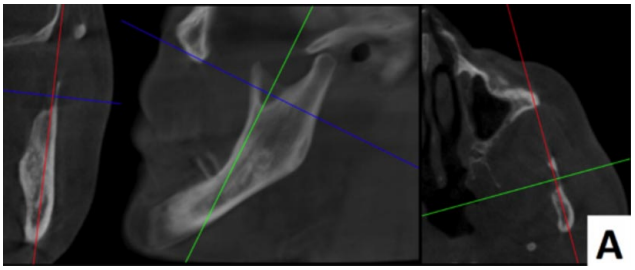

Fig. 2. Planes of reconstruction in multiplanar reformatting (a) and the orientation of the linear measurements lines of the depression depth and bone thickness.

RESULTS

Eighteen subjects with 36 MDMRs were included in this study (10 males and 8 females). They ranged in age from 18 to 76 years (average 41.9 years). All subjects had

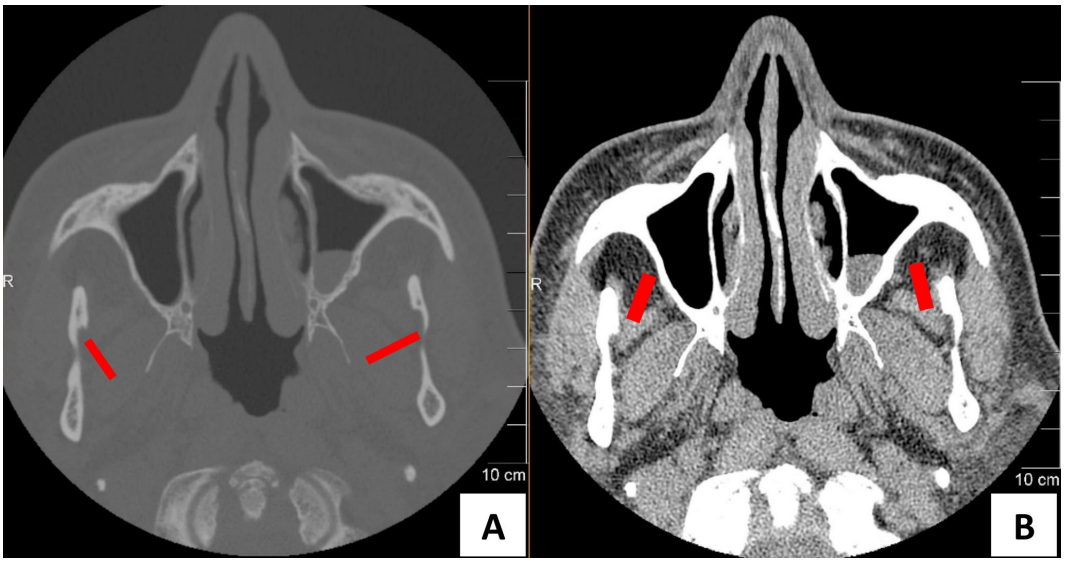

Fig. 3. Axial CT sections through the mandibular ramus with bone (A) and soft tissue (B) windows of the same case. The depression can be noted as well defined on the medial aspect of the ramus bilaterally (arrows). The images show that the temporalis tendon inserts at the depression (arrow heads).

upper and lower posterior teeth that were in occlusion. The depression occurred bilaterally in all subjects. When the medial depression of the mandibular ramus (MDMR) was viewed on corrected axial section of a CBCT/MDCT image, a smooth bone concavity with intact medial and lateral cortical plate located on the medial aspect and anterior of the mandibular ramus was noted. The depression can be found on the medial side of the mandibular ramus, anterior to the greatest depth of the sigmoid notch, and near the base of the coronoid process (Figs. 3 and 4). The average mediolateral depth of the depression was 1.64 mm (Std Dev 0.63 mm), while the average thickness of the thinnest area of the mandibular ramus at the site of the depression was 1.08 mm (Std Dev 0.33 mm). The average anteroposterior width of the depression was 10.39 mm (Std. Dev. 3.36 mm). The soft tissue window images showed that the temporalis tendon inserts at the depression in all cases (Figs. 4 and 5).

DISCUSSION

On MDCT and CBCT images, the medial depression of the mandibular ramus (MDMR) was found to occur bilaterally, on the medialsurface of the mandibular ramus, anterior to the inferior-most point of the sigmoid notch, and near the base of the coronoid process as a smooth triangular depression with its base toward the superior edge of the mandibular ramus and lined medially and laterally with intact corticated margins. This triangular shape and smooth margins can help distinguish it from salivary gland-related cortical defects involving the ascending ramus (Stafne bone defect) or pathological lesion. The temporalis tendon was observed inserting at the MDMR when assessed with soft tissue-CT windows, and thus we propose that this depression be named the temporalis depression (or fovea) of the mandibular

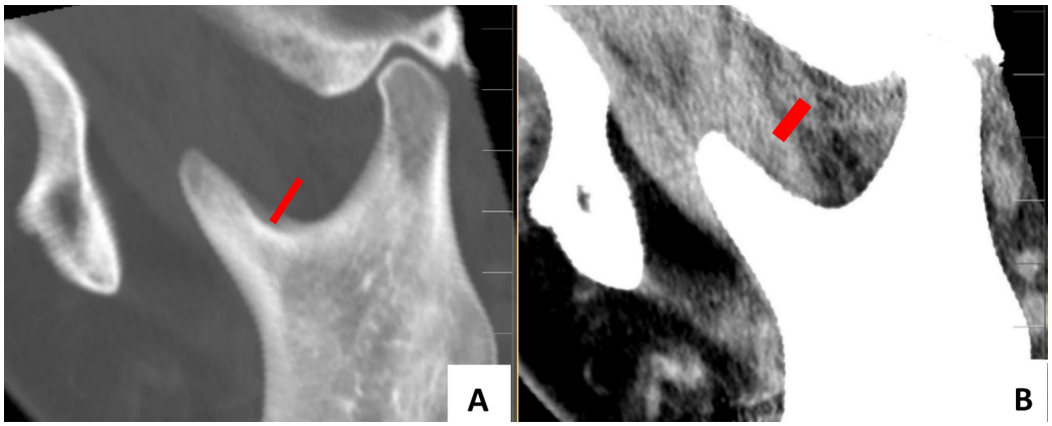

Fig. 4. Corrected sagittal CT sections through the mandibular ramus with bone window (A). The arrow demonstrates the semilunar shape of the medial depression of mandibular ramus. The soft tissue window (B) shows that the temporalis tendon inserts at the depression (arrow head).

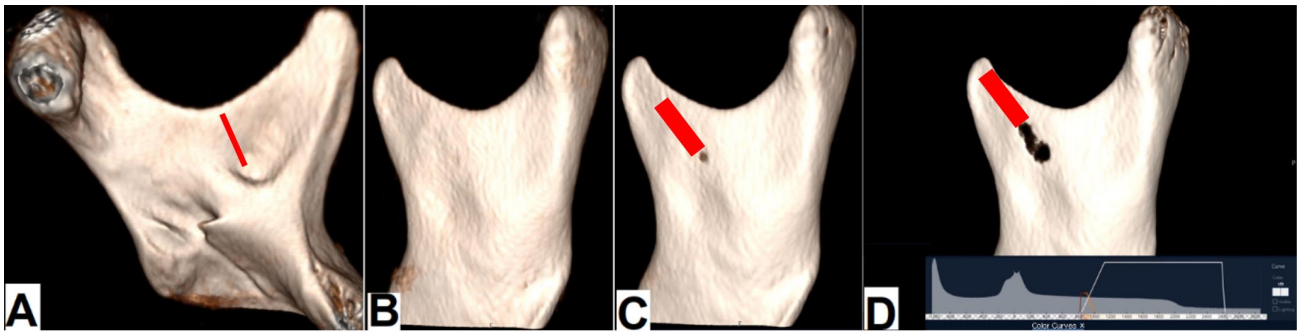

Fig. 5. (A) A volumetrically rendered 3-dimensional CT image of the medial surface of the mandibular ramus showing the depression with appropriate thresholding and transparency setting showing the MDMR (arrow). Same mandible is seen in (B) from the lateral aspect in appropriate thresholding setting appearing intact. (C and D) Incorrect thresholding setting resulting in the appearance of a false interruption in the lateral surface of the thin mandible at this site that could be erroneously interpreted as a foramen (arrow heads).

coronoid process since it is analogous to the depression found on the medial side of the neck of the condylar process of the mandible and known as pterygoid depression (or fovea) in which the inferior head of lateral pterygoid muscle inserts (Bravetti *et al*., 2004).

It has been proposed that the shape and size of MDMR could be attributed to differences in the muscle activity of the posterior and medial attachments of the temporalis muscle in the sigmoid region (Storey *et al*., 1975; Bravetti *et al*.). The maintenance of full or partial posterior occlusion observed in the patients in this study give support to the possible association between medial depression of mandibular ramus and maximum bite force that was proposed as the presence of MDMR may indicate high muscle activity (Adisen *et al*., 2018).

The mediolateral depth of the MDMR reported in this study ranged from 0.8 mm to 3.3mm (average 1.64 mm). A depression of such depth in the mandibular ramus is expected to result in a change in the radiographic density that would make it noticeable on panoramic radiographs. The mandibular ramus can be very thin at the area of the MDMR and in the thinnest area of the depression we found it to be on average about 1mm in mediolateral thickness and was found in this study to be as thin as 0.5 mm. Nevertheless, the radiographic features of the medial depression of the mandibular ramus were adequately assessed by thin CT sections free of metallic artifacts and its contents and relations to the adjacent structures were evaluated on bone window and soft tissue windows of CT. However, if it was assessed in volume rendered (VR) CT images in which the threshold or opacity and translucency settings was set to show structures deep to the bone surface, it can be erroneously interpreted as a foramen since very thin bone is not visible in such VR images because of the thresholding process. For visualization of thin bone, multiplanar reformatting (MPR) images provide the most accurate results with measurements in highest agreement to the anatomical findings (Patcas *et al*., 2015). Volume rendering of CT was shown to be less accurate than MPR and thus, one needs to keep in mind that such rendering of CT or CBCT examinations is for overall visualization purposes only, and not for diagnosis and analysis (Pauwels *et al*., 2015). When bone is very thin, volume rendered images may demonstrate such artificial holes in the bones of the skull (pseudoforamina), when in fact a thin shell of bone is actually present (Howard *et al*., 1990). The European Commission Guidelines on CBCT have listed the observation of pseudoforamina in VR CBCT images as a post-acquisition manipulation error due to incorrect thresholding and recommended operator training in appropriate use of windowing controls (European Commission, 2012).

If multidetector CT (MDCT) sections were used to assess the MDMR, bone-window is the method of choice while assessment of the content should be made on soft tissue-window. If CT sections in soft tissue window only are examined, the details of hard tissues such as bone will not be seen very well. Fine anatomical details of the bone such as integrity or interruption of the cortical bone are not usually seen very well on such window and a bone window is required. Furthermore, care must be taken when assessing thin bony surfaces on CT if there is a metallic streak artifact that usually results from metallic dental fillings. High-density materials, such as amalgam fillings or casted metal dental restorations cause beam-hardening and/or streak artifacts, which may limit visualization of the anatomy adjacent to such materials and the bone adjacent to such material may appear missing to variable degrees (Al-Ekrish, 2018).

CONCLUSION

The CT radiographic features of the medial depression of the mandibular ramus (MDMR) were

acknowledged as a normal anatomic variant that is observed as a radiolucency anterior and below the sigmoid notch on panoramic radiographs, which should be recognized to avoid the misinterpretation of the landmark as a pathology. It can be easily distinguished on CBCT and MDCT images as a depression or concavity located on the medial aspect of ramus, below and anterior to the greatest depth of the sigmoid notch. At this site, the mandibular ramus is very thin and it can be misinterpreted on MDCT or CBCT as an interruption or foramen or a pathological lesion (pseudoforamen or pseudocyst) especially if the CT images were inappropriately processed.

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RESUMEN: El objetivo de este estudio fue describir las características radiográficas de la depresión medial de la rama de la mandíbula humana (MDMR) en imágenes de TC. Las características radiográficas de la depresión se evaluaron en la sección de reformateo multiplanar (MPR) de tomografías computarizadas de las dieciocho mandíbulas con 36 MDMR. Se observó que el MDMR es una concavidad ósea lisa con placa cortical medial y lateral intacta ubicada en la cara medial y profundidad de la incisura mandibular. La profundidad mediolateral media de la depresión fue de 1,64 mm (DS 0,63 mm), mientras que el grosor medio del área más delgada de la rama mandibular en el sitio de la depresión fue de 1,08 mm (DS 0,33 mm). El ancho anteroposterior promedio de la depresión era de 10,39 mm (DS 3,36 mm). Las imágenes de tejido blando mostraron que el tendón temporal se insertaba en la depresión en todos los casos. Los MDMR tienen características CT que ayudan en su identificación.

PALABRAS CLAVE: Mandíbula; Anormalidades; Anatomía e histología; Diagnóstico por imagen.

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